Trends in and Determinants of Vaccination Among Children Age 12–23 Months, 2011–2022 Nepal DHS Surveys

DHS Further Analysis Reports No. 156

*Barun Kumar Singh, Resham Khatri,
Sanjay Kumar Mahaseth, Krishna Prasad Paudel,
Rachael Church*

September 2024

DHS Further Analysis Reports No. 156

Trends in and Determinants of Vaccination Among Children Age 12–23 Months, 2011–2022 Nepal DHS Surveys

Barun Kumar Singh[1]
Resham Khatri[1,2]
Sanjay Kumar Mahaseth[3]
Krishna Prasad Paudel[3]
Rachael Church[4,5,6]

ICF
Rockville, Maryland, USA

September 2024

[1] USAID Learning for Development, Nepal
[2] School of Public Health, University of Queensland, Australia
[3] Ministry of Health and Population, Nepal
[4] ICF, USA
[5] The DHS Program, USA
[6] Avenir Health, USA

Corresponding author: Barun Kumar Singh, USAID Learning for Development, Kathmandu, Nepal; barun272@gmail.com

Ministry of Health and Population

CONTENTS

TABLES

FIGURES

PREFACE

The 2022 Nepal Demographic and Health Survey (2022 NDHS) is the sixth survey of its kind implemented in the country as part of the worldwide Demographic and Health Surveys (DHS) Program. It was implemented under the aegis of the Ministry of Health and Population (MoHP) of the Government of Nepal with the objective of providing reliable, accurate, and up-to-date data for the country. The survey received funding from the United States Agency for International Development (USAID). 2022 NDHS information has assisted policymakers and program managers in policy formulation, monitoring, and designing programs and strategies for improving health services in Nepal. The 2022 NDHS is a key data source for tracking the progress of the Nepal Health Sector Strategic Plan 2023–2030 and the Sustainable Development Goal indicators.

The 2022 NDHS further analysis reports provide additional in-depth knowledge and insights into key issues that emerged from the 2022 NDHS. This information provides guidance for planning, implementing, refocusing, monitoring, and evaluating health programs in Nepal. This further analysis is also an important initiative to strengthen the technical capacity of Nepali professionals for analyzing and using large-scale data to better understand specific issues related to the country's needs. We are glad that in the sixth round of the NDHS, we were able to produce 11 further analysis reports. We urge that all policymakers, program administrators, program managers, health workers, and other key stakeholders optimally use the information from these reports in program planning and management. High-quality evidence should be the basis of our health programs planning, implementation, monitoring, and evaluation.

Finally, we would like to appreciate the leadership of the Policy Planning and Monitoring Division, and the efforts of the different individuals of the MOHP, and the Department of Health Services in generating these reports. We are thankful to USAID Nepal for their continued support in implementing the NDHS and further analysis studies in Nepal.

Hari Prasad Mainali
Secretary
Ministry of Health and Population

Dr. Roshan Pokhrel
Secretary
Ministry of Health and Population

Government of Nepal

Ministry of Health & Population

Phone : 4.
262987
262590
262802
262706
262935
262862

Ramshahpath, Kathmandu
Nepal

Ref: ....

Date : 12.07.2024

FOREWORD

The 2022 Nepal Demographic and Health Survey (2022 NDHS) is the sixth nationally representative comprehensive survey conducted as part of the worldwide Demographic and Health Surveys (DHS) Program in the country. The survey was implemented by New ERA under the aegis of the Ministry of Health and Population (MoHP). Technical support for this survey was provided by ICF, with financial support from the United States Agency for International Development (USAID) through its mission in Nepal.

The standard format of the survey's final report included descriptive presentations of findings and trends but not of analytical methods that could ascertain the significance of differences and associations among variables. Thus, although largely sufficient, the final report is limited, particularly in providing answers to "why" questions-answers those are essential for reshaping important policies and programs. After the dissemination of the 2022 NDHS, the MoHP, USAID, and other health development partners convened and agreed on key areas that are necessary for assessing progress, gaps, and determinants in high-priority public health programs being implemented by the MoHP. In this context, 11 further analysis studies have been conducted by Nepali consultants under the direct leadership of the MoHP. The consultants were supported by USAID through the Leaming for Development Activity in Nepal and through The DHS Program.

The primary objective of the analysis studies was to provide more in-depth knowledge and insights into key issues that emerged from the 2022 NDHS. This information provides guidance for planning, implementing, refocusing, monitoring, and evaluating health programs in Nepal. One of the learning objectives is to strengthen the technical capacity of Nepali professionals for analyzing and using data from complex national population and health surveys to better understand specific issues related to country needs.

The further analysis of the 2022 NDHS was the concerted effort of many individuals and institutions, and it is with the great pleasure that we acknowledge the work involved in producing this useful document. The participation and cooperation of the officials of the MoHP and the Department of Health Services are highly valued. We would like to extend our appreciation to USAID Nepal for providing financial support for the further analysis. We would also like to acknowledge The DHS Program for its technical assistance at all stages. Our sincere thanks also goes to the USAID Learning for Development Activity team for the overall management and coordination of the entire process. Our special appreciation goes to the Policy Planning and Monitoring Division, MoHP, for their efforts and dedication to the completion of the further analysis of the 2022 NDHS.

Dr. Tanka Prasad Barakoti
Additional Secretary
MOHP

Dr.Bikash Devkota
Additional Secretary
MOHP

Dr. Dipendra Raman Singh
Additional Secretary
MOHP

ACKNOWLEDGMENTS

Dr. Krishna Prasad Paudel
Chief, Policy Planning and Monitoring Division
Ministry of Health and Population

ABSTRACT

Nepal has made significant progress in child health by achieving consistently high coverage of childhood vaccination. However, the overall trend of children not being vaccinated has increased in recent years. This study aimed to examine trends in and determinants of vaccination coverage among children age 12–23 months. Trends were analyzed using data from the last three rounds of the Nepal Demographic and Health Survey (NDHS) (n=1,000 in 2011, n=1,034 in 2016, and n=954 in 2022). Determinants were analyzed among data from the 954 children included in the 2022 NDHS.

We found an increasing trend in no vaccination at both national and provincial levels, with large gaps in vaccination status by wealth quintile. Bagmati province had the highest rate of no vaccination in 2022, while Madhesh province had the highest rates of partial immunization in all three NDHS surveys. Approximately one-third of Muslim children, one in four Dalit children, and one in five children from the Terai caste had received only partial vaccination. Statistically significant associations were found between no vaccination and both number of antenatal care visits and whether children were born in health facilities. If mothers were not aware of health mothers' groups in their wards, their children were more likely to be partially immunized.

In the context of increasing rates of partial and no vaccination among children, and equity gaps between privileged and disadvantaged groups, health system efforts must focus on both supply- and demand-side factors. To create awareness of and demand for child immunization, communication among health care providers, parents, and other caretakers needs to emphasize the heightened risks of vaccine-preventable disease outbreaks. Communication barriers can be addressed by distributing linguistically appropriate materials in Madhesh province. Additionally, reminder systems, such as text messages or phone calls to mothers who miss vaccinations, could encourage mothers to bring their children to upcoming vaccination clinics. Integration of antenatal care checkups and immunization clinics could enhance children's vaccination rates. Additionally, Nepal's National Immunization Program could leverage and ensure the involvement of female community health volunteers in leading health mothers' group meetings at the local level. Conducting annual social audits of incomplete child immunization could effectively identify target children in each health post catchment.

Key words: childhood vaccination, immunization, full vaccination, partial vaccination, no vaccination, 12–23 months

ACRONYMS AND ABBREVIATIONS

ANC	antenatal care
ARRR	adjusted relative risk ratio
BCG	Bacille Calmette-Guérin
CI	confidence interval
cMYPI	Comprehensive Multi-Year Plan for Immunization
DHS	Demographic and Health Surveys
DoHS	Department of Health Services
DTP	diphtheria, tetanus toxoid, and pertussis
FCHV	female community health volunteer
HepB	hepatitis B
Hib	Haemophilus influenzae type b
HMG	health mothers' group
HPV	human papillomavirus
IPV	inactivated polio vaccine
JE	Japanese encephalitis
MoHP	Ministry of Health and Population
MR	measles-rubella
NDHS	Nepal Demographic and Health Survey
NIP	National Immunization Program
NIS	National Immunization Strategy
OPV	oral polio vaccine
PCV	pneumococcal conjugate vaccine
RI	Routine Immunization
TCV	typhoid conjugate vaccine
Td	tetanus-diphtheria
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VPD	vaccine-preventable disease
WHO	World Health Organization

1   INTRODUCTION

Improvement in child health has been a global focus for the past four decades.[1] Reducing child mortality has been a priority through the Millennium Development Goals and the Sustainable Development Goals.[2] Immunization[*] is a cost-effective public health intervention toward attaining Sustainable Development Goal 3: reducing under-5 mortality to less than 25 deaths per 1,000 live births by 2030.[3] Childhood immunization can avert an estimated 4–5 million deaths in all age groups yearly from vaccine-preventable diseases (VPDs) worldwide. Moreover, 1.5 million deaths could be avoided if universal coverage of vaccination was achieved globally.[4] The Global Vaccine Action Plan targeted 90% national coverage of the third dose of the diphtheria, tetanus toxoid, and pertussis (DTP) vaccine, a globally recognized proxy for vaccination system performance, and at least 80% coverage of DTP3 for every district or equivalent administrative level by 2015.[5] Further, the Global Vaccine Action Plan targeted 90% national and 80% district coverage for all vaccines included in the National Immunization Program (NIP) by 2020.[5] Despite ongoing efforts, global DTP3 vaccine coverage was estimated to be only 84% in 2022, leaving an estimated 20.5 million children either unvaccinated or under-vaccinated. The number of children receiving no vaccinations has, concerningly, been trending upward globally, from 12.8 million in 2019 to 14.5 million in 2023.[6]

Historically, vaccination coverage has been measured by the proportion of children receiving all "basic" antigens. A child is considered fully vaccinated against all basic antigens if the child has received the Bacille Calmette-Guérin (BCG) vaccine, three doses each of the oral polio vaccine (OPV) and the DTP or equivalent vaccine, and a single dose of the measles-rubella (MR) vaccine.[7] In Nepal, the BCG vaccine is given at birth or first clinic contact, while the OPV and DTP vaccine (given as the pentavalent vaccine, or DTP-HepB-Hib) are given together at 6, 10, and 14 weeks of age. The first dose of the MR vaccine is given at or soon after 9 months, whereas the second dose is given at age 15 months.[8–10] The NIP in Nepal has made significant progress and is often regarded as one of the most successful immunization programs among low- and middle-income countries.[11] Nepal's NIP has made significant progress in controlling, eliminating, and eradicating VPDs. Some examples of this success include the eradication of smallpox (1977), the elimination of maternal and neonatal tetanus (2005), polio-free certification (2014), rubella control certification (2018), and certification of hepatitis B control in children through immunization (2019).[12]

---

[*] In alignment with Nepal's National Immunization Program, this report uses immunization and vaccination interchangeably. However, vaccination specifically refers to the act of administering a vaccine, while immunization encompasses a more comprehensive view of the overall process of acquiring immunity.

By 2009, Nepal's immunization schedule included all eight vaccinations that the World Health Organization (WHO) recommended at the time (Box 1). More vaccines were added to the NIP, guided by the Comprehensive Multi-Year Plan for Immunization (cMYPI).[9] As per the cMYPI (2017–2021), the typhoid conjugate vaccine (TCV) was introduced into Nepal's Routine Immunization (RI) program (a mechanism for procuring and delivering vaccination in Nepal) in 2022 following a nationwide catch-up campaign, whereas the human papillomavirus (HPV) vaccine is planned to be introduced nationally in fiscal year 2024/2025. Children up to age 15 months receive 13 antigens, and pregnant women receive the tetanus-diphtheria (Td) vaccine, free of cost under the NIP through more than 16,000 service delivery outlets (fixed sessions), outreach sessions, and mobile clinics.[9–11,13] Children who miss vaccines as per the routine schedule can receive applicable vaccines up to age 5 through RI. Health facilities run by private and nongovernmental organizations have also provided immunization services per the NIP.[9] Access to immunization has improved in hard-to-reach areas and populations, including children from the lowest wealth quintile.[14]

Box 1 Introduction of vaccines to the immunization program after 2000

2002:	Hepatitis B (HepB) vaccine (monovalent)
2004:	Diphtheria, tetanus toxoid, and pertussis (DTP)-HepB vaccine (tetravalent)
2006:	Japanese encephalitis (JE) vaccine campaign started in phases (31 high risk districts) followed by introduction into Routine Immunization (RI) in phases
2009:	Haemophilus influenzae type b (Hib) in pentavalent vaccine (DTP-HepB-Hib)
2013:	Rubella as measles-rubella (MR) vaccine
2014:	Inactivated polio vaccine (IPV)
2015:	Pneumococcal conjugate vaccine (PCV); second dose of MR vaccine
2016:	JE vaccine (scaled up in RI in all remaining districts); switch from trivalent OPV to bivalent OPV
2016/17:	Human papillomavirus (HPV) vaccine (Kaski and Chitwan only as demonstration program)
2018:	Switch from IPV to fractional-dose IPV
2020:	Rotavirus vaccine
2022:	Typhoid conjugate vaccine (TCV)

In 2012/2013, Nepal introduced a unique full immunization declaration initiative with the support of external development partners to further accelerate vaccination coverage with equity.[9] Several health policies, programs, and strategies related to immunization were designed and implemented (Box 2).[9,12] These align with global commitments and have contributed to the ongoing decline in child mortality, as evidenced by periodic survey reports.[10,15,16] Nepal has engaged stakeholders at all levels to work toward full immunization and address the social inequity in vaccination for every child. The NIP has achieved several milestones in the reduction of morbidity, mortality, and disability associated with VPDs. As of November 2023, 72 of 77 districts and 724 of 753 municipalities have achieved "full immunization" status.[12]

The National Immunization Strategy (NIS) 2030 is currently being developed. The NIS 2030, with the vision of "Nepal, a country where everyone, everywhere, at every age fully benefits from vaccines for good health and well-being," is guided by national, regional, and global strategic documents, such as the Strategic Framework for the South-East Asia Regional Vaccine Action Plan 2022–2030, the Immunization Agenda 2030, and the Global Alliance for Vaccines and Immunization Strategy.[17] Moreover, the NIS fits within the broad and integrated framework of the Nepal Health Sector Strategic Plan 2022–2030 and other public health program-specific strategic plans.[17]

Box 2 Health policies, programs, and strategies related to immunization in Nepal

- **Expanded Program on Immunization:** Started in 1977
- **Female community health volunteer program:** Started in 1988
- **Constitution and Democracy:** 1990
- **First National Health Policy:** 1991
- **Second long-term health plan:** 1997–2017
- **Polio surveillance:** 1998
- **Nepal Health Sector Strategy:** 2004–2009
- **Measles vaccination campaigns:** 2004 and 2008
- **Comprehensive Multi-Year Plan for Immunization (cMYPI):** 2007–2011
- **Measles-rubella (MR) vaccination campaign:** 2012
- **Nepal Health Sector Strategy:** 2010–2015
- **cMYPI:** 2011–2016
- **MR vaccination campaigns:** 2015 and 2016
- **National Health Policy:** 2014
- **Constitution and Federalization:** 2015
- **Nepal Health Sector Strategy Implementation Plan:** 2016–2021
- **cMYPI:** 2017–2021
- **National Health Policy:** 2019
- **MR vaccination campaign:** 2020
- **Nepal Health Sector Strategic Plan:** 2022–2030
- **MR vaccination campaign:** 2023
- **National Immunization Strategy:** 2023–2030

1.1 Study Rationale

Nepal has made substantial improvements in infant and child mortality over the past 25 years. Between 1996 and 2022, under-5, infant, and neonatal mortality rates have decreased by 72%, 64%, and 58%, respectively. The NIP has been crucial in preventing several VPDs responsible for avoidable under-5 deaths.[9,10] However, some populations have low coverage of full immunization, and recent surveys have shown an increase in the proportion of children with partial or no vaccinations. For example, according to the 2022 Nepal Demographic and Health Survey (NDHS),[10] Nepal's current full immunization coverage is 79.8%, a modest increase from 77.8% in 2016. However, it has not rebounded to the higher level of full vaccination in 2011 (87%).[16]

A drop in the percentage of children receiving their DTP3 vaccine from 91.7% in 2011 to 85.9% in 2016 was the primary cause for Nepal's significant decline in full vaccination coverage between 2011 and 2016.[18] Meanwhile, coverage of the MR vaccine, provided after the DTP3 vaccine, increased from 88% in 2011 to 90.4% in 2016.[17] This pattern indicates a missed opportunity to administer the DTP3 vaccine at a later time, possibly during a child's contact with the health care system for the MR vaccine at age 9 months.[18] Although a modest 2% increase in full immunization coverage occurred between 2016 and 2022, the proportion of children with no vaccination also increased, from 0.8% in 2016 to 4.4% in 2022.[10] Hence, monitoring data at provincial and local levels is critical for prioritizing and tailoring vaccination strategies and operational plans to address immunization gaps and reach every child with life-saving vaccines.[19]

Children belonging to marginalized groups, such as internal migrants, certain ethnic groups, slum populations, those in areas neighboring India, and those of low socioeconomic status, have inadequate or limited access to childhood immunizations.[9] The 2022 NDHS showed that the Terai ecoregion in Nepal had lower coverage of full vaccination than did the Hill and Mountain ecoregions.[10] Likewise, Madhesh province, which is predominantly flat, had particularly low coverage, with only about two-thirds of children (67%) fully immunized in 2022.[10]

Previous research also showed that in 2001, the rate of full vaccination coverage in infants increased incrementally as maternal education increased, from 57% among children whose mothers had no education to 90.9% among children whose mothers had higher education.[14] This gap grew smaller by 2022, with full coverage increasing to 64.9% among children whose mothers had no education and decreasing to 86.4% among those whose mothers had secondary or higher education.[18,20] Children born in households with higher wealth quintiles had higher chances of being fully immunized than those born in the poorest households. Full vaccination coverage among children from the lowest wealth quintile improved from 58% in 2001 to 75.9% in 2022. In contrast, full vaccination coverage among those in the highest wealth quintile decreased slightly from 84.8% to 82.8% during the same period.[10,14] These observations highlight disparities in childhood vaccination coverage by sociodemographic group.

Non-health sector interventions and multisectoral collaborations, including with local communities, have partly contributed to improved equity in childhood immunization.[14] Nevertheless, more actions are needed to consistently achieve the target of 90% full vaccination coverage.[9] To bridge the current gaps, assessing inequalities in basic vaccination coverage, identifying gaps in routinely delivered immunization services, and gathering valuable information to roll out effective strategies and policies are essential. It is equally important to track those children who received partial or no vaccines to develop an equity-oriented immunization program to reach disadvantaged populations and reduce vaccine-preventable childhood morbidity and mortality in Nepal.

Previous studies in Nepal have addressed factors associated with full immunization.[14,20] However, especially since the proportion of children with no immunizations increased significantly from 0.8% in the 2016 NDHS to 4.4% in the 2022 NDHS, studies are needed to examine the sociodemographic trends in and determinants of childhood vaccination in Nepal.

1.2   Objectives

The overall aim of this study was to examine trends in and determinants of vaccination coverage among children age 12–23 months at the national and provincial levels in Nepal. Specific objectives were:

- To determine the national and provincial levels of full, partial, and no vaccination coverage using data from the three most recent NDHS surveys (2011, 2016, and 2022)
- To evaluate the trends in levels of vaccination and disparities in vaccination status between 2011 and 2022 according to sociodemographic characteristics
- To identify factors associated with partial and no vaccination among children in the 2022 NDHS

2 METHODS

2.1 Data Sources

Trends in childhood vaccination were analyzed using data from three most recent nationally representative surveys: the 2011 Nepal Demographic and Health Survey (NDHS), the 2016 NDHS, and the 2022 NDHS. Determinants of partial and no immunization were analyzed using the 2022 NDHS data. The 2011, 2016, and 2022 NDHS final reports describe the detailed sampling strategy and participants.[10,15,16] Women age 15–49 who were permanent residents of selected households, or were visitors who stayed in the households the night before the survey, were asked about the immunization status of their children age 12–23 months. Total samples for the trend analysis were 1,000 children for the 2011 NDHS, 1,034 children for the 2016 NDHS, and 959 (weighted) children from the 2022 NDHS. The analysis of determinants included the 959 children age 12–23 months from the 2022 NDHS. Throughout this report, "children" refers specifically to children age 12–23 months.

2.2 Study Variables

The outcome variable of this study was children's vaccination status, with three categories: full vaccination, partial vaccination, and no vaccination (Box 3). Children were considered fully vaccinated if they received the following recommended basic vaccines:

- One dose of the Bacille Calmette-Guérin (BCG) vaccine against tuberculosis
- Three doses of the pentavalent DTP-HepB-Hib vaccine against diphtheria, tetanus toxoid, and pertussis (DTP); hepatitis B (HepB); and Haemophilus influenzae type b (Hib)
- Three doses of the oral polio vaccine (OPV)
- First dose of the measles-rubella (MR) vaccine

Each vaccine antigen (variable) was classified as "1" or "Yes" for a child who received the dose and "0" or "No" for a child who did not receive it. These values were then refined to reflect the child's overall vaccination status. The vaccination status was recoded as "1" (full vaccination) if a child received all the recommended vaccine doses, "2" (partial vaccination) if at least one of the vaccine doses was missing, and "3" (no vaccination) if the child did not receive any vaccine doses. The vaccination status of each child was obtained from a written vaccine card or, if the card was not available, the mother's verbal report.

> **Box 3 Categories of outcome variable**
>
> - **Full vaccination:** Received the Bacille Calmette-Guérin (BCG) vaccine, pentavalent DTP-HepB-Hib vaccine, oral polio vaccine (OPV), and first dose of the measles-rubella (MR) vaccine
> - **Partial vaccination:** Missed any of the basic vaccines mentioned and was not fully immunized or coded
> - **No vaccination:** Had not received any doses of any of the basic vaccines

The independent background variables of interest were based on a literature review,[14,18,21,22] team discussion, and which variables were available in the datasets. These variables were:

- Place of residence
- Province

- Ecoregion
- Sex of child
- Maternal age
- Maternal education
- Paternal education
- Ethnicity
- Wealth quintile
- Household size
- Work status of mother in the previous 12 months
- Media exposure of mother
- Birth order of child
- Completion of at least four antenatal care visits
- Place of delivery
- Postnatal care visits within 2 months of birth
- Distance to health facility
- Health mothers' group in ward
- Decision-making by mother
- Vaccination card retention

Wealth quintile was based on the composite measure (index) of a household's cumulative living standard. The index was calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles, materials used for housing construction, and water access and sanitation facilities.[23] "Decision-making by mother" referred to the mother's ability to refuse sex, decide on health care, and/or choose contraceptives. Vaccination card referred to a government-issued vaccination card, booklet, or other home-based record of immunization. A vaccination card was considered "retained" if the interviewer saw the card during the interview.

With the exclusion of health mothers' group in ward, decision-making by mother, and vaccination card retention, all other variables were grouped into geographic variables, sociodemographic variables, and maternal health service use and accessibility variables. Details about the categorization of the background variables can be found in Table A1.

2.3 Data Analysis

Descriptive analyses (of frequencies and proportions) of the background variables were conducted among children age 12–23 months from the three NDHS surveys (2011, 2016, and 2022). We also examined levels of and disparities in vaccination coverage (full/partial/no vaccination) by background variables, including whether the disparities stagnated, narrowed, or widened, over the three NDHS surveys. Trends were analyzed by performing pairwise comparisons among the most recent surveys.

Bivariate analyses were used to determine the proportions of children with full, partial, and no vaccination coverage. We assessed the bivariate association between each background variable and vaccination status (full/partial/no vaccination) by performing chi-square tests.

We then followed Hosmer and Lemeshow's (2000) incremental process for specifying the initial model, refining the set of determinants, and determining the final form of the logistic regression model.[24] Multivariable multinomial logistic regression analyses were used to examine the associations of background variables with vaccination status (full/partial/no vaccination). Potential determinants with a bivariate association with vaccination status at significance $p<.25$ were selected for the model. Variables were excluded based on a $p\geq.25$ in the chi-square test or following a multicollinearity check with a variance inflation factor ≥5.

Results were expressed as odds ratios (which Stata interprets as relative risk ratios) with 95% confidence intervals. We ran the model fitness test using multiparameter Wald tests to determine the overall significance of each determinant.

We created and used the *svyset* command to adjust the complex sampling design for inverse probability weighting, clustering, and stratification to provide unbiased estimates of the population parameters. All data were analyzed using Stata 18.0 software.

3   TRENDS IN CHILDHOOD VACCINATION

3.1   Trends in Vaccination at the National and Provincial Levels

Figure 1 shows the trends in vaccination status (full/partial/no vaccination) among children age 12–23 months from the 2011 Nepal Demographic and Health Survey (NDHS) to the 2022 NDHS. The proportion of children with no vaccination increased significantly by 3.6 percentage points between the two most recent surveys, from 0.8%—95% confidence interval (CI) [0.4–1.8]—in 2016 to 4.4%—95% CI [3.1–6.3]—in 2022. Full immunization coverage improved slightly from 77.8% (95% CI [74.2–81.1]) in 2016 to 79.8% (95% CI [76.2–82.8]) in 2022. However, it did not rebound to the level of full immunization that was seen in 2011, which was 86.9% (95% CI [82.2–90.5]). Partial immunization coverage dropped between the two most recent surveys, from 21.3% (95 % CI [18.1–24.9]) in 2016 to 15.8% (95% CI [13.0–19.0]) in 2022.

Figure 1   Trends in childhood vaccination status at the national level, 2011–2022 Nepal DHS surveys
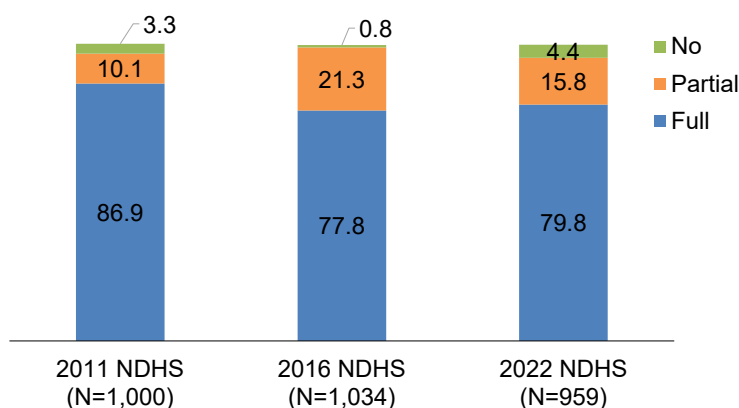
Figure 2 shows the trends in no vaccination among children age 12–23 months over the past three NDHS surveys at the provincial level. The proportion of unvaccinated children in Bagmati province increased sharply from 0.6% (95% CI [0.1–4.5]) in 2016 to 9.3% (95% CI [4.7–17.6]) in 2022. Likewise, the proportion of unvaccinated children increased heavily in Koshi and Lumbini provinces, reaching 5.6% (95% CI [2.6–11.7]) in Koshi in 2022, from 0.8% (95% CI [0.1–5.5]) in 2016. The proportion of unvaccinated children in Lumbini province increased from 0% in 2016 to 3.4% (95% CI [1.2–8.7]) in 2022. However, children in Gandaki province maintained a no vaccination status of 0% between the two most recent surveys.

Figure 2   Trends in no vaccination among children age 12–23 months at the national and provincial levels, 2011–2022 Nepal DHS surveys

Note: If color is not visible, value is 0.
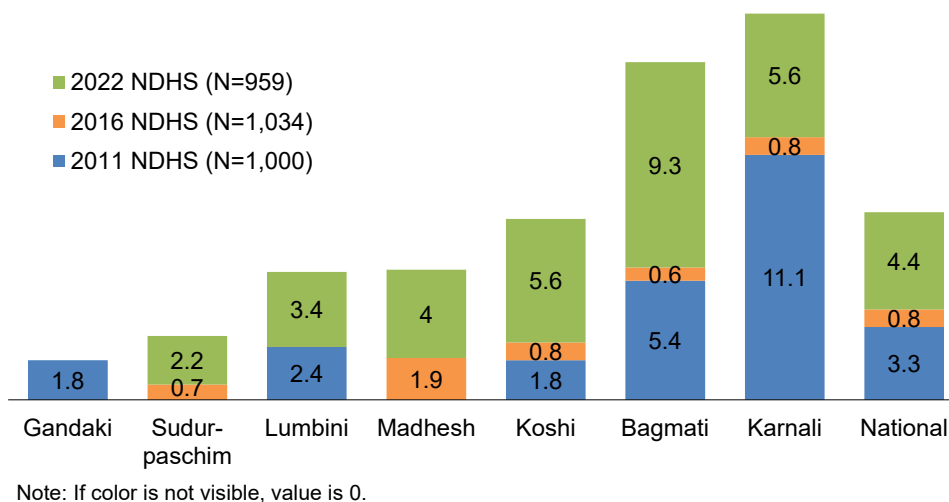
3.2   Trends in Geographic and Sociodemographic Variables

Table A2 presents data on the trends in geographic and sociodemographic variables among children age 12–23 months in the three NDHS surveys. Results showed substantial sociodemographic changes in Nepal over the past one-and-a-half decades. For example, the proportion of mothers with no education dropped from 45.2% in 2011 to 20.5% in 2022.

In terms of geography, minimal changes were seen in the proportion of respondents from the Mountain ecoregion. However, the proportion of respondents from the Hill ecoregion decreased gradually from 40.2% in 2011 to 31.4% in 2022. In contrast, the proportion of respondents from the Terai ecoregion increased gradually from 52.3% in 2011 to 61.6% in 2022. The proportion of respondents from the Terai caste increased from 12.2% in 2011 to 19.4% in 2022. In contrast, the proportion of children belonging to the Hill Janajati ethnic group decreased from 27.3% in 2011 to 20.1% in 2022. Likewise, the proportion of children from the Brahmin Hill ethnic group decreased from 8.9% in 2011 to 5.9% in 2022. Male children were oversampled in 2016 compared with female children, while almost equal proportions of male and female children were included in the 2011 and 2022 NDHS surveys (see Table A2).

3.3   Trends in Vaccination by Geographic and Sociodemographic Variables

Figure 3 presents trends in partial immunization among eligible children by ecoregion, maternal education, ethnicity, and wealth quintile. The proportion of partially immunized children increased in the Terai ecoregion from 12.6% in 2011 to 19.6% in 2022. The proportion of partially immunized children declined from 2016 to 2022 in all categories of maternal education, except for mothers with a School Leaving Certificate or higher education. The percentage of partially immunized children increased slightly among Dalits over the study period, but it was highest among Muslims (compared with children from any other ethnicity) in both 2011 (28.6%) and 2022 (30.3%). The proportion of partially immunized children decreased over time in all wealth quintiles, with a relatively greater decline in the middle wealth quintile.

See Table A3 for additional results of trend analyses by geographic variables and Table A4 for a summary of all percentage-point changes in partial vaccination over time.

Figure 3   Trends in partial vaccination among children age 12–23 months by ecoregion, maternal education, ethnicity, and wealth quintile, 2011–2022 Nepal DHS surveys

SLC = School Leaving Certificate
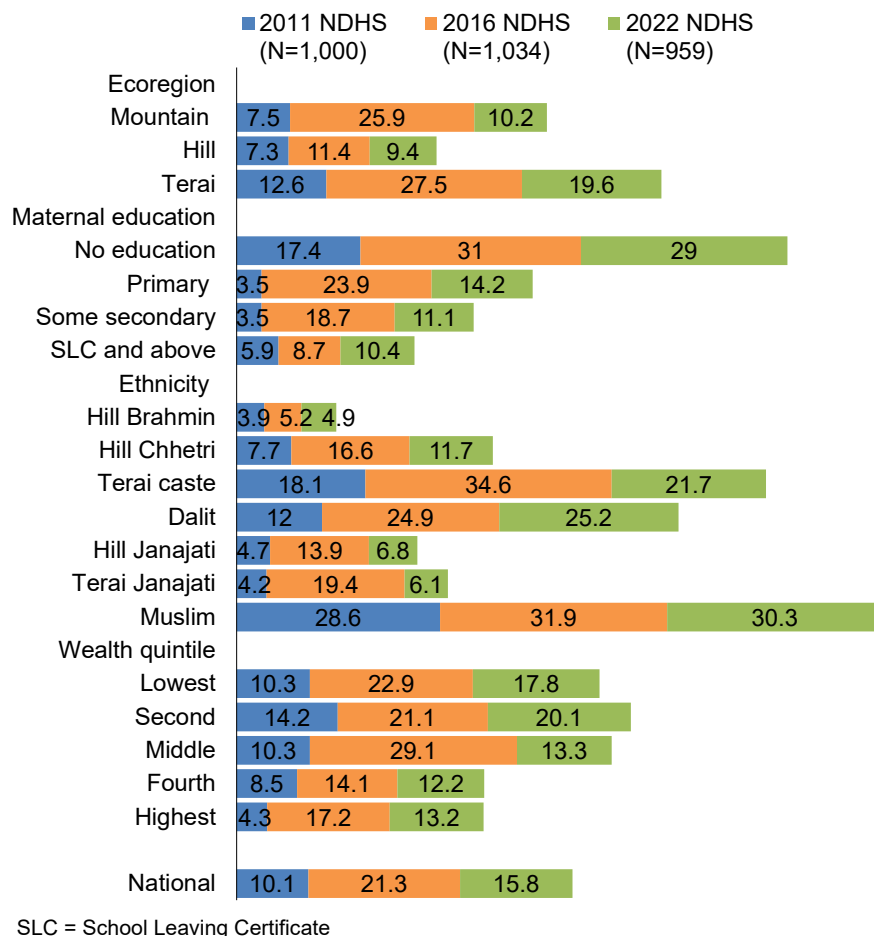
Figure 4 presents trends in no vaccination among eligible children by the same key geographic and sociodemographic variables. The proportion of unvaccinated children in the Hill ecoregion rose from approximately 3% in 2011 to approximately 6% in 2022, while the proportion in the Terai ecoregion increased from 2.5% in 2011 to 4.0% in 2022. However, the proportion of unvaccinated children in the Mountain ecoregion declined from 4.3% in 2011 to 0.7% in 2022.

The trend in no vaccination followed a downward trajectory as maternal education levels increased from no education to some secondary education. The trajectory shifted after that, with the proportion of children with no vaccination increasing marginally among those whose mothers had a School Leaving Certificate or higher education. The disparity between the percentage of unvaccinated children whose mothers had no education and the percentage whose mothers had higher education did not diminish from 2011 (2.8 percentage points) to 2022 (2.9 percentage points). See Table A3 for additional results of trend analyses by sociodemographic variables and Table A5 for a summary of all percentage-point changes in no vaccination over time.

Figure 4   Trends in no vaccination among children age 12–23 months by ecoregion, maternal education, ethnicity, and wealth quintile, 2011–2022 Nepal DHS surveys
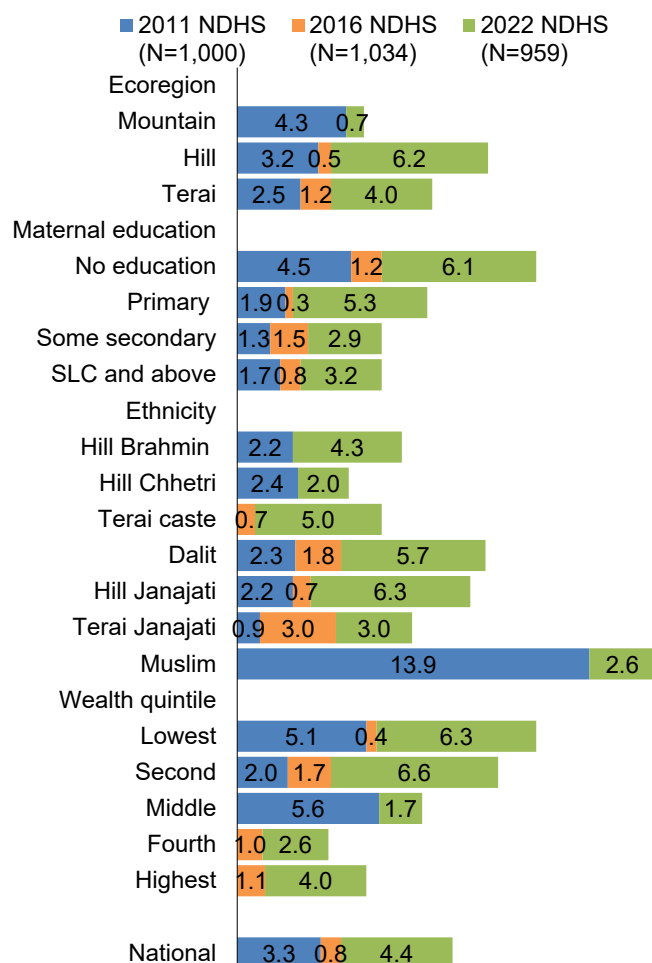
Note: If color is not visible, value is 0.

The proportion of unvaccinated children increased between 2011 and 2022 among all ethnicities, except for the Hill Chhetri and Muslim groups. To elaborate on this disparity, the proportion of unvaccinated children born into Terai families rose from 0% in 2011 to 5% in 2022, while the proportion born to Muslim families decreased from 13.9% in 2011 to 2.6% in 2022. Similarly, a disparity in the proportion of unvaccinated children between the lowest and highest wealth quintiles narrowed from 4.0 percentage points in 2011 to 2.3 percentage points in 2022. However, the percentage of unvaccinated children increased over time across all wealth quintiles except the middle quintile, in which it declined from 5.6% in 2011 to 1.7% in 2022.

4   DETERMINANTS OF CHILDHOOD VACCINATION

4.1   Distribution of Children by Background Variables

Table 1 shows the percent distribution of children age 12–23 months according to background variables in the 2022 Nepal Demographic and Health Survey (NDHS). Almost two-thirds of the children (65%) lived in urban areas, with the remainder in rural settings. The province with the highest proportion of children age 12–23 months was Madhesh (28%), followed by Lumbini (17.9%). Six out of 10 children were from the Terai ecoregion, while less than 1 in 10 (7%) were from the Mountain ecoregion. About two-fifths of mothers (40.2%) mentioned distance to health facilities as a big problem in accessing health care.

Table 1   **Distribution of children age 12–23 months by background variables, 2022 Nepal DHS**

Variable	%	Number
Geographic variables		
Place of residence		
Urban	65.0	623
Rural	35.0	336
Province		
Koshi	17.5	167
Madhesh	28.0	269
Bagmati	13.9	134
Gandaki	5.3	51
Lumbini	17.9	172
Karnali	8.2	79
Sudurpaschim	9.0	87
Ecoregion		
Mountain	7.0	67
Hill	31.4	301
Terai	61.6	591
Sociodemographic variables		
Sex of child		
Male	50.6	486
Female	49.4	473
Maternal age		
<20	8.0	76
20–24	41.6	399
25–29	31.2	299
30–34	13.3	128
≥35	5.9	57

Continued…

15

Table 1—*Continued*

Variable	%	Number
Maternal education		
No education	20.5	197
Primary	35.3	338
Some secondary	27.2	261
SLC and above	17.0	163
Paternal education		
No education	10.8	103
Primary	37.6	361
Some secondary	41.0	393
SLC and above	7.07	68
Missing	3.56	34
Ethnicity		
Hill Brahmin	5.9	57
Hill Chhetri	18.3	176
Terai caste	19.5	187
Dalit	20.3	194
Hill Janajati	20.1	192
Terai Janajati	9.0	87
Muslim	6.9	66
Wealth quintile		
Lowest	24.2	233
Second	23.3	224
Middle	18.8	180
Fourth	20.1	193
Highest	13.9	129
Household size		
1–3 members	12.1	116
4–5 members	38.6	370
6+ members	49.3	473
Birth order		
1	41.6	399
2–3	48.3	463
4+	10.1	97
Mother worked in previous 12 months		
Yes	61.5	590
No	38.5	369
Media exposure of mother		
None	26.0	250
Less than once a week	30.0	287
At least once a week	44.0	422
Maternal health service use and accessibility		
At least four antenatal care visits		
Yes	75.9	728
No	24.1	231
Place of delivery		
Health facility	77.7	745
Elsewhere	22.3	214
Postnatal care visits within 2 months of birth		
No	79.5	762
Yes	17.5	168
Don't know	.18	2
Missing	2.9	27

Table 1—*Continued*

Variable	%	Number
Distance to health facility		
Not big problem	59.8	574
Big problem	40.2	385
Additional variables		
Health mothers' group in ward		
No	69.7	669
Yes	30.3	290
Decision-making by mother		
No	39.3	377
Yes	57.8	554
Missing	2.9	28
Vaccination card retention		
Never received	1.2	11
Vaccination card retained	78.4	752
Vaccination card not retained	20.5	196
SLC = School Leaving Certificate		

Among all children age 12–23 months, 50.6% were male and 49.4% were female. At the time of the 2022 NDHS, around two-fifths (41.6%) of mothers were age 20–24 years, 31.2% were age 25–29 years, and fewer than 10% were younger than age 20 years (8%) or were age 35 years or older (5.9%). Nearly one-fifth (20.5%) of the mothers had no education, while one-third (35%) had primary education. About 1 in 10 fathers (10.8%) had no education, while 27.2% had some secondary education. The largest proportion of children were of Dalit ethnicity (20.3%), followed by children of Hill Janajati ethnicity (20.1%) and those from the Terai caste (19.5%). About one-fourth of children (24.2%) were from the lowest wealth quintile, followed by the second (23.3%) and fourth (20.1%) wealth quintiles, while the smallest proportion (13.9%) was from the highest wealth quintile. Close to half of the children lived in a household with six or more members, while 12.1% lived in a household with one to three members. Nearly half of the children (48.3%) were of second or third birth order, while 41.6% were of first birth order. About three-fifths of the mothers (61.5%) were engaged in work in the past 12 months. Around a quarter of the mothers (26%) had no exposure to media, while 30% had exposure less than once a week and 44% had exposure at least once a week.

Approximately three-fourths (75.9%) of children's mothers had completed all four antenatal care (ANC) visits, and 77.7% of deliveries had been in health facilities. More than one-sixth (17.5%) of the mothers attended postnatal care visits within 2 months of giving birth. About two-fifths of mothers (40.2%) admitted that the distance to health facilities was a big problem in accessing health care.

Nearly one-third of mothers (30.3%) were aware of a health mothers' group (HMG) in the ward, whereas more than two-thirds (69.7%) were unaware. Almost two-fifths of mothers (39.3%) were able to make their own decisions (to refuse sex/decide on health care/choose contraceptives). More than three-fourths (78.4%) had retained their children's vaccination cards (Table 1).

4.2 Vaccination Status by Geographic Variables

Figure 5 shows levels of full, partial, and no vaccination by geographic variables in the 2022 NDHS. Results of bivariate analysis showed that vaccination status was significantly associated with province and ecoregion. Among eligible children, the proportion with no vaccination was highest in Bagmati province

(9.3%), followed by Koshi (5.7%) and Lumbini (3.4%). Gandaki province reported an absence of unvaccinated children. Children in the Hill ecoregion had the highest proportion of unvaccinated children (6.2%), followed by children in the Terai (4%) and Mountain (0.7%) ecoregions. No significant differences in immunization status were found by place of residence.

Figure 5   Childhood vaccination status by geographic variables (N=959), 2022 Nepal DHS

***p<.001*
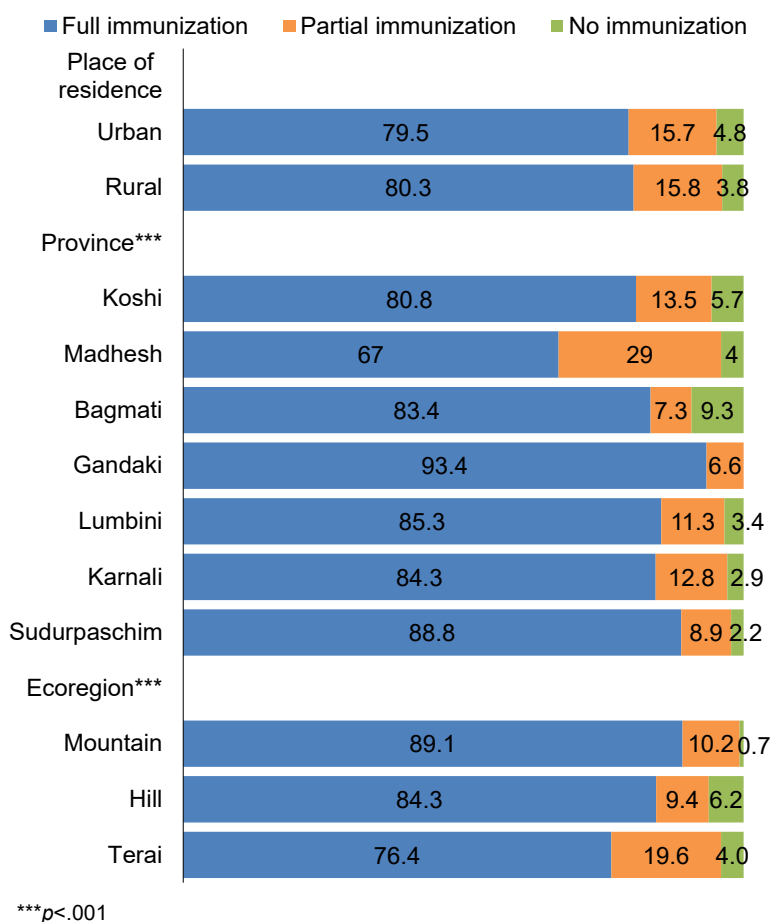
4.3   Vaccination Status by Sociodemographic Variables

Figure 6 shows levels of full, partial, and no vaccination by key sociodemographic variables at the time of the 2022 NDHS. Results of bivariate analysis showed that the proportion of children with no vaccination significantly increased with increasing levels of maternal education, from no education to some secondary education (*p*<.001). Children of Hill Janajati ethnicity had the highest level of no vaccination (6.3%), followed by Dalits (5.7%) and children from the Terai caste (5%). In comparison, children of Hill Chhetri ethnicity had the lowest level of no vaccination (2%). The proportion of unvaccinated children was highest among the second wealth quintile (6.7%), followed by the lowest (6.3%) and highest (4%) wealth quintiles. The prevalence of no vaccination was lowest (1.7%) among children in the middle wealth quintile. The proportion of unvaccinated children was highest among those with a fourth or higher birth order (6.9%), followed by first-born children (4.9%). A lower proportion of children whose mothers were employed in the past 12 months were unvaccinated (4.0%) when compared with children whose mothers were not engaged in work during the same period (5.2%). Regarding media exposure, the proportion of children with

no vaccination was highest among those whose mothers reported no exposure to the media (5%), followed by those whose mothers had media exposure at least once a week (4.5%).

Figure 6   Childhood vaccination status by sociodemographic variables (N=959), 2022 Nepal DHS

■ Full immunization   ■ Partial immunization   ■ No immunization

	Full immunization	Partial immunization	No immunization
Maternal education*			
No education	64.8	29	6.1
Primary	80.5	14.2	5.3
Some secondary	85.9	11.1	2.9
SLC and above	86.4	10.4	3.2
Ethnicity*			
Hill Brahmin	90.8	4.9	4.3
Hill Chhetri	86.3	11.7	2.0
Terai caste	73.3	21.7	5.0
Dalit	69.1	25.1	5.7
Hill Janajati	86.9	6.8	6.3
Terai Janajati	90.8	6.1	3.0
Muslim	67	30.4	2.6
Birth order**			
1	81.8	13.3	4.9
2–3	81.3	15.1	3.6
4+	64	29.1	6.9
Mother worked past 12 months**			
Not employed	73.8	21.0	5.2
Employed	83.5	12.5	4.0
Media exposure of mother*			
Not at all	72	23.0	5.0
Less than once a week	80.6	15.4	3.9
At least once a week	83.8	11.7	4.5

*p<.05, **p<.01, ***p<.001
SLC = School Leaving Certificate

4.4   Vaccination Status by Maternal Health Service Use and Accessibility

The proportion of unvaccinated children varied significantly by place of delivery, with a lower proportion among children born in health facilities than among those born elsewhere (Figure 7). The proportion of unvaccinated children was also significantly lower among children whose mothers had completed four or more ANC visits than among those whose mothers had not. The proportion was significantly higher if mothers reported that the distance to the nearest health facility was a big problem in accessing health care (6.4%) than if they did not (Figure 7). No significant difference in immunization status was found based on whether mothers had received postnatal care within 2 months of giving birth.

Figure 7

Figure 7   Childhood vaccination status by maternal health service use and accessibility (N=959), 2022 Nepal DHS

*p<.05, ***p<.001
ANC = antenatal care
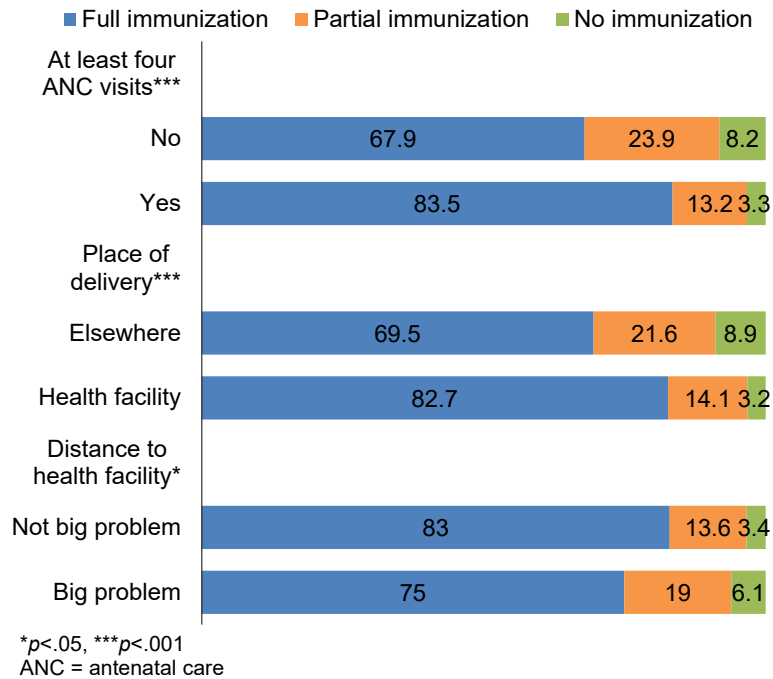
4.5   Vaccination Status by Additional Background Variables

Figure 8 presents the distribution of children's vaccination status by whether mothers reported an HMG in the ward, women's empowerment as measured through decision-making by mothers, and vaccination card retention. Children whose mothers reported an HMG in the ward had a significantly lower rate of no immunization (2%) than children whose mothers reported no HMG in the ward. Additionally, the proportion of unvaccinated children was marginally higher among women with decision-making authority (4.7%) than among women lacking decision-making power (4%). The level of no vaccination was higher among children whose mothers did not retain the vaccination card (17%) than among those whose mothers retained the card (0.3%).

Figure 8   Childhood vaccination status by health mothers' group in ward, decision-making by mother, and vaccination card retention (N=959), 2022 Nepal DHS

*p<.05, **p<.01, ***p<.001
HMG = health mothers' group
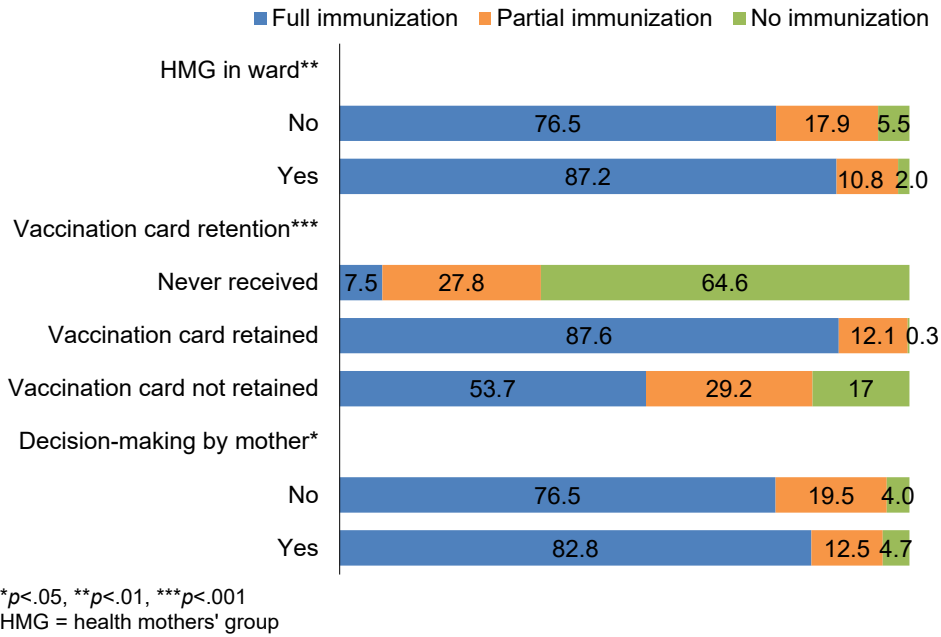
4.6   Determinants of Childhood Vaccination Status

In the final model of multivariate multinomial regression analysis, place of residence was excluded based on $p \geq .25$ in the previous chi-square test. Ecoregion and vaccination card retention were excluded following the multicollinearity check, as they each had a variance inflation factor ≥ 5. Figure 9 shows the background variables that were significantly associated with vaccination status in the final model (see Table A6 for details).

Results showed that children born outside of health facilities (i.e., elsewhere) were 3.78 times more likely to be unvaccinated—adjusted relative risk ratio (ARRR): 3.78; 95% confidence interval (CI) [1.63–8.79]—than were children born in health facilities, with full vaccination as a base outcome. If mothers had not completed at least four ANC visits during their pregnancies, their children were 2.86 times more likely to be unvaccinated (ARRR: 2.86; 95% CI [1.27–6.45]) (compared with being fully vaccinated) than children born to mothers who had completed at least four ANC visits (Figure 9).

Figure 9   Effects of place of delivery and completion of at least four antenatal care visits on no vaccination among children age 12–23 months, with full vaccination as a base outcome (N=959), 2022 Nepal DHS
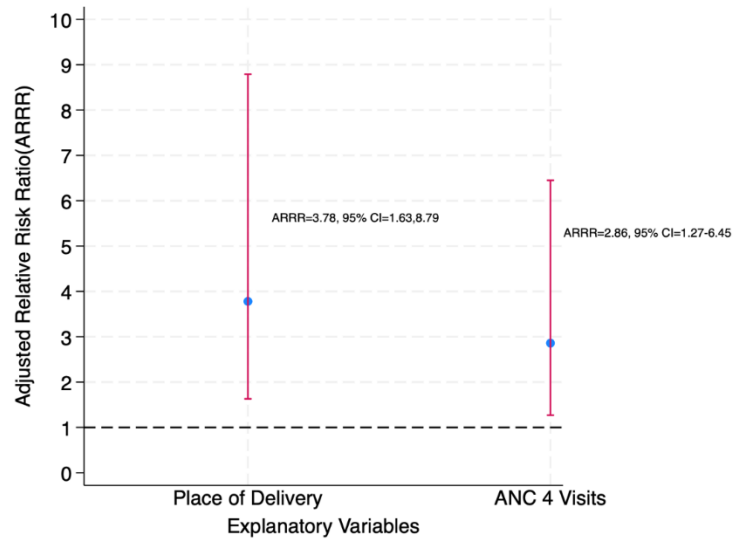
We also found evidence of an association between household size and partial vaccination (*p*<.05) and between an HMG in the ward and partial vaccination (*p*<.05). With full vaccination as the base outcome, children from medium households (four to five members) were 2.55 times more likely to be partially vaccinated (ARRR: 2.55 95% CI [1.05–6.15]) than were children from small households (one to three members). Compared with children whose mothers mentioned an HMG in the ward, children whose mothers were not aware of an HMG in the ward were 71% more likely to be partially vaccinated (ARRR: 1.71; 95% CI [1.12–2.60]) (Figure 10).

Figure 10   Effects of household size and health mother's group in ward on partial vaccination among children age 12–23 months, with full vaccination as a base outcome (N=959), 2022 Nepal DHS
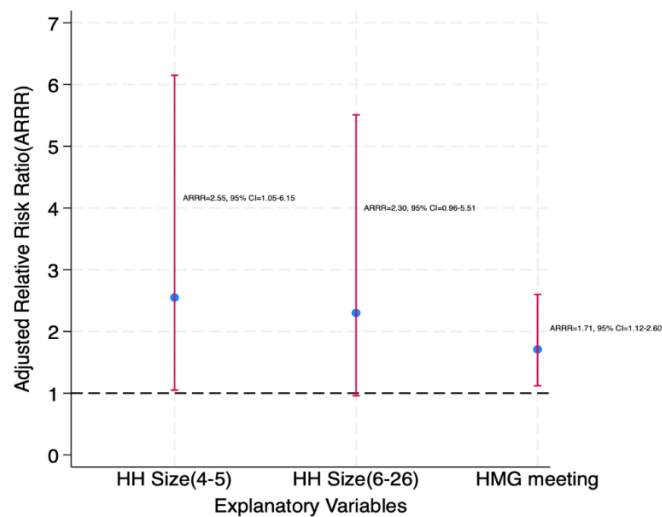
5   DISCUSSION

5.1   Increasing trend of no vaccination among children

The proportion of unvaccinated children increased significantly from 0.8% in 2016 to 4.4% in 2022, with a rise across most wealth quintiles. Immunization services were disrupted during the COVID-19 pandemic, which could have influenced the increases in levels of no and partial immunization in 2022.[25] Nepal's Immunization Act (2016) recognizes immunization as a right of all children in line with Article 20 of the United Nations Convention on the Rights of the Child, which declared that no child should be left behind or deprived of his or her rights to access health care, including the right to be fully immunized.[26] Nepal also initiated and implemented a unique, ongoing initiative known as the "Full Immunization Declaration Initiative" in 2012/2013 to reach and fully vaccinate all children with equity.[12,27] Further studies should use a qualitative approach to explore the reasons behind the increase in no immunization.

Recommendations: At the policy level, communicating with parents about the heightened risks of outbreaks of vaccine-preventable diseases in children and communities is crucial. These communications should be integrated into social and behavior change communication strategies for immunization that are developed and updated by the Ministry of Health and Population.[28] At the implementation level, to ensure the sustainability of the full immunization declaration initiative, an annual household survey to identify partially or unvaccinated children could be conducted locally during the months of Falgun and Chaitra (February, March, and April) each year. Subsequently, any missed vaccine doses could be promptly completed by the month of Chaitra (March and April).[27]

5.2   High levels of no vaccination in Bagmati province and partial vaccination in Madhesh province

The proportion of children with no vaccination increased sharply between 2016 and 2022 in Bagmati province, where the prevalence of no immunization was disproportionately high in 2022. This high prevalence could be due to the prolonged disruption of routine immunization services in that region. Bagmati province, home to the country's capital city, was the worst affected by COVID-19 and had the most deaths.[29] The relatively high proportion of urban residents in Bagmati province might have contributed to no immunization due to high population movement/migration and the accompanying challenges of maintaining consistent immunization schedules. Additionally, health services are more readily available in urban areas, but some individuals in those areas may become complacent about preventive measures like vaccinations, assuming they are less vulnerable to vaccine-preventable diseases.

Similarly, the prevalence of partial immunization has consistently been highest in Madhesh province (compared with other provinces) over the 2016 Nepal Demographic and Health Survey (NDHS) and 2022 NDHS, with almost one-third of children missing some basic antigens. Sociocultural practices and traditional beliefs could be major barriers hindering mothers from accessing immunization services.

Recommendations: At the policy level, digital health records can be implemented and strengthened to track and monitor immunization coverage in real time, considering preparedness for future pandemics. At the implementation level, targeted public awareness campaigns can be conducted locally to assure parents that immunization services are safe during pandemics. Likewise, a vaccination catch-up program can be

rolled out to address missed vaccinations during lockdowns or disruption of health services. Building the capacity of health workers to handle vaccination services during emergencies and pandemics and to emphasize safety protocols is equally important.

5.3   High rates of partial and no vaccination in disadvantaged groups

Approximately one-third of Muslim children, one in four Dalit children, and one in five children from the Terai caste received partial vaccination, according to data from the 2022 NDHS. Conversely, the Hill Janajati ethnic group had the highest proportion of children who had received no vaccination. A potential reason for partial vaccination could be the relatively high dropout rates for the diphtheria, tetanus toxoid, and pertussis (DTP)3 and measles vaccines when compared with the Bacille Calmette-Guérin (BCG) vaccine and the first dose of the DTP vaccine. This finding is consistent with results of other surveys conducted in similar settings in India.[30] Religious beliefs affecting immunization coverage, particularly among Muslim communities, have been seen both in low- and middle-income countries and in high-income countries.[31] Meanwhile, the relatively low literacy rates and prevalences of sociocultural practices among the Terai caste and the Dalit ethnic group could also help explain the higher rates of partial vaccination among children belonging to these groups. The reason behind the relatively high rate of no vaccination among Hill Janajati children should be further explored with a qualitative study.

Recommendations: At the policy level, to address the high partial immunization rate among Muslims, collaborating with local imams, religious leaders, and scholars to deliver pro-vaccination messages during religious gatherings is crucial. Fulfilling positive attitudes through open discussions is essential to tackle parental vaccine refusal and incomplete immunization behavior, as well as to design and implement reminder systems such as text messages or phone calls to parents about upcoming vaccination appointments. Communication materials could also be tailored to the diverse population in Madhesh province to address cultural and language barriers. At the implementation level, implementing a community-focused campaign model, integrating religious teachings with scientific information, and utilizing respected role models could effectively counteract misconceptions and promote complete immunization.[32] Community engagement could also be ensured through dialogue meetings with influential people in target groups (i.e., Dalits, individuals from the Terai caste, and Hill Janajatis) at the local level to address misconceptions and concerns about vaccinations.

5.4   High rate of partial vaccination among children from large households

Vaccinations were more likely to be incomplete in children with multiple siblings (those from larger households). Large families tend to place conflicting demands on mothers, restricting the time and resources available to care for each child. Other studies have also identified this link, attributed to the higher costs of services and demands on service providers caused by having more children in a family, which can decrease health care utilization.[33–35]

Recommendations: At the policy level, financial support could be provided to large families to offset the costs associated with vaccination, such as transportation and time off work.[35] Health care providers can also be trained to effectively communicate with parents from large families about the importance of immunization. At the implementation level, health professionals involved with immunization services should be aware of large families (and be able to identify them) so they can target them more effectively to

achieve high rates of vaccination. Moreover, encouraging peer-to-peer support and sharing positive vaccination experiences with parents of large families could help address incomplete childhood vaccination coverage.[35]

5.5 High rate of full vaccination with high coverage of maternal health services

Children whose mothers completed at least four antenatal care (ANC) visits and those whose mothers had institutional deliveries had higher likelihoods of full immunization coverage. After adjusting for other independent background variables, failure to complete at least four ANC visits was associated with no immunization among children. Studies from Bangladesh,[36] Indonesia,[22] and Nigeria[37] also reported that a mother's ANC attendance was related to her child being fully immunized. Our findings are also consistent with results of studies conducted in low-income and lower-middle-income countries showing that health facility delivery was positively associated with full childhood immunization.[22,37,38] This could be explained by the fact that mothers who give birth at health facilities have better access to health education, counseling, and child health services, including childhood vaccination. Moreover, the first vaccination dose is usually given in the health facility just after birth.[39] However, in our study, some children born at health facilities did not receive the BCG vaccine, possibly attributed to its high wastage rate, often exceeding 90% in the municipality, as the BCG vaccine comes in multi-dose vials (20 doses per vial).

Recommendations: At the policy level, potential strategies for increasing ANC visits in Nepal could help achieve the national coverage target of at least 95% for routine childhood immunization. The model of a minimum of eight ANC visits recommended by the World Health Organization (WHO) could increase the opportunity to detect maternal and child health problems early. Many birthing centers at the local level are significantly underutilized for BCG vaccination. High wastage can be minimized by introducing smaller BCG vials, such as single-dose, five-dose, or 10-dose vials.[40] At the implementation level, operational integration of ANC visits and immunization clinics could be an avenue to improve the rate of immunization among children in the health posts. To promote institutional deliveries, local governments could specifically target women from the poorest households and mobilize campaigns for full vaccination.

5.6 Contribution of health mothers' groups to immunization program

Children whose mothers were not aware of health mothers' groups (HMGs) in their communities were more likely to be partially immunized than children whose mothers were mindful of HMGs in the ward. HMGs are community groups led by female community health volunteers (FCHVs) that bring together women of reproductive age (15–49 years) monthly to discuss and promote health, particularly maternal, newborn, and child health.[41] However, HMG meetings are not regularly conducted by FCHVs; less than half of FCHVs reported routinely conducted HMG meetings in 2014.[42] Studies from Nepal (Makwanpur district)[43] and eastern India (Orisha and Jharkhand)[44] showed that participatory women's groups reduced neonatal mortality and improved service use.

Recommendations: At the policy level, social and behavior change communication strategies for immunization can be developed and updated based on the findings of this study. At the implementation level, the National Immunization Program can leverage and ensure the involvement of FCHVs and other community volunteers in communication and social mobilization for immunization. Anecdotal evidence

suggests that HMGs are nonfunctional in many communities. Thus, local health post management committees and health posts in charge should mobilize their staff to revitalize inactive groups.

5.7   Study Limitations

This study had several limitations. First, the proportion of children with no vaccination in the weighted sample from the 2022 NDHS was only 4.4% (42 out of 959). As a result, we could not examine disparities by sociodemographic characteristics within each province, as the sample size was too small.

Secondly, the team faced a problem estimating the relative risk ratio with the empty cell frequency. For example, no child received zero doses of basic antigens in the sample in Gandaki province, which produced zero regression coefficients and standard error (adjusted relative risk ratio and 95% confidence interval of 0). This was due to the nonexistence of maximum likelihood estimates (pseudo maximum likelihood estimation in complex survey design), making it difficult for researchers to make appropriate decisions.[45]

Furthermore, the inclusion of childhood vaccination status from verbal reports of mothers might have introduced differential misclassification into this study due to potential under-reporting of children who were not fully immunized. This is because mothers, in the absence of health records, may provide false reports about the immunization status of their children to appear socially acceptable.[46]

Finally, vaccine stockouts, poor or inadequate cold chain systems, and the unreadiness of health care providers to administer vaccines during mothers' use of maternal health services could contribute to children not being fully immunized. Because these potential health system barriers were not captured in the data we used for this study, the impact we found of maternal health service use (ANC visits and place of delivery) on routine immunization coverage could be an underestimation.

6   CONCLUSION

6.1   Key Findings

▪ Overall, the proportion of unvaccinated children increased at national and provincial levels during the study period.

▪ The proportion of unvaccinated children increased across all wealth quintiles except the middle wealth quintile.

▪ Bagmati had the highest prevalence of no vaccination among all provinces, and Madhesh consistently had the highest prevalence of partial immunization.

▪ Approximately one-third of Muslim children, one in four Dalit children, and one in five children from the Terai caste received only partial vaccination.

▪ The highest proportion of children with no vaccination was reported from the Hill Janajati ethnic group.

▪ Vaccinations were more likely to be incomplete in large families with more children.

▪ A minimum of four antenatal care visits and place of delivery were significantly associated with no immunization.

▪ Children whose mothers were unaware of health mothers' groups in their wards were more likely to be partially immunized than were children whose mothers were aware of such groups.

6.2   Key Recommendations

The Government of Nepal is dedicated to meeting the health-related targets outlined in Sustainable Development Goal 3, mainly through the attainment of universal child immunization coverage. Moreover, immunization is the cornerstone of primary health care systems and a pivotal catalyst toward achieving universal health coverage. However, coverage of routine full vaccination for children was below the national immunization target in 2022. The proportion of unvaccinated children increased among all wealth quintiles, all provinces, and all ethnicities, probably due to the impact of COVID-19 on vaccination in 2022 compared with 2016. Antenatal care attendance and place of delivery positively impacted the proportions of fully immunized children. The following recommendations could help achieve universal coverage of full vaccination:

▪ Reminder systems such as text messages or phone calls could be designed and implemented to remind parents about upcoming vaccination appointments.

▪ Providing financial support to large families could offset vaccination costs such as transportation and time off work.

▪ Increasing maternal health service use in Nepal could effectively improve the routine immunization of children.

▪ Mobilizing female community health volunteers to organize health mothers' groups in their communities could reduce rates of incomplete child immunization.

▪ Supply-side barriers could be addressed by ensuring that health workers are trained in maternal health care.

▪ Auditing the incomplete immunization of children annually could identify target children in each health post catchment.

▪ Full immunization campaigns should be renamed to focus on the identification of incompletely immunized children and ensure their full immunization.

REFERENCES

1. World Health Organization. *Declaration of Alma-Ata*. World Health Organization, Regional Office for Europe; 1978.

2. Fukuda-Parr S. From the Millennium Development Goals to the Sustainable Development Goals: Shifts in purpose, concept, and politics of global goal setting for development. *Gender & Development* 2016;24(1):43–52.

3. United Nations. *The Sustainable Development Goals Report 2016.* United Nations; 2016.

4. World Health Organization. Immunization. World Health Organization website. December 5, 2019. Accessed July 22, 2024. https://www.who.int/news-room/facts-in-pictures/detail/immunization

5. World Health Organization. *Global Vaccine Action Plan 2011–2020.* World Health Organization; 2013.

6. United Nations Children's Fund (UNICEF). *Vaccination and Immunization Statistics - UNICEF Data.* UNICEF; 2024. https://knowledge.unicef.org/resource/vaccination-immunization-statistics-unicef-data

7. World Health Organization. *Fully Immunized Child Rate Geneva.* World Health Organization; 2024. Accessed May 5, 2024. https://www.who.int/data/gho/indicator-metadata-registry/imr-details/3376

8. Shen AK, Fields R, McQuestion M. The future of routine immunization in the developing world: Challenges and opportunities. *Glob Health Sci Pract.* 2014;2(4):381–94. doi:10.9745/GHSP-D-14-00137

9. Ministry of Health and Population [Nepal]. *Annual Report 2021/2022.* Department of Health Services; 2022.

10. Ministry of Health and Population [Nepal], New ERA, ICF. *Nepal Demographic and Health Survey 2022.* Ministry of Health and Population; 2023.

11. Hester KA, Sakas Z, Ellis AS, et al. Critical success factors for high routine immunization performance: A case study of Nepal. *Vaccine X.* 2022;12:100214. doi:10.1016/j.jvacx.2022.100214

12. Ministry of Health and Population [Nepal]. *Annual Health Report 2079/2080.* Department of Health Services; 2023.

13. Ministry of Health and Population [Nepal]. *Reference Manual for Health Workers (2079), National Immunization Program*. Department of Health Services, Family Welfare Division; 2022.

14. Ashish KC, Nelin V, Raaijmakers H, Kim HJ, Singh C, Målqvist M. Increased immunization coverage addresses the equity gap in Nepal. *Bull World Health Organ*. 2017;95(4):261–69. doi:10.2471/BLT.16.178327

15. Ministry of Health and Population [Nepal] New ERA, ICF. *Nepal Demographic and Health Survey 2016*. Ministry of Health and Population, New ERA, and ICF; 2017.

16. Ministry of Health and Population [Nepal], ICF International Inc. *Nepal Demographic and Health Survey 2011*. Ministry of Health and Population, New ERA, and ICF International; 2012.

17. Ministry of Health and Population [Nepal]. *National Immunization Strategy (2023–2030).* Ministry of Health and Population; 2023.

18. Acharya K, Lacoul M, Bietsch K. *Factors Affecting Vaccination Coverage and Retention of Vaccination Cards in Nepal.* DHS Further Analysis Reports No. 121. ICF; 2019.

19. World Health Organization. Immunization coverage. July 18, 2023. Accessed July 22, 2024. https://www.who.int/en/news-room/fact-sheets/detail/immunization-coverage

20. Acharya K, Paudel YR, Dharel D. The trend of full vaccination coverage in infants and inequalities by wealth quintile and maternal education: Analysis from four recent demographic and health surveys in Nepal. *BMC Public Health.* 2019;19(1):1673. doi:10.1186/s12889-019-7995-3

21. Song IH, Palley E, Atteraya MS. Inequalities in complete childhood immunisation in Nepal: Results from a population-based cross-sectional study. *BMJ Open.* 2020;10(9):e037646.

22. Putri H, Abdel D. Determinants of immunisation coverage of children aged 12–59 months in Indonesia: A cross-sectional study. *BMJ Open.* 2017;7(12):e015790. doi:10.1136/bmjopen-2016-015790

23. Rutstein SO, Johnson K. *The DHS Wealth Index.* DHS Comparative Reports No. 6. ORC Macro; 2004.

24. Heeringa SG, West BT, Berglund PA. *Applied Survey Data Analysis*. CRC Press; 2017.

25. Khatiwada AP, Maskey S, Shrestha N, et al. Impact of the first phase of COVID-19 pandemic on childhood routine immunisation services in Nepal: A qualitative study on the perspectives of service providers and users. *J Pharm Policy Pract.* 2021;14(1):79. doi:10.1186/s40545-021-00366-z

26. Office of the United Nations High Commissioner for Human Rights. *Convention on the Rights of the Child.* United Nations Children's Fund; 1989.

27. Ministry of Health and Population [Nepal]. Full immunization declaration guideline. In: Department of Health Services, ed. *Services.* 3rd ed. Ministry of Health and Population.

28. Beric-Stojsic B, Kalabalik-Hoganson J, Rizzolo D, Roy S. Childhood immunization and COVID-19: An early narrative review. *Front Public Health.* 2020;8:587007. doi:10.3389/fpubh.2020.587007

29. Adhikari SK, Ranabhat K, Bhattarai S, et al. Epidemiology of COVID-19 mortality in Nepal: An analysis of the National Health Emergency Operation Center data. *Public Health Challenges.* 2023;2(4):e127. doi.org/10.1002/puh2.127

30. Devansenapathy N, Jerath SG, Sharma S, Allen E, Shanker AH, Zodpey S. Determinants of childhood immunisation coverage in urban poor settlements of Delhi, India: A cross-sectional study. *BMJ Open.* 2016;6(8):e013015. doi:10.1136/bmjopen-2016-013015

31. Glatman-Freedman A, Nichols K. The effect of social determinants on immunization programs. *Hum Vaccin Immunother.* 2012;8(3):293–301. doi:10.4161/hv.19003

32. Jinarong T, Chootong R, Vichitkunakorn P, Songwathana P. Muslim parents' beliefs and factors influencing complete immunization of children aged 0–5 years in a Thai rural community: A qualitative study. *BMC Public Health.* 2023;23(1):1348. doi:10.1186/s12889-023-15273-y

33. Mutua MK, Kimani-Murage E, Ettarh RR. Childhood vaccination in informal urban settlements in Nairobi, Kenya: Who gets vaccinated? *BMC Public Health.* 2011;11(1):6. doi:10.1186/1471-2458-11-6

34. Noh J-W, Kim Y-M, Akram N, et al. Factors affecting complete and timely childhood immunization coverage in Sindh, Pakistan: A secondary analysis of cross-sectional survey data. *PLoS One.* 2018;13(10):e0206766. doi:10.1371/journal.pone.0206766

36. Costa FS, Silva LAN, Cata-Preta BO, et al. Child immunization status according to number of siblings and birth order in 85 low- and middle-income countries: A cross-sectional study. *eClinicalMedicine.* 2024;71:102547. doi.org/10.1016/j.eclinm.2024.102547

36. Boulton ML, Carlson BF, Power LE, Wagner AL. Socioeconomic factors associated with full childhood vaccination in Bangladesh, 2014. *Int J Infect Dis.* 2018;69:35–40. doi:10.1016/j.ijid.2018.01.035

37. Anichukwu OI, Asamoah BO. The impact of maternal health care utilisation on routine immunisation coverage of children in Nigeria: A cross-sectional study. *BMJ Open.* 2019;9(6):e026324. doi:10.1136/bmjopen-2018-026324

38. Restrepo-Méndez MC, Barros AJ, Wong KL, et al. Missed opportunities in full immunization coverage: Findings from low- and lower-middle-income countries. *Glob Health Action.* 2016;9:30963. doi:10.3402/gha.v9.30963

39. Abegaz MY, Seid A, Awol SM, Hassen SL. Determinants of incomplete child vaccination among mothers of children aged 12–23 months in Worebabo district, Ethiopia: Unmatched case-control study. *PLoS Glob Public Health.* 2023;3(8):e0002088. doi:10.1371/journal.pgph.0002088

40. Nepal Health Research Council and United Nations Children's Fund. *Factors Affecting Health-Seeking Behaviour Among People in Nepal: Exploratory Study on Institutional Delivery, Routine Child Immunization and COVID-19 Vaccination.* Nepal Health Research Council; 2023.

41. New ERA. *Family Planning, Maternal, Newborn and Child Health Situation in Rural Nepal: A Mid-Term Survey for NFHP II.* New ERA; 2010.

42. Family Health Division. *Female Community Health Volunteer National Survey Report.* Family Health Division; 2014.

43. Manandhar DS, Osrin D, Shrestha BP, et al. Effect of a participatory intervention with women's groups on birth outcomes in Nepal: Cluster-randomised controlled trial. *Lancet.* 2004;364(9438):970–79. doi:10.1016/S0140–6736(04)17021-9

44. Tripathy P, Nair N, Sinha R, et al. Effect of participatory women's groups facilitated by accredited social health activists on birth outcomes in rural eastern India: A cluster-randomised controlled trial. *Lancet Glob Health* 2016;4(2):e119-e28. doi:10.1016/S2214-109X(15)00287-9

45. Devika S, Jeyaseelan L, Sebastian G. Analysis of sparse data in logistic regression in medical research: A newer approach. *J Postgrad Med.* 2016;62(1):26–31. doi:10.4103/0022-3859.173193

46. Leggett CG, Kleckner NS, Boyle K, Dufield JW, Mitchell RC. Social desirability bias in contingent valuation surveys administered through in-person interviews. *Land Economics.* 2003;79(4):561–75.

APPENDIX

Table A1 **Descriptive definition of explanatory variables**

Variable	Variable categories	Definition
Geographic variables		
Province	Koshi, Madhesh, Bagmati, Gandaki, Lumbini, Karnali, Sudurpaschim	Seven provinces
Place of residence	Urban, Rural	Respondents at the time of the survey lived in either rural or urban areas
Ecoregion	Hill, Mountain, Terai	Three zones horizontal division
Sociodemographic variables		
Maternal age	15–19, 20–24, 25–29, 30–34, ≥35	Age of mothers at the time of the interview
Ethnicity	Hill Brahmin, Hill Chhetri, Terai caste, Terai Janajati, Hill Janajati, Dalit, Muslim	Categorized into seven castes/ethnicities, others were merged into the Terai caste
Education	No education, Primary, Some secondary, SLC and above	No education meant illiterate, primary referred to classes 1–8, some secondary referred to classes 9–10, and SLC and above referred higher levels of education
Wealth quintile	Lowest, Second, Middle, Fourth, Highest	Five quintiles
Sex of child	Male, Female	Sex of the index child
Birth order	1, 2–3, 4+	Birth order of a most recent child
Household size	1–3, 4–5, 6+	Number of members in the sampled household
Media exposure of mother	Not at all, Less than once a week, At least once a week	Frequency of exposure to any mass media (radio/television/newspaper) in a week
Mother worked in previous 12 months	Yes, No	Mother's engagement in employment in the past year
Maternal health service use and accessibility		
At least four ANC visits	Yes, No	Number of respondent's ANC checkups during last pregnancy
Institutional delivery	Yes, No	Institutional delivery of respondent's last birth
Postnatal care visit within 2 months of birth	Yes, No	Respondent's postnatal care history for last delivery
Distance to health facility a big problem	Yes, No	Respondent asked about accessibility of health facility in terms of distance as a big problem
Additional variables		
Decision-making by mother	Yes, No	Proxy composite indicator for women empowerment based on "can refuse sex," "can decide own health care," and "combined contraceptive decisions"
Health mothers' group in ward	Yes, No	Asked respondents about whether they were aware of health mothers' groups in the ward
Vaccination card retention	Never received, Vaccination card retained, Vaccination card not retained	Information on vaccination coverage based on vaccination card shown by the mother

ANC = antenatal care; SLC = School Leaving Certificate

Table A2	**Trends in geographic and sociodemographic variables among children age 12–23 months, 2011–2022 Nepal DHS surveys**		
	2011 NDHS (N=1,000)	**2016 NDHS (N=1,034)**	**2022 NDHS (N=959)**
Variable	**Percentage (95% CI)**	**Percentage (95% CI)**	**Percentage (95% CI)**
Geographic variables			
Place of residence			
Urban	9.7 (8.2–11.4)	54.5 (50.6–58.3)	65.0 (61.9–67.9)
Rural	90.3 (88.5–91.8)	45.4 (41.6–49.3)	35.0 (32.0–38.0)
Ecoregion			
Mountain	7.5 (6.3–8.9)	7.2 (4.8–10.7)	7.0 (4.8–10.1)
Hill	40.2 (25.3–45.2)	37.7 (32.2–43.6)	31.4 (27.2–35.9)
Terai	52.3 (47.0–57.6)	55.0 (49.4–60.6)	61.6 (57.2–65.8)
Province			
Koshi	20.0 (15.2–25.8)	16.4 (13.9–19.2)	17.5 (15.2–19.9)
Madhesh	14.5 (8.5–23.5)	25.0 (21.9–28.5)	28.0 (24.9–31.4)
Bagmati	22.9 (15.9–32.0)	16.3 (12.8–20.5)	14.0 (11.6–16.7)
Gandaki	10.6 (6.8–16.4)	9.0 (7.5–10.9)	5.3 (4.4–6.3)
Lumbini	15.0 (11.0–20.1)	19.0 (16.0–22.4)	17.9 (15.6–20.5)
Karnali	6.9 (4.7–10.1)	6.1 (5.1–7.3)	8.2 (6.9–9.8)
Sudurpaschim	10.1 (8.2–12.3)	8.2 (6.7–9.9)	9.0 (7.6–10.7)
Sociodemographic variables			
Sex of child			
Male	50.1 (46.4–53.8)	55.8 (52.5–59.1)	50.6 (46.9–54.3)
Female	49.9 (46.2–53.6)	44.2 (40.9–47.5)	49.3 (45.6–53.1)
Maternal education			
No education	45.2 (39.4–51.2)	31.1 (27.2–35.2)	20.5 (17.1–24.4)
Primary	20.0 (16.6–23.8)	20.5 (17.6–23.8)	35.3 (31.9–38.8)
Some secondary	21.1 (17.4–25.3)	25.8 (22.3–29.6)	27.1 (24.2–30.5)
SLC and above	13.7 (11.0–16.9)	22.6 (19.0–26.7)	17.0 (14.3–20.1)
Maternal age			
<20	9.8 (7.8–12.1)	11.3 (9.4–13.5)	8.0 (6.1–10.2)
20–24	39.9 (36.2–43.7)	38.6 (35.0–42.3)	41.6 (38.4–44.9)
25–29	28.4 (24.5–32.6)	30.5 (27.2–34.0)	31.2 (28.0–34.5)
30–34	13.0 (10.7–15.6)	14.0 (11.8–16.6)	13.3 (11.1–15.9)
≥35	9.0 (7.0–11.4)	5.6 (4.2–7.5)	5.9 (4.4–7.9)
Ethnicity			
Hill Brahmin	8.9 (6.5–12.0)	9.9 (7.4–13.1)	5.9 (4.2–8.3)
Hill Chhetri	16.8 (13.5–20.7)	15.2 (12.4–18.6)	18.3 (15.4–21.6)
Terai caste	12.2 (8.1–17.9)	21.0 (17.0–25.8)	19.4 (15.9–23.6)
Dalit	16.9 (12.8–21.8)	15.5 (12.5–19.0)	20.3 (17.0–24.0)
Hill Janajati	27.3 (21.7–33.8)	22.5 (18.5–27.0)	20.1 (16.8–23.8)
Terai Janajati	8.8 (5.6–13.7)	8.4 (6.1–11.4)	9.1 (6.7–12.1)
Muslim	8.9 (3.6–20.3)	7.4 (4.8–11.3)	6.9 (4.2–11.0)
Wealth quintile			
Lowest	24.8 (20.8–29.1)	20.7 (17.2–24.8)	24.2 (21.0–27.8)
Second	22.7 (19.0–26.8)	22.1 (19.0–25.6)	23.3 (19.7–27.4)
Middle	21.7 (17.6–26.6)	22.9 (19.7–26.3)	18.8 (16.0–21.9)
Fourth	18.2 (15.2–21.9)	21.8 (18.4–25.6)	20.1 (17.1–23.6)
Highest	12.6 (9.4–16.6)	12.4 (9.7–15.8)	13.4 (10.7–16.9)

CI = confidence interval; NDHS = Nepal Demographic and Health Survey; SLC = School Leaving Certificate

34

Table A3 **Trends in childhood vaccination status by geographic and sociodemographic variables, 2011–2022 Nepal DHS surveys**

Variable	2011 NDHS (N=1,000) Percentage (95% CI)		2016 NDHS (N=1,034) Percentage (95% CI)		2022 NDHS (N=959) Percentage (95% CI)	
Geographic variables						
Place of residence	**Partial**	**No**	**Partial**	**No**	**Partial**	**No**
Urban	9.9 (6.2–15.8)	0.0	20.8 (16.4–26.0)	0.7 (0.2–1.8)	15.8 (12.1–20.2)	4.8 (3.1–7.2)
Rural	10.1 (6.8–14.7)	3.2 (2.0–5.2)	21.9 (17.7–26.8)	1.0 (0.3–3.2)	15.8 (12.0–20.5)	3.8 (2.0–7.1)
Ecoregion						
Mountain	7.5 (3.5–15.2)	4.3 (1.6–10.7)	25.9 (17.9–35.8)	0.0	10.2 (5.5–18.1)	0.7 (0.1–4.8)
Hill	7.3 (4.7–11.1)	3.2 (1.7–6.1)	11.4 (8.2–15.8)	0.5 (0.1–1.7)	9.4 (6.7–13.2)	6.2 (3.7–10.2)
Terai	12.6 (7.7–20.0)	2.5 (1.1–5.8)	27.5 (22.9–32.6)	1.2 (0.5–3.0)	19.6 (15.5–24.5)	4.0 (2.5–6.3)
Province						
Koshi	10.8 (4.3–24.4)	1.8 (0.5–6.6)	19.8 (14.1–27.0)	0.8 (0.1–5.5)	13.5 (7.3–23.6)	5.6 (2.6–11.7)
Madhesh	16.3 (8.3–29.5)	0.0	32.9 (25.3–41.6)	1.9 (0.6–5.7)	29.0 (22.7–36.2)	4.0 (2.1–7.6)
Bagmati	10.9 (4.1–25.8)	5.4 (2.8–10.4)	14.1 (7.6–24.8)	0.6 (0.1–4.5)	7.3 (3.4–15.0)	9.3 (4.7–17.6)
Gandaki	5.6 (1.6–17.3)	1.8 (0.3–10.1)	7.3 (3.8–13.6)	0.0	6.6 (2.9–14.4)	0.0
Lumbini	6.6 (3.7–11.6)	2.4 (0.7–7.4)	21.7 (14.4–31.3)	0.0	11.3 (6.6–18.9)	3.4 (1.2–8.7)
Karnali	12.4 (6.7–22.0)	11.1 (5.0–22.8)	23.6 (15.8–33.8)	1.5 (0.4–5.8)	12.8 (7.8–20.2)	2.9 (0.9–9.0)
Sudurpaschim	6.3 (3.2–11.9)	0.0	15.9 (10.0–24.3)	0.7 (0.1–5.1)	8.9 (5.3–14.5)	2.2 (0.7–6.5)
Sociodemographic variables						
Sex of child						
Male	9.0 (6.0–13.2)	2.8 (1.2–6.3)	22.0 (17.9–26.8)	0.5 (0.2–1.6)	14.2 (10.9–18.4)	4.2 (2.6–6.8)
Female	11.3 (7.4–16.7)	3.0 (1.7–5.4)	20.4 (16.4–25.0)	1.3 (0.4–3.5)	17.2 (13.7–21.6)	4.7 (2.9–7.4)
Maternal education						
No education	17.4 (12.2–24.3)	4.5 (2.4–8.1)	31.0 (25.2–37.3)	1.2 (0.3–4.5)	29.0 (21.2–38.4)	6.1 (3.4–10.6)
Primary	3.5 (1.3–9.0)	1.9 (0.5–7.3)	23.9 (17.6–31.6)	0.3 (0.04–2.1)	14.2 (10.4–19.0)	5.3 (3.1–9.1)
Some secondary	3.5 (1.7–7.1)	1.3 (0.3–5.4)	18.7 (14.0–24.6)	1.5 (0.5–4.1)	11.1 (7.3–16.6)	2.9 (1.3–6.2)
SLC and above	5.9 (2.6–12.8)	1.7 (0.3–8.7)	8.7 (5.6–13.2)	0.8 (0.4–1.8)	10.4 (6.2–17.0)	3.2 (1.1–9.1)
Maternal age						
<20	11.4 (5.0–24.1)	3.1 (0.6–14.4)	22.3 (15.3–31.5)	0.0	20.2 (11.4–33.2)	7.4 (3.0–17.1)
20–24	6.9 (4.1–11.4)	1.3 (0.4–3.5)	21.6 (17.3–26.6)	0.5 (0.1–1.9)	16.8 (12.9–21.5)	4.1 (2.3–7.1)
25–29	14.2 (9.3–21.1)	3.9 (1.9–7.8)	21.9 (16.8–28.0)	0.8 (0.2–2.9)	14.6 (10.5–20.0)	5.1 (2.9–8.8)
30–34	12.1 (4.5–28.4)	2.3 (0.6–7.6)	18.1 (11.2–28.1)	2.9 (0.8–9.7)	10.8 (6.2–18.2)	1.7 (0.4–6.7)
≥35	7.2 (2.4–19.6)	8.0 (3.0–19.8)	21.9 (12.9–34.9)	0.0	19.8 (10.4–34.3)	5.9 (2.1–15.4)
Ethnicity						
Hill Brahmin	3.9 (1.1–13.1)	2.2 (0.3–13.9)	5.2 (2.4–11.0)	0.0	4.9 (1.9–12.0)	4.3 (1.0–16.3)
Hill Chhetri	7.7 (4.7–12.2)	2.4 (0.7–7.8)	16.6 (11.3–23.7)	0.0	11.7 (7.3–18.2)	2.0 (0.6–6.3)
Terai caste	18.1 (9.7–31.2)	0.0	34.6 (26.5–43.6)	0.7 (0.1–3.6)	21.7 (14.4–31.2)	5.0 (2.3–10.5)
Dalit	12.0 (6.6–20.8)	2.3 (0.8–6.5)	24.9 (18.4–32.9)	1.8 (0.4–8.7)	25.1 (18.3–33.4)	5.7 (2.9–10.9)
Hill Janajati	4.7 (2.1–10.1)	2.2 (0.9–5.2)	13.9 (9.3–20.4)	0.7 (0.2–2.7)	6.8 (3.8–12.0)	6.3 (3.1–12.2)
Terai Janajati	4.2 (1.0–15.6)	0.9 (0.1–6.7)	19.4 (11.0–32.0)	3.0 (0.7–11.4)	6.1 (2.2–15.7)	3.0 (0.6–12.8)
Muslim	28.6 (17.8–42.3)	13.9 (6.0–28.9)	31.9 (21.4–44.5)	0.0	30.3 (18.9–45.0)	2.6 (0.6–10.0)
Wealth quintile						
Lowest	10.3 (6.7–15.8)	5.1 (2.8–9.2)	22.9 (17.2–29.9)	0.4 (0.1–1.8)	17.8 (13.2–23.6)	6.3 (3.5–11.2)
Second	14.2 (8.6–22.4)	2.0 (0.5–7.7)	21.1 (15.4–28.0)	1.7 (0.5–6.3)	20.1 (13.9–28.1)	6.6 (3.8–11.4)
Middle	10.3 (4.7–21.2)	5.6 (2.1–14.0)	29.1 (22.8–36.3)	0.0	13.3 (8.2–20.8)	1.7 (0.6–2.4)
Fourth	8.5 (4.1–16.5)	0.0	14.1 (9.4–20.7)	1.0 (0.2–4.1)	12.2 (7.8–18.7)	2.6 (0.9–7.2)
Highest	4.3 (1.6–11.2)	0.0	17.2 (19.0–28.1)	1.1 (0.2–6.1)	13.2 (7.6–22.0)	4.0 (3.2–6.3)

CI = confidence interval; NDHS = Nepal Demographic and Health Survey; SLC = School Leaving Certificate

	Table A4	**Percentage-point differences in levels of partial vaccination among children over time, 2011–2022 Nepal DHS surveys**				

	NDHS (2022 versus 2011)		NDHS (2022 versus 2016)		NDHS (2016 versus 2011)	
Variable	Change (percentage points)	*p* value	Change (percentage points)	*p* value	Change (percentage points)	*p* value
National	**5.7**	*******	**-5.5**	******	**11.2**	*******
Ecoregion						
Mountain	2.7	NS	-15.7	***	18.4	***
Hill	2.1	NS	-2.0	NS	4.1	**
Terai	7.0	***	-7.9	***	14.9	***
Province						
Koshi	2.7	NS	-6.3	***	9.0	***
Madhesh	12.7	***	-3.9	***	16.6	***
Bagmati	-3.6	**	-6.8	***	3.2	***
Gandaki	1.0	NS	-0.7	NS	1.7	NS
Lumbini	4.7	***	-10.4	***	15.1	***
Karnali	0.4	NS	-10.8	***	11.2	***
Sudurpaschim	2.6	***	-7.0	*	9.6	***
Maternal education						
No education	11.6	***	-2.0	*	13.6	***
Primary	12.3	***	-9.7	***	20.4	***
Some secondary	7.6	***	-7.6	***	15.2	***
SLC and above	4.5	***	1.7	***	2.8	***
Ethnicity						
Brahmin Hill	1.0	NS	-0.3	NS	1.3	NS
Chhetri Hill	4.0	**	-4.9	**	8.9	***
Terai caste	3.6	*	-12.9	***	16.5	***
Dalit	13.1	***	0.2	***	12.9	***
Hill Janajati	2.1	*	-7.1	***	9.2	***
Terai Janajati	1.9	NS	-13.3	***	15.2	***
Muslim	1.7	NS	-1.6	***	3.3	NS
Wealth quintile						
Lowest	7.5	***	-5.1	**	12.6	***
Second	5.9	***	-1.0	NS	6.9	***
Middle	3.0	*	-15.8	***	18.8	***
Fourth	3.7	**	-1.9	NS	5.6	***
Highest	8.9	***	-4.0	*	12.9	***

* *p*<.05, ** *p*<.01, *** *p*<.001

ARRR = adjusted risk reduction ratio; CI = confidence interval; NDHS = Nepal Demographic and Health Survey; NS = not significant; Ref. = reference; SLC = School Leaving Certificate

Note: Positive cell values denote declines and negative cell values denote increases.

Table A5 **Percentage-point differences in levels of no vaccination among children over time, 2011–2022 Nepal DHS surveys**

Variable	NDHS (2022–2011) Change (percentage points)	p value	NDHS (2022–2016) Change (percentage points)	p value	NDHS (2016–2011) Change (percentage points)	p value
National	**1.1**	**NS**	**3.6**	*******	**-2.5**	*******
Ecoregion						
Mountain	-6.8	***	0.7	**	-4.3	***
Hill	3.0	**	5.7	***	-2.7	***
Terai	1.5	NS	2.8	***	-1.3	***
Province						
Koshi	3.8	***	4.8	***	-1.0	*
Madhesh	4.0	***	2.1	**	1.9	***
Bagmati	3.9	***	8.7	**	-4.8	Ns
Gandaki	-1.8	***	0.0	NS	-1.8	***
Lumbini	1.0	NS	3.4	***	-2.4	***
Karnali	-8.2	***	1.4	*	-9.6	***
Sudurpaschim	2.2	**	1.5	**	0.7	**
Maternal education						
No education	1.6	NS	4.9	***	-3.3	***
Primary	3.4	***	5.0	***	-1.6	***
Some secondary	1.6	*	1.4	*	0.2	**
SLC and above	1.5	***	2.4	***	-0.9	NS
Ethnicity						
Hill Brahmin	2.1	NS	4.3	***	-2.2	***
Hill Chhetri	-0.4	NS	2.0	***	-2.4	***
Terai caste	5.0	***	4.3	***	0.7	**
Dalit	3.4	***	3.9	NS	-0.5	NS
Hill Janajati	4.1	***	5.6	***	-1.5	**
Terai Janajati	2.1	***	0.0	NS	2.1	**
Muslim	-11.3	***	2.6	***	-13.9	***
Wealth quintile						
Lowest	1.2	NS	5.9	***	-4.7	***
Second	4.6	***	4.9	***	-0.3	NS
Middle	-3.9	***	1.7	***	-5.6	***
Fourth	2.6	***	1.6	***	1.0	**
Highest	4.0	***	2.9	***	1.1	***

* p<.05, ** p<.01, *** p<.001

ARRR = adjusted risk reduction ratio; CI = confidence interval; NDHS = Nepal Demographic and Health Survey; NS = not significant; Ref. = reference; SLC = School Leaving Certificate

Note: Positive cell values denote declines and negative cell values denote increases.

Table A6   **Multivariable multinomial logistic regression analysis of childhood vaccination status, 2022 Nepal DHS**

Variable	Full versus no vaccination		Full versus partial vaccination	
	ARRR	95% CI	ARRR	95% CI
Geographic variables				
Province				
Koshi (Ref.)	1.00		1.00	
Madhesh	0.28	0.06–1.24	1.51	0.53–4.30
Bagmati	2.77	0.90–8.52	0.57	0.19–1.70
Gandaki	0.00***	0.00–0.00	0.56	0.16–1.87
Lumbini	0.88	0.23–3.42	0.79	0.26–2.36
Karnali	0.46	0.07–2.90	0.64	0.23–1.75
Sudurpaschim	0.83	0.14–4.90	0.73	0.24–2.22
Sociodemographic variables				
Child sex				
Male (Ref.)	1.00		1.00	
Female	1.01	0.45–2.30	1.14	0.77–1.69
Maternal age in years				
<20 (Ref.)	1.00		1.00	
20–34	0.80	0.17–3.66	0.84	0.38–1.87
≥35	1.40	0.18–10.60	1.57	0.51–4.83
Maternal education				
No education (Ref.)	1.00		1.00	
Primary	0.92	0.28–3.05	0.87	0.43–1.73
Some secondary	0.70	0.16–3.07	1.07	0.52–2.19
SLC and above	0.55	0.12–2.50	0.90	0.32–2.54
Paternal education				
No education (Ref.)	1.00		1.00	
Primary	0.25	0.05–1.17	1.00	0.53–1.89
Some secondary	0.52	0.10–2.75	0.48	0.22–1.05
SLC and above	0.36	0.02–5.71	2.18	0.65–7.30
Ethnicity				
Hill Brahmin (Ref.)	1.00		1.00	
Hill Chhetri	0.42	0.04–4.18	2.53	0.66–9.65
Terai caste	2.23	0.17–29.20	2.50	0.64–9.70
Dalit	1.20	0.16–8.66	3.63	0.97–13.51
Hill Janajati	0.67	0.13–3.60	1.28	0.30–5.41
Terai Janajati	0.61	0.07–5.28	0.87	0.15–4.95
Muslim	0.30	0.01–6.44	3.15	0.66–14.95
Wealth quintile				
Lowest (Ref.)	1.00		1.00	
Second	1.12	0.40–3.16	0.99	0.52–1.91
Middle	0.27	0.05–1.52	0.55	0.25–1.21
Fourth	0.60	0.11–3.14	0.71	0.32–1.55
Highest	0.77	0.17–3.56	0.48	0.18–1.26
Household size				
1–3 members (Ref.)	1.00		1.00	
4–5 members	2.68	0.72–10.03	2.55*	1.05–6.15
6+ members	2.18	0.50–9.39	2.30	0.96–5.51
Birth order				
1 (Ref.)	1.00		1.00	
2–3	0.52	0.24–1.12	0.96	0.57–1.60
4+	0.79	0.14–4.50	1.26	0.58–2.71
Mother worked in previous 12 months				
Yes (Ref.)	1.00		1.00	
No	0.63	0.22–1.81	0.70	0.42–1.17

Continued…

Table A6—*Continued*

Variable	Full versus no vaccination		Full versus partial vaccination	
	ARRR	**95% CI**	**ARRR**	**95% CI**
Media exposure of mother				
Not at all (Ref.)	1.00		1.00	
Less than once a week	1.27	0.45–3.59	1.18	0.70–2.01
At least once a week	2.41	0.74–7.86	1.00	0.55–1.82
Maternal health service use and accessibility				
Place of delivery				
Elsewhere (Ref.)	1.00		1.00	
Health facility	0.26**	0.11–0.61	0.85	0.54–1.36
At least four antenatal care visits				
No (Ref.)	1.00		1.00	
Yes	0.35*	0.15–0.79	0.74	0.46–1.17
Distance to health facility				
No big problem (Ref.)	1.00		1.00	
Big problem	1.87	0.66–5.32	1.30	0.78–2.17
Health mothers' group in ward				
No (Ref.)	1.00		1.00	
Yes	0.26	0.06–1.15	0.58*	0.38–0.89
Decision-making by mother				
No (Ref.)	1.00		1.00	
Yes	1.19	0.54–2.62	0.88	0.55–1.41

* *p*<.05, ** *p*<.01, *** *p*<.001

ARRR = adjusted risk reduction ratio; CI = confidence interval; Ref. = reference; SLC = School Leaving Certificate