Trend and inequity in infant vaccination coverage: Analysis from three recent Demographic Health Surveys in Nepal

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Abstract

Background Despite policy intention to reach disadvantaged populations, inequities in child health care use and health outcomes persist in Nepal. The current study aimed to investigate the trend of full vaccination coverage among infants and its equity gaps between 2002 and 2016.

Methods Using data from demographic health surveys conducted in 2006, 2011 and 2016, we investigated the trend of coverage of six antigens: Bacille Calmette Guerin (BCG), Diptheria, Pertussis, Tetanus (DPT), Polio, and Measles) between 2002 to 2016. Rich-poor difference, Rich: Poor ratio and concentration index were calculated to measure income inequity. Lorentz curve was drawn to show the change in income-related inequity over time. Bivariate and multivariate logistic regression analyses were conducted to investigate socio-demographic correlates of full vaccination coverage.

Results Full immunization coverage was slightly increased from an average of 83% during 2002-2006 to 87% during 2007-2011, but it decreased to 78% during 2012-2016. There was a significant increase in full vaccination coverage among infants from the poorest income quintile and a simultaneous decrease among infants from richer income quintiles. Province 2 saw the largest drop, from 79.2% (95%CI 64.8-88.8) during 2002-2006 to 65.2% (95%CI 56.4-73.0) during 2012-2016. In Province 2, maternal education was the independent predictor of full vaccination coverage; the mother with secondary education was over three times more likely to fully immunize their children compared to mothers with no formal education (AOR 3.2; 95% CI:1.5-6.7).

Conclusion Full vaccination coverage in Nepal saw significant decrement away from the national target after 2011. A sharp decrease in coverage of full vaccination among infants from wealthier income quintiles and an increase in coverage among infants from the poorest income quintile between 2002 and 2016 created a pro-poor equity gain. While a national effort to improve full vaccination coverage is overdue, children from province 2, specifically those born to mothers with no or primary education need particular programmatic focus. Further research is needed to understand the reasons behind decrement in full vaccination coverage, particularly among rich income quintiles.

Introduction

Government of Nepal (GoN) aims to reach all children under-five years of age with vaccines to prevent vaccine-preventable diseases. Immunization services are being provided through a network of static clinics located at health facilities, and outreach clinics located at the community (1). Private and Non-government organization run health facilities have been increasingly mobilized to provide immunization services. These services can be availed from routine immunization clinics as well as during special campaigns(1).

Reaching all children with full immunization services is vital to meet Nepal's commitment to Sustainable Development Goals. The success of the National Immunization Program (NIP) depends on vaccination coverage, quality of vaccination reporting, and strategies to effectively reach Nepal's diverse and geographically dispersed population(2). Nepal Health Sector Strategy 2015-2020 and its implementation plan have a target are to achieve more than 90% full vaccination coverage for children(3). Previous research has shown that national or regional statistics on coverage can mask the underlying inequalities among population groups(2). Therefore, it is essential to present disaggregated data on immunization coverage to identify unreached population groups.
GoN, along with its development partners, have taken various strategies to strengthen immunization services, including full immunization declaration of wards, municipalities, and districts. However, concerns have been raised regarding the sustainability of full immunization declaration program as being a one-off activity rather than a continuous improvement.

A wealth of evidence suggests that inequalities in child survival outcomes exist mainly by wealth quintiles(4), mother’s educational status(5) and geographical region (6). However, whether these inequalities are driven by the differences in coverage and service utilization remains poorly understood. A recent study by KC et al. showed an equity gap to have been narrowed in Nepal with increased coverage of immunization service between 2001 and 2014(7). However, they used data from different surveys - Demographic Health Surveys and Multiple indicators Cluster Survey (MICS) with different methods to compare immunization coverage. Furthermore, the findings might have been subjected to recall bias since they included all eligible children under-five years of age in their analyses, while much of the literature includes only 12-23 months children to measure immunization coverage(8, 9). Therefore, current study reports trend and disparities in full vaccination coverage of six antigens available during most recent three rounds of Nepal demographic Health Surveys conducted in 2006, 2011 and 2016 among children of age 12-23 months. The findings will help to understand the recent trend in full immunization coverage along with the trend in equity gap among different population groups. This could help policymakers identify disadvantaged groups in terms of immunization service utilization and facilitate policymaking to reduce inequalities and achieve universal health coverage in line with sustainable development goals.

Methods

Data Source

This study uses data from three Nepal Demographic and Health Surveys (NDHS), conducted in 2006, 2011, and 2016, which obtained comparable nationally representative samples of children under five years. DHS is an extensive survey which covers a variety of indicators including vaccination coverage among children 12-23 months, and has a rigorous design, (10). The DHS sample typically is selected in two stages. The first stage involves selecting clusters with probability proportional to size from a national master sample frame. At the second stage, a systematic sample of households is drawn from a listing of households in each of the DHS clusters. Both 2006 and 2011 DHS were selected in two stages while 2016 NDHS sample was stratified and selected in two stages in rural areas and three stages in urban areas(11-13).

Measures

Full vaccination refers to having a vaccination against tuberculosis, i.e. Bacille Calmette Guerin (BCG), three doses of combination vaccine including at least diphtheria, pertussis, and tetanus (DPT), three doses of oral polio vaccines, and a dose of measles-containing vaccine by the age of 12 months. The full immunization rate is calculated based on vaccination data collected from mothers of children of 12-23 months. If vaccination cards were not available at selected households at the time of the survey, interviewers relied on mother’s reports to determine vaccination record. Predictor variables used to assess disparities included: mothers’ education (i. no education, ii. primary, iii. secondary, and iv. higher education), wealth quintiles (i. poorest, ii. Poorer, iii. Middle, iv. Richer, and v. richest), sex of the child (i. male and ii. female), caste/ethnicity (i. Brahmin/Chettri, ii. Female).
Terai/Madhesi other, iii. Dalits, iv. Newar/Janajatis and v. Muslims/others), place of residence (i. rural and ii. urban), province (i.to7) and ecological zone (i. Mountain, ii. Hills, and iii. Terai). These variables were taken from the available literature(7, 14, 15) and were used to demonstrate the disaggregated rates of full immunization coverage in Nepal.

**Statistical analysis**

**Measurements of inequalities**

Given the difficulty of collecting income and expenditure data in developing countries, DHS surveys collect data on household ownership of consumer goods, dwelling materials, source of drinking water, types of sanitation facilities, and other characteristics that relate to economic status. With this data, an index score is computed for each household, using principal component analysis. The entire sample is then ranked according to this score and is divided into quintiles, from the first quintile (Q1)—the poorest 20 percent of the household population—to the fifth quintile (Q5)—the wealthiest 20 percent(16). Wealth quintile ranking indicates relative rather than the absolute economic status of the household. The bottom 20 percent measured in the 2006 NDHS may not have the same absolute level of wealth as the bottom 20 percent measured in the 2011 and 2016 NDHS. In other words, wealth status is not comparable across surveys and countries. This study, however, is not affected by this limitation because it focused on the disparities in vaccination coverage between the wealthy and the poor only within each survey.

We calculated three inequality indicators—the ratio between Q5 and Q1 (ratio of Q1 to Q5 for health indicators and the ratio of Q5 to Q1 for indicators of health care) and, Rich Poor difference and the concentration index. The ratio indicator compares the level of health or use of health services between the wealthiest and the poorest quintiles. Rich-poor difference provides an absolute difference in coverage between the wealthiest quintiles and the poorest quintiles. To some extent, these two indicators provide information on the disparities between the wealthy and the poor. However, it is only based on the information of the two extremes among the wealth groups but ignores the other three quintiles between the top and bottom, and therefore cannot provide a picture of inequalities across the entire population.

The second indicator, the concentration index, quantifies the degree of economic inequality using information from all five quintiles. Therefore, it is a composite summary of inequality across the entire population. The concentration index is calculated in reference to the Lorenz curve. On a Lorenz curve, the x-axis represents the cumulative percentage of the sample, ranked by wealth status from low to high (i.e., from the poorest to the wealthiest); the y-axis plots the cumulative percentage of the outcome variable (i.e., immunization coverage) corresponding to each wealth group.

Analyses were performed initially using the full national sample. Bivariate and multivariate logistic regression models were developed to obtain crude and adjusted odds ratios for full immunization coverage taking into account survey design (sampling weights and strata). Time trends were examined by background characteristics to assess if immunization coverage was changing at the same rate during the study period. Given the significant decline in full immunization coverage in province 2, further analysis on determinants of full vaccination coverage was carried out in province 2sample. Combining data from three rounds of DHS resulted in a sample of 667 children aged 12-23 months in province 2. Variables that showed p<0.10 in bivariate models were included in the multivariate model. All analyses were carried out in STATA 15.0 Stata corporation.
Ethics

DHS surveys were conducted after receiving ethical approval from the Nepal Health Research Council (NHRC) ethical review committee. All of the respondents were informed of the purpose of the survey and were informed that participation was not compulsory and that if they did choose to participate, were assured of the confidentiality of the information. Verbal consent was sought before beginning the interview as per NHRC ethical review guidelines. Separate ethical approval was not required for this analysis.

Results

Trend data showed that there had been considerable socio-demographic changes in Nepal over the last fifteen years (Table 1). The proportion of respondents dwelling in urban areas increased from 12% in 2002-2006 to 54% in 2012-2016. The percentage of mothers with no formal education decreased from 56% in 2002-2006 to 31% in 2012-2016.

Table 1 Trend in socio-demographic characteristics of children aged 12-23 months in last five years (2002-2016) and trends based on Nepal demographic and health surveys.
|                          | 2002-2006 (95% CI) | 2007-2011 (95% CI) | 2012-2016 (95% CI) |
|--------------------------|---------------------|--------------------|--------------------|
|                          | N=984               | N=1000             | N=1034             |
| **Place of residence**   |                     |                    |                    |
| Urban                    | 12.3 [10.3,14.7]    | 9.7 [8.2,11.5]     | 54.5 [48.4,60.5]   |
| Rural                    | 87.7 [85.3,89.7]    | 90.3 [88.5,91.8]   | 45.5 [39.5,51.6]   |
| **Ecological region**    |                     |                    |                    |
| Mountain                 | 9.9 [8.0,12.3]      | 7.5 [6.3,8.9]      | 7.2 [4.9,10.7]     |
| Hill                     | 43.0 [38.9,47.3]    | 40.2 [35.4,45.2]   | 37.7 [32.2,43.5]   |
| Terai                    | 47.0 [42.9,51.3]    | 52.3 [47.0,57.6]   | 55.0 [49.4,60.6]   |
| **Province**             |                     |                    |                    |
| Province 1               | 17.4 [14.1,21.2]    | 20.0 [15.3,25.7]   | 16.4 [13.9,19.2]   |
| Province 2               | 17.2 [13.1,22.3]    | 23.9 [16.9,32.5]   | 25.1 [21.9,28.5]   |
| Province 3               | 16.7 [12.9,18.1]    | 13.5 [10.3,17.6]   | 16.3 [12.8,20.5]   |
| Province 4               | 12.4 [8.4,18.1]     | 10.6 [6.8,16.2]    | 9.1 [7.6,10.7]     |
| Province 5               | 14.4 [11.3,18.1]    | 15.0 [11.0,20.1]   | 19.0 [16.0,22.3]   |
| Province 6               | 6.6 [4.2,10.3]      | 6.9 [4.7,10.0]     | 6.1 [5.1,7.3]      |
| Province 7               | 15.3 [11.8,19.5]    | 10.1 [8.3,12.2]    | 8.2 [6.7,9.9]      |
| **Sex of child**         |                     |                    |                    |
| Male                     | 52.3 [48.8,55.8]    | 50.1 [46.4,53.8]   | 55.8 [52.5,59.1]   |
| Female                   | 47.7 [44.2,51.2]    | 49.9 [46.2,53.6]   | 44.2 [40.9,47.5]   |
| **Educational level of mother** |             |                    |                    |
| No education             | 56.3 [51.7,60.7]    | 45.2 [39.4,51.2]   | 31.1 [27.2,35.2]   |
| Primary                  | 18.9 [15.9,22.4]    | 20.0 [16.6,23.8]   | 20.5 [17.6,23.8]   |
| Secondary                | 18.2 [15.2,21.6]    | 21.1 [17.4,25.3]   | 25.8 [22.4,29.5]   |
| Higher                   | 6.6 [4.7,9.2]       | 13.7 [11.0,16.9]   | 22.6 [19.0,26.7]   |
| **Wealth quintile**      |                     |                    |                    |
| Poorest                  | 25.8 [21.6,30.6]    | 24.8 [20.8,29.1]   | 20.8 [17.2,24.8]   |
| Poorer                   | 20.2 [16.7,24.3]    | 22.7 [19.0,26.8]   | 22.1 [19.0,25.6]   |
Table 2 shows that the full immunization coverage increased by 4% from 83% during 2002-2006 to 87% during 2007-2011, while it decreased by 9% during 2012-2016 compared to 2007-2011 level. Coverage in Terai region saw a drop of nearly 15% from 86% in 2002-2006 to 71% in 2012-2016, while the coverage in Mountain and Hills saw an increase during 2012-2016 from the level of 2002-2006. Province-wise Province 2 saw the most significant drop of 14%, followed by Province 1 during 2012-2016 compared to 2002-2006. Province 6 had consistently low coverage, with close to four-quarters infants getting full vaccination. There was a decrease in vaccination coverage among infants from all groups of maternal education by variable degree. Interestingly, children born to the poorest households saw an increase in full immunization coverage to 76.6% during 2012-2016 compared to 68% during 2002-2006; while all other categories of wealth quintile saw a decrease in coverage during this period, middle wealth quintile having the most substantial drop (71% from 87%). Caste-ethnicity wise, children born to families belonging to Terai/Madhesi castes and Muslim/others saw a more substantial decrease in full immunization coverage from the years 2002-2006 to 2012-2016, while children from Dalits (the most disadvantaged caste group) had an increase in coverage from 70.6% to 73.2%.

Table 2 Trend of full immunization by socio-demographic characteristics of children aged 12-23 months (2002–2016)
|                          | 2002-2006 (95% CI) N=984 | 2007-2011 (95% CI) N=1000 | 2012-2016 (95% CI) N=1034 |
|--------------------------|--------------------------|--------------------------|--------------------------|
| **Place of residence**   |                          |                          |                          |
| Urban                    | 86.3 (77.1-92.2)         | 90.0 (84.2-93.8)         | 78.5 (73.3-83.0)         |
| Rural                    | 82.4 (77.8-86.1)         | 86.6 (81.4-90.5)         | 77.0 (71.7-81.6)         |
| **Ecological region**    |                          |                          |                          |
| Mountain                 | 71.3 (55.5-83.2)         | 88.2 (76.8-94.4)         | 74.1 (64.1-82.1)         |
| Hill                     | 81.6 (74.3-87.2)         | 89.5 (84.6-92.9)         | 88.0 (83.6-91.4)         |
| Terai                    | 86.4 (81.4-90.3)         | 84.8 (76.6-90.5)         | 71.3 (66.1-76.0)         |
| **Province**             |                          |                          |                          |
| Province 1               | 84.7 (77.2-90.1)         | 87.3 (75.7-93.0)         | 79.4 (72.4-85.1)         |
| Province 2               | 79.2 (68.5-87.0)         | 79.3 (64.8-88.8)         | 65.2 (56.4-73.0)         |
| Province 3               | 80.6 (63.9-90.7)         | 91.3 (83.0-95.8)         | 85.3 (74.7-91.9)         |
| Province 4               | 89.5 (80.1-94.8)         | 92.6 (75.2-98.1)         | 92.7 (86.5-96.2)         |
| Province 5               | 87.0 (79.2-92.1)         | 91.0 (86.0-94.3)         | 78.3 (68.8-85.5)         |
| Province 6               | 76.8 (60.4-87.8)         | 76.5 (60.1-87.5)         | 74.9 (64.7-82.9)         |
| Province 7               | 80.5 (67.6-89.1)         | 93.7 (88.1-96.8)         | 83.4 (74.9-89.4)         |
| **Sex of child**         |                          |                          |                          |
| Male                     | 84.9 (80.3-88.6)         | 88.2 (82.8-92.1)         | 77.4 (72.8-81.5)         |
| Female                   | 80.6 (75.6-84.8)         | 85.7 (80.5-89.7)         | 78.4 (74.2-81.1)         |
| **Educational level of mother** |                      |                          |                          |
| No education             | 74.3 (68.2-79.6)         | 78.1 (70.0-84.4)         | 67.8 (61.0-73.9)         |
| Primary                  | 88.2 (81.4-92.7)         | 94.6 (88.6-97.5)         | 75.8 (68.2-82.1)         |
| Secondary                | 97.7 (94.6-99.1)         | 95.2 (89.4-97.9)         | 79.8 (74.0-84.6)         |
| Higher                   | 99.0 (95.5-99.8)         | 92.4 (85.1-96.3)         | 91.2 (86.7-94.3)         |
| **Wealth quintile**      |                          |                          |                          |
| Poorest                  | 68.0 (58.5-76.2)         | 84.5 (78.0-89.4)         | 76.6 (69.7-82.4)         |
| Poorer                   | 82.4 (73.9-88.5)         | 83.9 (75.8-89.6)         | 77.2 (69.6-83.3)         |
Middle & 87.1 (79.9-92.0) & 84.0 (72.4-91.4) & 70.9 (63.7-77.2) \\
Richer & 90.7 (84.0-94.7) & 91.5 (83.4-95.9) & 84.8 (78.2-89.7) \\
Richest & 93.5 (85.7-97.2) & 95.7 (88.8-98.4) & 81.6 (70.8-89.1) \\

**Caste/Ethnicity**

| Caste/Ethnicity        | Coverage Rate |
|------------------------|---------------|
| Brahamin/Chhetri       | 87.7 [81.2,92.2] | 90.7 [85.3,94.3] | 87.3 [82.4,91.0] |
| Terai/Madhesi other    | 77.9 [63.9,87.5] | 82.0 [67.9,90.7] | 64.3 [55.3,72.5] |
| Dalits                 | 70.6 [59.1,80.0] | 85.7 [76.4,91.7] | 73.2 [65.1,80.0] |
| Janajatis/Newar        | 85.2 [77.7,90.5] | 93.5 [88.4,96.4] | 83.3 [77.8,87.6] |
| Muslim/Other           | 79.6 [64.4,89.4] | 58.5 [48.9,67.5] | 69.0 [56.9,78.9] |
| **Total**              | 82.8 (78.8-86.3) | 87.0 (82.3-90.6) | 77.8 (74.2-81.1) |

Although there was more than twice likelihood of receiving full immunization by children born in the wealthiest quintile households compared to the poorest, our analysis suggests that the inequity is reducing over time in terms of rich: poor ratio, rich-poor difference and concentration indices (fig.1). The rich: poor ratio reduced from 1.38 in 2002-2006 to 1.13 in 2007–2011, and further reduced to 1.07 in 2012-2016. The rich-poor difference (measured in percentage points) also showed equity gains over time, reducing from 25.5 in 20012-2006 to 5.0 in 2012-2016. Furthermore, the concentration index was reduced from 0.20 (0.12-0.29) in 2002-2006 to 0.054(-0.01-0.12) in 2012-2016, showing progressive equity gains over time in full immunization coverage in Nepal. The Lorentz curve confirms these findings, as the curve has shifted towards the line of equality in 2012-2016 compared to 2002-2006.

The overall adjusted yearly trend showed a significant decline of full immunization coverage from 2002 to 2016 (AOR 0.78; 95% CI: 0.64-0.94). Rural areas, Terai region, and Province 2 showed a significant annual decline between 2002 and 2016 (Table 3). A significant annual increase was observed among children born in the poorest wealth quintile households, while a significant decline was observed among children born in middle and wealthiest wealth quintile households. Interestingly, significant annual decline was observed only among children born to mothers with secondary education, and there was no significant difference among various caste/ethnic groups.

Table 3 Logistic regressions analysis showing trends in vaccination coverage of children 12-23 months in Nepal (2002-2016), stratified by residence, ecological region, province, wealth quintile, sex of the child, education of mother and caste/ethnicity.
|                                | Vaccination Coverage (N=3018) |
|--------------------------------|-------------------------------|
|                                | Univariate OR (95% CI)        | Multivariate OR (95% CI) |
| **Overall yearly trend**       | 0.84 (0.70-1.0)               | 0.78 (0.64-0.94)         |
| **Place of residence**         |                               |                            |
| Urban                          | 0.70 (0.49-0.99)              | 0.76 (0.52-1.11)          |
| Rural                          | 0.88 (0.70-1.1)               | 0.76 (0.61-0.95)          |
| **Ecological region**          |                               |                            |
| Mountain                       | 1.12(0.69-1.84)               | 1.21 (0.75-1.97)          |
| Hill                           | 1.33(0.97-1.81)               | 1.37 (0.97-1.94)          |
| Terai                          | 0.59 (0.47-0.76)              | 0.56 (0.43-0.73)          |
| **Province**                   |                               |                            |
| Province 1                     | 0.82 (0.58-1.16)              | 0.86 (0.59-1.25)          |
| Province 2                     | 0.67 (0.46-0.96)              | 0.63 (0.43-0.94)          |
| Province 3                     | 1.20 (0.65-2.22)              | 1.65 (0.76-3.60)          |
| Province 4                     | 1.24 (0.71-2.17)              | 0.97 (0.55-1.72)          |
| Province 5                     | 0.68 (0.44-1.05)              | 0.64 (0.40-1.02)          |
| Province 6                     | 0.95 (0.60-1.51)              | 1.0 (0.58-1.76)           |
| Province 7                     | 1.22 (0.72-2.10)              | 1.45 (0.79-2.68)          |
| **Sex of child**               |                               |                            |
| Male                           | 0.76 (0.60-0.94)              | 0.65 (0.52-0.81)          |
| Female                         | 0.93 (0.75-1.15)              | 0.79 (0.63-0.99)          |
| **Educational level of mother**|                               |                            |
| No education                   | 0.87 (0.70-1.09)              | 0.94 (0.74-1.20)          |
| Primary                        | 0.57 (0.38-0.86)              | 0.76 (0.48-1.21)          |
| Secondary                      | 0.26 (0.15-0.43)              | 0.26 (0.15-0.47)          |
| Higher                         | 0.57 (0.33-0.97)              | 0.60 (0.34-1.04)          |
| **Wealth quintile**            |                               |                            |
There was a striking and statistically significant trend of annual decrease in full immunization coverage throughout the study period in province 2 while no significant difference was observed in other provinces. On further analysis of 667 children in province 2, the odds of receiving full immunization was 60% less for children aged 12-23 months during 2012-2016 compared to those during 2002-2006 (Table 4). Educational status of mothers showed a positive association with the likelihood of receiving full immunization. Children born to mothers with secondary education were over three times more likely to receive full immunization compared to children born to mothers with no formal education (AOR 3.2; 95% CI: 1.5-6.7). Similarly, children born to mothers with higher education were over two times more likely to receive full immunization compared to women with no formal education, although the difference did not reach statistical significance (AOR 2.4; 95% CI: 0.9-6.4). Other variables, namely, sex of the child, wealth quintile, caste/ethnicity, urban/rural place of residence, were not associated with full vaccination among children of province 2 from 2002-2016.

Table 4: Socio-demographic predictors of vaccination coverage in Province-2
| Survey Year       | Univariate OR (95% CI) | Multivariate OR (95% CI) |
|-------------------|------------------------|--------------------------|
| 2002-2006         | 1                      | 1                        |
| 2007-2011         | 1.0 (0.4-2.6)          | 0.9 (0.3-2.2)            |
| 2012-2016         | 0.5* (0.3-0.9)         | 0.4* (0.2-0.9)           |

**Place of residence**

| Residence | Univariate OR (95% CI) | Multivariate OR (95% CI) |
|-----------|------------------------|--------------------------|
| Urban     | 1                      | 1                        |
| Rural     | 1.6 (0.9-2.8)          | 1.2 (0.6-2.2)            |

**Educational level of mother**

| Level      | Univariate OR (95% CI) | Multivariate OR (95% CI) |
|------------|------------------------|--------------------------|
| No education | 1                      | 1                        |
| Primary    | 1.6 (0.8-3.1)          | 1.8 (0.9-3.6)            |
| Secondary  | 2.9** (1.4-6.0)        | 3.2* (1.5-6.7)           |
| Higher     | 2.3* (1.1-4.7)         | 2.4 (0.9-6.4)            |

**Wealth quintile**

| Quintile  | Univariate OR (95% CI) | Multivariate OR (95% CI) |
|-----------|------------------------|--------------------------|
| Poorest   | 1                      | 1                        |
| Poorer    | 0.5 (0.2-1.1)          | 0.5 (0.2-1.2)            |
| Middle    | 0.7 (0.3-1.5)          | 0.7 (0.3-1.5)            |
| Richer    | 1.4 (0.5-4.1)          | 1.2 (0.4-3.2)            |
| Richest   | 1.2 (0.4-3.6)          | 0.8 (0.2-2.6)            |

* p<0.05

Only those variables showing p value <0.1 in the bivariate model were included in the multivariate model.

**Discussion**

Our objective was to assess trend and inequalities in full immunization coverage of infants in Nepal using three recent DHS data. Our results show that full immunization coverage increased from an average of 83% during 2002-2006 to 88% during 2007-2011, then it decreased to 78% during 2012-2016, with the adjusted annual decrement of 22% (95% CI: 6%-36%). However, children born to the poorest households saw an increase in full
immunization coverage to 76.6% during 2012-2016 from 68% during 2002-2006, with inequity in full immunization coverage reducing over time in terms of rich: poor ratio, rich-poor difference and concentration indices and confirmed by Lorentz curve. The decrease in pro-rich inequalities from 2002 to 2016 was partly attributable to a substantial decrease in full immunization coverage among the children from the wealthier quintiles and a slight increase among children from the lowest income quintile. A significant declining trend in full immunization coverage in Nepal, albeit retention of equity gain among the children from households with poorest wealth quintile, puts Nepal's immunization program far behind GoN's target to fully immunize more than 90% of children by 2020(3). Nepal's experience of the significant simultaneous decline in overall full immunization coverage together with a decline in pro-rich inequity is similar to that experienced by the Central African Republic(8).

A similar study by KC et al. (7) used data from the Demographic and Health Surveys carried out in 2001, 2006, 2011 and MICS 2014 showing that the poorest wealth quintile with the most significant improvement in immunization coverage, from 58% in 2001 to 77.9% in 2014 while the wealthiest quintile showing a little improvement from 84.8% to 86.0%. The study also found improving slope index of inequality for children who received all vaccines improved from 0.070 (95% CI: 0.061–0.078) to 0.026 (95% CI: 0.013–0.039) and relative index of inequality from 1.13 to 1.0. The authors attributed the improvement in immunization coverage between 2001 and 2014, mainly to the interventions targeting the disadvantaged populations. Case studies from 10 of 75 countdown countries, also showed an increased coverage for interventions administered at lower levels of the health system including immunization, along with reduced equity gaps and improvements in associated health outcomes during the MDG era(17).

The steady improvement in full immunization coverage, as shown by NDHS 2006(11) and NDHS 2011 (12), and decreased equity gap, (by wealth, education and caste), can be attributed to the concentrated efforts of the GoN in collaboration with non-governmental organizations and local community, to focus on hard-to-reach and disadvantaged populations (18). However, full immunization coverage declined after the 2011 DHS survey mainly due to decline in DPT3 coverage. KC et al. reported similar findings where the decline in DPT3 and polio vaccine were the main contributor to the decrease in full immunization coverage(7). Phase-out of community health workers' position such as Village Health Workers might have affected immunization service utilization since direct communication through the household visit by health workers had a positive impact on immunization service utilization (15, 19). However, the decline in full vaccination coverage, mainly driven by the decline in DPT3 coverage is difficult to interpret. The decline may be due to health system factors such as changes in national immunization program and the introduction of new vaccines (PCV, IPV, MR, JE). Logistics and supply chain management issues after the introduction of new vaccines contributed to the decline in DPT3 coverage in South Africa in 2009(20). Other possible explanation could be due to mothers’ and their newborns’ temporary move to her mother’s house(21) around 10-14 weeks of childbirth and less familiarity with vaccination schedule, and place in the new place. Another reason may be people’s perception of not feeling the importance of three doses of vaccine after one or two doses of the same vaccine has already been received. It may also be associated with a reduced feeling of threat against polio(7) since DPT and polio are administered simultaneously at 6,10 and 14 weeks. However, this needs further investigation.

Further analysis of NDHS 2016 showed the main reason for the significant decline in full vaccination to be the decline in the percentage of children who received the third dose of DPT containing vaccine from 91.7% in 2011 to 85.9% in 2016(14). The drop out in the third dose of DPT is an increase from 5% (95% CI 3.1-7.6) in 2011 to
11% (95% CI 8.8-13.8) in 2016. However, the coverage of measles-containing vaccine, which is provided after the third dose of DPT, has increased from 88.0% in 2011 to 90.4% in 2016, suggesting a missed opportunity for vaccination of DPT3 at nine months. Also, vaccination card was retained by just over half of the mothers (52.3%) (13). Card retention was one of the factors associated with full immunization coverage, along with the place of delivery (14). In their analysis, geographic and urban/rural place of residence were not associated with differences in full immunization coverage. However, current analysis using recent three NDHS demonstrated the decreasing trend in full immunization coverage over last 15 years to be significant for children living in rural areas, Terai region and in province 2(Table 3). While an increase was observed among most disadvantaged Caste/ethnicity 'Dalits,' other relatively disadvantaged castes/ethnicity groups such as "Terai/Madhesi and Muslim/others" saw a decreasing trend. The more substantial decline in caste groups primarily residing in the Terai region requires further ethnographic exploration. In addition, the reason for the statistical difference in annual coverage among specific population groups may be partly due to a more substantial relative change in full vaccination coverage (increasing and then decreasing) between 2002 to 2016. It could also be due to health service or health belief related factors not included in DHS data.

We analyzed factors associated with a continuously decreasing trend in immunization coverage in province 2. Surprisingly, only maternal education was the independent predictor of full immunization coverage in province 2, and wealth quintile did not make any difference. Maternal education was found to be a strong predictor of immunization uptake in Nepal (7) and other settings (22).

The overall decline in full immunization coverage, coupled with a significant declining trend among the rich income quintiles has multiple implications. In one hand, as the coverage of full immunization starts to decline, the momentum of pro-poor equity gain may be reversed, and poor and disadvantaged groupswill be most likely to be missed out. On the other, a significant declining trend of full immunization coverage among rich income quintiles needs an urgent investigation and timely action. A study from Nepal has shown that improving the quality of the vaccination program maybe even more important than improving access to it (19). While improving access is essential to reach some sections of the populations, improving service quality is equally important.

**Strengths and Limitations**

We used nationally representative data from the DHS survey. Furthermore, we merged dataset from 3 recent DHS surveys conducted in 2006, 2011, and 2016, which increased the power of our regression analyses. We also used three inequality indicators, namely the ratio between Q5 and Q1, the rich-poor difference, and the concentration index for the analysis of equity gaps in full immunization coverage. However, the study has some limitations. Only six antigens administered during the infancy were considered for comparison of coverage over the years because some of the antigens recently introduced were not available during the period covered by earlier surveys conducted in 2006 and 2011.

Additionally, no supply-side factors were included in the models since DHS data lacks health service-related data. Variables related to socio-cultural practices, social norms, and beliefs regarding immunization were not available. Furthermore, we included income quintiles as a proxy measure of socioeconomic status. However, multiple aspects of poverty might reflect SES better than income quintiles. When vaccination cards were not
available, interviewers relied on mothers' reports to determine receipt of immunization. Therefore, misclassification could have arisen if mothers did not correctly recall the name and receipt of the vaccine.

**Conclusion**

This study, utilizing data from three demographic health surveys from Nepal, demonstrates a recent decreasing trend in full immunization coverage in infants, moving away from the national target, while equity gain among the poor is still preserved. Besides, province 2 saw a significant drop in coverage, with maternal education being the independent predictor. This implies a need to redirect the focus of the national immunization program towards an overall increase in immunization coverage in the country, with additional measures in Province 2, particularly among mothers with no or primary education. Effectively reaching all sections of the populations is critical to attaining the goal of universal coverage at a fast pace.

**Abbreviations**

| Abbreviation | Definition                      |
|--------------|---------------------------------|
| AOR          | Adjusted Odds Ratio             |
| BCG          | Bacille Calmette Guerin         |
| CI           | Confidence Interval             |
| DHS          | Demographic and Health Survey   |
| DPT          | Diphtheria, Pertussis and Tetanus|
| GoN          | Government of Nepal             |
| IPV          | Inactivated Polio Vaccine       |
| JE           | Japanese Encephalitis           |
| NIP          | National Immunization Program   |
Declarations

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Ethics approval and consent to participate

All round of DHS surveys in Nepal were approved by the Institutional Review Board of Nepal Health Research Council, Nepal; data were publicly available and did not include individual identities and thus did not require ethics approval.

Consent for publication

Not Applicable

Availability of data and materials

Data can be easily available through DHS program website (www.dhsprogram.com) upon the request.

Competing interests

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Authors’ contributions

Conceptualization (KA, YRP and DD), Data Analysis (KA), Methodology (KA and YRP), Supervision (KA, YRP and DD), Validation (KA, YRP and DD), Writing-original draft, review and editing (KA, YRP and DD), read and approved the final version of the manuscript (KA, YRP and DD)

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References

1. Ministry of Health Nepal. Annual Report, Department of Health Services 2073/2074 (2016/2017). Ministry of Health, Nepal; 2018.

2. Ashbaugh HR, Hoff NA, Doshi RH, Alfonso VH, Gadoth A, Mukadi P, et al. Predictors of measles vaccination coverage among children 6–59 months of age in the Democratic Republic of the Congo. Vaccine. 2018 2018/01/25/;36(4):587-93.

3. Ministry of Health Nepal. Nepal Health Sector Strategy 2015–2020: Ministry of Health, Nepal; 2015. Available from: http://nhsp.org.np/nepal-health-sector-strategy-2015-2020/.

4. Fenn B, Kirkwood BR, Popatia Z, Bradley DJ. Inequities in neonatal–survival interventions: evidence from national surveys. Archives of Disease in Childhood-Fetal and Neonatal Edition. 2007.
5. Sreeramareddy CT, Kumar HH, Sathian B. Time trends and inequalities of under-five mortality in Nepal: a secondary data analysis of four demographic and health surveys between 1996 and 2011. PloS one. 2013;8(11):e79818.

6. Nguyen K-H, Jimenez-Soto E, Morgan A, Morgan C, Hodge A. How does progress towards the MDG 4 affect inequalities between different subpopulations? Evidence from Nepal. J Epidemiol Community Health. 2013;67(4):311-9.

7. Kc A, Nelin V, Raaijmakers H, Kim HJ, Singh C, Målqvist M. Increased immunization coverage addresses the equity gap in Nepal. Bulletin of the World Health Organization. 2017;95(4):261-9.

8. Restrepo-Méndez MC, Barros AJ, Wong KL, Johnson HL, Pariyo G, França GV, et al. Inequalities in full immunization coverage: trends in low-and middle-income countries. Bulletin of the World Health Organization. 2016;94(11):794.

9. Arsenault C, Harper S, Nandi A, Rodríguez JMM, Hansen PM, Johri M. Monitoring equity in vaccination coverage: a systematic analysis of demographic and health surveys from 45 Gavi-supported countries. Vaccine. 2017;35(6):951-9.

10. World Health Organization's Expanded Programme on Immunization. Harmonizing vaccination coverage measures in household surveys: A primer2019 16 Aug 2019]: Available from: https://www.who.int/immunization/monitoring_surveillance/Surveys_White_Paper_immunization_2019.pdf.

11. Ministry of Health and Population (MoHP) Nepal, New ERA, and ICF International Inc. Nepal Demographic and Health Survey 2006. Kathmandu: Ministry of Health and Population2007.

12. Ministry of Health and Population (MoHP) Nepal, New ERA, and ICF International Inc. Nepal Demographic and Health Survey 2011. Kathmandu: Ministry of Health and Population2012.

13. Ministry of Health and Population (MoHP) Nepal, New ERA, and ICF International Inc. Nepal Demographic and Health Survey 2016. Kathmandu: Ministry of Health and Population2017.

14. Acharya K, Mona Lacoul, Bietsch K. Factors Affecting Vaccination Coverage and Retention of Vaccination Cards in Nepal.DHS Further Analysis Reports No. 121. Rockville, Maryland, USA 2019.

15. Maekawa M, Douangmala S, Sakisaka K, Takahashi K, Phathammavong O, Xeuatvongsa A, et al. Factors affecting routine immunization coverage among children aged 12-59 months in Lao PDR after regional polio eradication in western Pacific region. Biosci Trends. 2007;1(1):43-51.

16. Rutstein SO, Johnson K, MEASURE OM. The DHS wealth index: ORC Macro, MEASURE DHS; 2004.

17. Moucheraud C, Owen H, Singh NS, Ng CK, Requejo J, Lawn JE, et al. Countdown to 2015 country case studies: what have we learned about processes and progress towards MDGs 4 and 5? BMC public health. 2016;16(2):794.

18. Ministry of Health CHD. National Immunization Program: Reaching Every Child: Comprehensive Multi-year Plan 2017–2022. Kathmandu, Nepal 2016.

19. Acharya LB, Cleland J. Maternal and child health services in rural Nepal: does access or quality matter more? Health policy and planning. 2000;15(2):223-9.

20. Mthiyane TN. Factors associated with vaccination status in children under 5 years of age in two communities in South Africa 2016.

21. Hughes MM, Katz J, Englund JA, Khatry SK, Shrestha L, LeClerq SC, et al. Infant vaccination timing: Beyond traditional coverage metrics for maximizing impact of vaccine programs, an example from southern Nepal.
22. Moïsi JC, Kabuka J, Mitingi D, Levine OS, Scott JAG. Spatial and socio-demographic predictors of time-to-immunization in a rural area in Kenya: Is equity attainable? Vaccine. 2010;28(35):5725-30.

**Figures**

**Figure 1**

Inequalities in Full Immunization coverage

**Figure 2**

Lorentz curve showing income inequality in vaccination coverage over time