Original Article

Coverage and Determinants of Birth Dosage of Newborn Immunization in Rural Areas of Dehradun District, Uttarakhand, India: A Community-Based Cross-Sectional Study

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Abstract

Backgrounds: The Universal Immunization Program of India is one of the most cost-effective interventions in public health. Missing or delaying vaccination may elicit an uncertain immune response in the body, making the population susceptible to vaccine-preventable diseases. The objectives of this study were to determine the coverage of newborn immunization for birth doses under the National Immunization Schedule and its epidemiological determinants in the rural areas of the Dehradun district, Uttarakhand. **Materials and Methods:** A community-based cross-sectional study was conducted for a period of one year with a sample size of 570. World Health Organization (WHO) 30 Cluster sampling technique was used with 19 children in each cluster. The data on determinants were collected using a semi-structured, pre-designed schedule through a house-to-house survey. Multivariate analysis was conducted to identify factors associated with immunization coverage, taking the significance level as $P < 0.05$. **Results:** The coverage of the Bacillus Calmette–Guérin vaccine, oral polio vaccine zero dose and hepatitis B birth dose were 100%, 91.9%, and 58.8%, respectively in the study area with an overall prevalence of incomplete coverage of newborn immunization as 42.5%. The most cited reason for children being unimmunized with birth doses was the unavailability of vaccines at the birthplace center (29.6%). **Conclusions:** The prevalence of incomplete coverage of newborn immunization was quite high, which was undermining the holistic approach of the National Immunization Program. Vaccine availability and accessibility at the birthplace with capacity building and training of the healthcare workers may be considered to ensure coverage of birth doses.

Keywords: BCG, birth dose, birth dose vaccination, hepatitis B, immunization, India, polio, vaccines

Introduction

Immunization has been defined jointly by Pan American Health Organization (PAHO) and World Health Organization (WHO) as "Immunization is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine."[1] Being one of the most cost-effective interventions in public health, it quite effectively reduces the burden of disease among young children and prevents 4–5 million deaths globally.[2]

The Universal Immunization Program of India is one of the largest immunization programs in the world, targeting 2.6 crore newborns and 2.9 crore pregnant women for vaccination each year.[3] The immunization program covers the following vaccines: oral polio vaccine (OPV), Bacillus Calmette–Guérin (BCG), pentavalent (contains Diphtheria-Pertussis-Tetanus, hepatitis B, and Hemophilus influenza type B), measles, fractionated inactivated polio vaccine (f-IPV), tetanus-diphtheria (Td), and in endemic areas, Japanese encephalitis. Rotavirus, pneumococcal, and measles-rubella vaccines have also been introduced in selected high-burden areas.[4] The above-mentioned vaccines have a well-established efficacy for preventing certain serious childhood illnesses.

Although newborns get a varying degree of passive immunity from their mothers which may last up to six months of their

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life, still vaccinating infants against specific infectious diseases especially vaccine-preventable diseases (VPDs) at an age-appropriate enough to develop protective immunity remains essential.[5]

As we move closer to polio eradication, it remains important to ensure the protection of the newborn through immunization as early as possible. Thus, it becomes necessary to administer a birth dose of OPV (known as zero doses because it is not counted in the primary series) in all polio-endemic countries and countries at high risk for importation and subsequent spread.[6] According to research, OPV given at birth or as early as possible after birth can significantly enhance the seroconversion rates of the next doses and provide mucosal protection before enteric pathogens can interfere with the immune response.[7]

A single dose of the BCG vaccine should be given to all healthy neonates at birth for the prevention of severe forms of TB and leprosy in countries with a high incidence of TB and leprosy.[8]

Perinatal transmission of hepatitis B infection is the most important source of chronic infection globally, which can be prevented by the administration of one dose of the hepatitis B vaccine within 24 hours of birth (birth dose). A delay in the birth dose results in an increased risk of hepatitis B infection.[9]

India has seen a rising trend in institutional deliveries from 39% in 2005–2006 to 79% in 2015–2016 and 89% in 2019–2021.[10,11] Looking at this trend, one can easily catch the opportunity to vaccinate neonates at birth during institutional deliveries thus reducing child morbidity and mortality and enhancing the vaccination coverage rate.[12]

Reports from WHO and United Nations Children's Fund (UNICEF) on immunization coverage have noted that India has achieved 73% coverage of the birth dose of the hepatitis B vaccine and 84% coverage of the BCG vaccine at the national level.[13] No such data are available for OPV birth dose at the national level. The above-mentioned data show that incomplete coverage of newborn immunization for birth doses is quite high. In developing countries like India, the timeliness of birth-dose vaccination remains a remarkable problem.[14] Missing or delaying vaccination may elicit an uncertain immune response in the body, making the population susceptible to VPDs and providing difficulties in planning and monitoring immunization programs. All these challenges provide hindrances in preventing diseases.

Uttarakhand is a state where overall immunization coverage has been reported as 88.6%;[15] however, very little is known about the current coverage status of newborn immunization with birth doses of the three vaccines in the study area. Therefore, this study aims to fill this knowledge gap with the objective to determine the coverage of newborn immunization for birth doses under the National Immunization Schedule and its epidemiological determinants in the rural areas of the Dehradun district, Uttarakhand.

Materials and Methods

The present study, a part of a larger project titled "Prevalence of incomplete immunization and its epidemiological determinants among children aged 12-23 months: A cross-sectional study in the rural areas of Block Doiwala, Dehradun," was a community-based cross-sectional study conducted for a period of one year from August 2021 to August 2022. The Institutional Ethical Committee (IEC) approval was taken before conducting the study. Informed written consent was also taken from the respondents.

With an anticipated incomplete immunization among 12–23 months of 41.9%[16] (as per National Family and Health Survey-4) and 6% absolute precision at 95% confidence, an effective sample size of 260 was required. With a design effect of two and an additional 5% attrition, the total sample size of 546 was obtained, which was further enhanced to 570 for a cluster of 30.

Children in the age group of 12–23 months and residing in the rural areas of Doiwala block of Dehradun district since birth were included in the study.

WHO 30 Cluster sampling technique with 19 children in each cluster was used and conducted in two stages to select the representative population. In the first stage, a list was prepared which consisted of 75 villages of Block Doiwala with respective populations taken from "The Census of India 2011,"[17] and then, 30 Clusters were randomly selected according to the cluster sampling technique. In the second stage, 19 children from each of the selected clusters were randomly selected. If in one cluster all 19 children could not be found then the contiguous cluster was taken to complete the count.

For the house-to-house survey, a quantitative semi-structured, pre-designed, pre-tested interview schedule was used to record information taking the key elements of socioeconomic status, age of mother, type of place of delivery, birth order, and information regarding the immunization. Reasons for not being vaccinated as well as for delayed vaccination were also collected.

The primary respondents were interviewed for which the first preference was given to the mother followed by the father or any adult in the household who remained with the child for most of the time or at least for the first year of the child's life. The mother and child protection card or immunization card was also checked to verify the immunization status.

The collected data were entered in Microsoft Excel 2019 and analyzed using SPSS Inc. Version 18.0 (SPSS Inc, Chicago, USA). The sociodemographic details and birth dose coverage details for each vaccine were estimated using percentages for qualitative data and mean with standard deviation for quantitative data. Multivariate analysis was conducted to identify factors associated with immunization coverage, taking the significance level as $P < 0.05$.

Operational definition

1. Unimmunized for birth doses—Those children who have never been vaccinated for any of the vaccines, that is, the BCG and birth doses of OPV (zero dose) and hepatitis B.
2. Delayed immunization—Those who were vaccinated beyond the stipulated age limits of any of the vaccines viz. BCG (after one year) and birth doses of OPV (after 15 days) and hepatitis B (after 24 hours).[18]

Result

A total of 570 children were included in the study. The study revealed that coverage of BCG was 100%, OPV birth dose was 91.9%, and hepatitis B birth dose was 58.8%. Overall newborn immunization coverage with birth doses was 57.5%. Most of the study participants were male (52.5%) and were born at a private healthcare facility (56.8%). The sociodemographic details with proportions are shown in Table 1.

Figure 1 shows that a total of 159 children were not vaccinated for birth doses of any of the three vaccines. Among 159, 2 participants and 121 participants did not receive a birth dose of OPV and hepatitis B, respectively while 36 were such who were not vaccinated for both. It also highlighted 83 such children who received birth doses after the recommended upper age limits of vaccines.

Tables 2 and 3 depict the reasons for children being unvaccinated and delayed vaccinated for birth doses. The study participants' place of birth, birth weight, birth order, and mode of delivery were found to be significantly associated with the immunization status of newborns for the birth doses ($P < 0.05$) as shown in Table 4.

Discussion

Being unimmunized or immunized beyond the specified upper age limit as per the National Immunization Schedule is one of the major hindrances to getting the actual benefits of the immunization program to children, which ultimately compromises the holistic vision of the program. Addressing

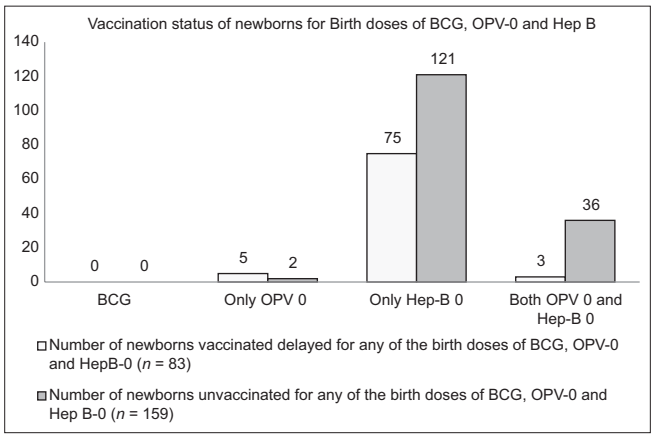

Figure 1: Vaccination status of newborns for Birth doses of BCG, OPV-0 and Hep B

Table 1: Sociodemographic characteristics of the study participants (*n*=570)

Characteristics	*n*	%
Primary respondent		
Mother	460	80.7
Father	84	14.7
Others	26	4.6
Religion		
Hindu	456	80.0
Muslim	87	15.3
Others	27	4.7
Category		
General	254	44.6
OBC	204	35.8
SC	90	15.8
ST	22	3.9
Socioeconomic status*		
Upper class	35	6.1
Upper-middle class	82	14.4
Middle class	107	18.8
Lower-middle class	165	28.9
Lower class	181	31.8
Family type		
Nuclear	198	34.7
Joint	372	65.3
Education of the mother		
Illiterate	46	8.1
Up to primary	100	17.5
Up to senior secondary	202	35.4
Graduate and above	222	38.9
Occupation of the mother**		
Housewife	521	91.4
Unskilled	10	1.8
Semiskilled	39	6.8
Education of the father		
Illiterate	33	5.8
Up to primary	114	20.0
Up to senior secondary	243	42.6
Graduate and above	180	31.6
Occupation of the father**		
Unemployed	13	2.3
Unskilled	159	27.9
Semiskilled	398	69.8
Gender of the baby		
Male	299	52.5
Female	271	47.5
Birth order		
1st	240	42.1
2nd	249	43.7
3rd	58	10.2
4th	23	4
Place of delivery		
Government facility	227	39.8
Private facility	323	56.7
Home delivery	20	3.5

*Modified B. G. Prasad Socio-economic Scale 2021 was used. ** None was present in the skilled category of occupation of both mother and father

Table 2: Reasons for unimmunized newborns for BCG, OPV-0, and hepatitis B-0 (*n*=159)*

Reasons for being unvaccinated for birth doses	Frequency	%
The vaccine was not available at the delivery center	47	29.6
The baby was admitted to NICU (for varying reasons)	27	17
The primary informant did not know whether any vaccine was missed at birth, as per his/her knowledge all vaccines have been administered	26	16.4
The baby was delivered at home	18	11.3
The primary informant neither knew birth doses nor did anyone tell about the same before/at the time/after birth	18	11.3
The baby was of low birth weight	13	8.2
The baby was born prematurely	5	3.1
The baby was having neonatal jaundice	4	2.5
The baby was having respiratory distress at birth	4	2.5
Parents refused to get their babies vaccinated at the delivery center and assured to get them vaccinated at the nearby subcenter	2	1.3
The baby was having a Fever	2	1.3
The mother was COVID positive	2	1.3
It was not a vaccination day at the delivery center when the baby was born	2	1.3
The baby was having meconium aspiration syndrome	2	1.3
The baby was having an aphthous ulcer in the oral cavity since birth	2	1.3
The baby was having hypoglycemia	2	1.3
The baby was an adopted one	2	1.3
The baby was having a birth defect	1	0.6

*Multiple responses

Table 3: Reasons for delayed newborn immunization for BCG, OPV-0, and hepatitis B-0 (*n*=83)*

Reasons for delayed vaccination for birth doses	Frequency	%
Not a vaccination day at the delivery center	28	33.7
The primary informant neither knew birth doses nor did anyone tell about the same before/at the time/after birth	18	21.7
The baby was admitted to NICU (for different reasons)	13	15.7
The vaccination vial available at the delivery center was multidose and the center did not have enough number beneficiaries to vaccinate on that day	5	6
The baby was suffering from neonatal jaundice	5	6
The baby was having low birth weight	4	4.8
The baby was sick (unspecified reasons)	4	4.8
The vaccine was not available at the delivery center	4	4.8
The baby was premature	2	2.4
Mother was sick (blood infection-septicemia)	2	2.4
Parents refused to get their babies vaccinated at the delivery center and vaccinated them at the nearby subcenter	2	2.4

*Multiple responses

the same issue, the present study was conducted to find out the coverage of newborn immunization. There was a paucity of studies on the concerned topic, which in turn increased the importance of this study.

A total of 570 study participants were included in this study. Most of the study participants were male (52.5%) and of second birth order (43.7%). Similar findings were noted in a study conducted by Verma RK *et al*. and Ibraheem R *et al*.[12,19] Studies conducted byMiyahara R *et al*., Bansod VP *et al*., and Hughes MM *et al*. noted that the majority of the children were male (52%, 54.3%, and 53% respectively).[20-22] Contrary to our finding, the study by Joy TM *et al*. evaluated vaccination coverage in urban areas of Kochi in Kerala where most children were female (51.9%) and of first birth order (48%).[23] This finding well explains the sex ratio at birth in the present study area (848 females per 1,000 males) and that of Kerala (968 females per 1,000 males),[24] and the acceptance of family planning in both study areas (57.8% in Uttarakhand and 52.8% in Kerala).[25,26]

In the present study, it was noted that most children were born at a private medical facility (56.7%) and the least were delivered at home (3.5%). Noh JW *et al*. conducted a study in the Sindh Province of Pakistan and noted that most of the children were born at a private healthcare facility (61.9%) but the least were delivered at a government healthcare facility (17.3%).[27] This can be due to the huge gap in the socioeconomic strata in Pakistan compared with India as well as a poor government health facility which on the contrary is very developed in India providing quality services.

Our study noted the coverage of the immunization of newborns to be 57.5%, which was quite low when compared with the

Table 4: Factors associated with newborn vaccination coverage (*n*=570)

Variables	Vaccinated for birth doses *n* (%)	Unvaccinated/delayed vaccination for birth doses *n* (%)	Total *n* (%)	Chi-square (dF)	*P*
Place of birth					
Government facility	172 (75.8)	55 (24.2)	227 (100)	56.942 (2)	<0.001
Private facility	152 (47.1)	171 (52.9)	323 (100)		
Home delivery	04 (20)	16 (80)	20 (100)		
Birth weight*					
Less than or equal to the mean birth weight	145 (49.8)	146 (50.2)	291 (100)	14.487 (1)	<0.001
More than the mean birth weight	183 (65.6)	96 (34.4)	279 (100)		
Birth order**					
≤2	324 (58.9)	226 (41.1)	550 (100)	11.959	0.001
>2	04 (20)	16 (80)	20 (100)	(1)	
Mode of delivery					
Normal vaginal delivery	280 (65.3)	149 (34.7)	429 (100)	42.353 (1)	<0.001
LSCS	48 (34)	93 (66)	141 (100)		
Socio-economic status***					
Upper	76 (65)	41 (35)	117 (100)	4.012 (2)	0.135
Middle	147 (54)	125 (46)	272 (100)		
Lower	105 (58)	76 (42)	181 (100)		
Mother's education					
Illiterate	24 (52.2)	22 (47.8)	46 (100)	1.488 (3)	0.685
Primary	57 (57)	43 (43)	100 (100)		
Secondary	113 (55.9)	89 (44.1)	202 (100)		
Graduate and above	134 (60.4)	88 (39.6)	222 (100)		
Mother's occupation					
None	296 (56.8)	225 (43.2)	521 (100)	2.432 (2)	0.296
Unskilled	08 (80)	02 (20)	10 (100)		
Semiskilled	24 (61.5)	15 (38.5)	39 (100)		
Father's education					
Illiterate	17 (51.5)	16 (48.5)	33 (100)	3.174 (3)	0.366
Primary	64 (56.1)	50 (43.9)	114 (100)		
Secondary	134 (55.1)	109 (44.9)	243 (100)		
Graduate and above	113 (62.8)	67 (37.2)	180 (100)		
Father's occupation					
None	09 (69.2)	04 (30.8)	13 (100)	1.338 (2)	0.512
Unskilled	87 (54.7)	72 (45.3)	159 (100)		
Semiskilled	232 (58.3)	166 (41.7)	398 (100)		
Distance from the vaccination center					
≤500 m	125 (58.4)	89 (41.6)	214 (100)	1.507 (2)	0.471
500 m–5 km	201 (57.4)	149 (42.6)	350 (100)		
>5 km	04 (66.7)	02 (33.3)	6 (100)		

*Birth weight was categorized into two groups based on the mean birth weight of 2.89 kg. **Birth order has been merged and categorized into two groups. ***For analysis purposes upper and upper-middle classes have been grouped to make the "upper" category and lower-middle and upper-lower into the "middle" category

findings of the study conducted byVerma RK *et al*. (71.1%) and Bassoum O *et al*. (69.46%).[12,28] This study also tried to find out the reasons for the non-immunization or delayed immunization of newborns from the primary informants. This difference can also be attributed to the geography of the study area, which is mostly hilly and has hard-to-reach pockets due to poor connectivity through transport. The place of birth, birth weight, birth order, and mode of delivery of the children were significantly associated with the coverage of the newborn immunization for BCG, OPV-0, and Hep B-0. Verma RK *et al*.[12] found the mode of delivery and birth order to be associated significantly with immunization status for birth doses whereas Ibraheem RM *et al*.[14] found birth order, as well as the place of delivery, and Ibraheem R *et al*.,[19] the only place of birth to be significantly associated with immunization status with the birth doses.

The present study also tried to determine the barriers to newborn immunization. It was found that the most cited reason for a child being unvaccinated was the unavailability

of a vaccine at the delivery center, followed by the baby being sick and admitted to the neonatal intensive care unit (NICU). Most of the babies were born at a private healthcare facility where one could expect better care at a higher consumer price which was unacceptable, and so with the government facilities. This could be attributed to the administrative failure as well as the lack of training and skill development of staff posted in the labor room, obstetrics and gynecology, and pediatric ward. Those babies who were admitted to NICU due to sickness (for varying reasons) were not vaccinated and discharged could be due to a lack of supervision and incoordination between the staff of the NICU and the immunization center. The primary informant's confusion about any birth dose being missed showed a lack of awareness in the community about the same. Another main issue with the barrier to newborn immunization was the fixed day of immunization at the delivery center. If a center had a good workload in terms of delivery, then it should make sure the availability of the birth doses.

Conclusion

The coverage of newborn immunization was quite low, undermining the holistic approach of the National Immunization Program and its vision of controlling as well as eliminating VPDs. It is time to address issues existing in the local policies regarding newborn immunization and take steps to improve newborn immunization coverage in healthcare facilities as few VPDs are on the brink of elimination in the near future. This is to be ensured that vaccines are available and accessible at birthplaces. Attention should be given to capacity building and conducting regular training of healthcare workers posted in delivery rooms and NICU for newborn vaccination, with effective supervision and monitoring of the same. The community-level workers can also be utilized to ensure proper coverage of newborn immunization in terms of incorporating birth doses of OPV and hepatitis B in the module of Home-Based Newborn Care along with the other pre-existing vaccine checklist at no extra added cost. Further research needs to be conducted to find out in detail about the sociocultural barriers and different operational issues at the institutional level.

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Conflicts of interest

There are no conflicts of interest.

References

1. Pan American Health Organization. Immunization. Available from: https://www.paho.org/en/topics/immunization. [Last accessed on 2022 May 10].
2. World Health Organization. Immunization. Available from: http://www.who.int/news-room/facts-in-pictures/detail/immunization. [Last accessed on 2022 May 10].
3. National Health Mission Department of Health & Family Welfare, Ministry of Health & Family Welfare, Government of India. Immunization. Available from: https://www.nhm.gov.in/index1.php?lang=1&level=2&sublinkid=824&lid=220. [Last accessed on 2022 May 10].
4. Summan A, Nandi A, Deo S, Laxminarayan R. Improving vaccination coverage and timeliness through periodic intensification of routine immunization: Evidence from Mission Indradhanush. Ann N Y Acad Sci 2021;1502:110-20.
5. Taneja G, Mentey VK, Jain M, Sagar KS, Tripathi B, Favin M, *et al*. Institutionalizing early vaccination of newborns delivered at government health facilities: Experiences from India. Int J Med Res Rev 2015;3:521-7.
6. WHO Publication. Polio vaccines and polio immunization in the pre-eradication era: WHO position paper--recommendations. Vaccine 2010;28:6943-4.
7. Bhaskaram P, Nair KM, Hemalatha P, Murthy N, Nair P. Systemic and mucosal immune response to polio vaccination with additional dose in newborn period. J Trop Pediatr 1997;43:232-4.
8. World Health Organization. BCG vaccine: WHO position paper, February 2018 - Recommendations. Vaccine 2018;36:3408-10.
9. World Health Organization. Hepatitis B vaccines: WHO position paper, July 2017 - Recommendations. Vaccine 2019;37:223-5.
10. India Fact Sheet: National Family Health Survey – 4. International Institute for Population Sciences; 2018. Available from: http://rchiips.org/nfhs/pdf/NFHS4/India.pdf. [Last accessed on 2022 May 14].
11. India Fact Sheet: National Family Health Survey - 5. International Institute for Population Sciences; 2022 Available from: http://rchiips.org/nfhs/NFHS-5_FCTS/India.pdf. [Last accessed on 2022 May 14].
12. Verma RK, Kadyan A. Barriers of newborn vaccination coverage among institutional deliveries: A mixedmethod study from Sonepat, Haryana. J Clin Diagn Res 2022;16:LC01-05.
13. India: WHO and UNICEF estimates of immunization coverage: 2021 revision, 2022 Jul 8:03-13. Available from: https://data.unicef.org/wp-content/uploads/country_profiles/India/Immunization-coverage-country-profiles-2019rev/Immunization-coverage-estimates-2019_ind.pdf. [Last accessed on 2022 Nov 10].
14. Ibraheem RM, Garba BI, Aliu R, Ibrahim OR, Bello AO, Mohammed SS, *et al*. Assessment of the timely administration of birth dose vaccines in northern Nigeria and associated factors. Ann Glob Health 2022;88:60. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9336735/. [Last accessed on 10 Nov 2022].
15. District Fact Sheet- Dehradun, Uttarakhand: National Family Health Survey-5. International Institute for Population Sciences; 2022. Available from: http://rchiips.org/nfhs/factsheet_nfhs-5.shtml. [Last accessed on 2022 May 14].
16. National Family Health Survey-4 State Fact Sheet- Uttarakhand. Mumbai. International Institute for Population Sciences; 2018. Available from: http://rchiips.org/nfhs/pdf/NFHS4/UT_FactSheet.pdf. [Last accessed on 2022 May 10].
17. Census of India 2011. Uttarakhand - Series 06 - Part XII A - District Census Handbook, Dehradun. Uttarakhand: Directorate of Census operations Uttarakhand; 2014. Available from: https://censusindia.gov.in/nada/index.php/catalog/1310/download/4254/DH_2011_0505_PART_A_DCHB_DEHRADUN.pdf. [Last accessed on 2022 Sep 4].
18. National Immunization Schedule (NIS) for Infants, Children and Pregnant Women. Ministry of Health and Family Welfare. Available from: https://main.mohfw.gov.in/sites/default/files/24545352106148966387 3.pdf. [Last accessed on 2022 May 10].
19. Ibraheem R, Abdulkadir M, Akintola M, Adeboye M. Determinants of timely presentation for birth dose vaccination at an immunization centre in north-central Nigeria. Ann Glob Health 2019;85:20. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7052312/. [Last accessed on 10 Nov 2022].
20. Miyahara R, Jasseh M, Gomez P, Shimakawa Y, Greenwood B, Keita K, *et al*. Barriers to timely administration of birth dose vaccines in The Gambia, West Africa. Vaccine 2016;34:3335-41. Available from: https://www.sciencedirect.com/science/article/pii/S0264410X16303000. [Last accessed on 10 Nov 2022].
21. Bansod VP, Nannaware MN, Kulkarni SS, Gore HD, Agawane SU, Chawla PS *et al*. A hospital-based cross-sectional study for assessment of immunization status of children in western Maharashtra, India. MGM J Med Sci 2021;8:390-7.
22. 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. Vaccine 2016;34:933-41. Available from: https://www.sciencedirect.com/science/article/pii/S0264410X15018721. [Last accessed on 10 Nov 2022].
23. Joy TM, George S, Paul N, Renjini BA, Rakesh PS, Sreedevi A. Assessment of vaccine coverage and associated factors among children in urban agglomerations of Kochi, Kerala, India. J Family Med Prim Care 2019;8:91-6.
24. Sex ratio at birth (2022) Press Information Bureau. Ministry of Women and Child Development. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=1806605. [Last accessed on 2022 Dec 9].
25. National Family Health Survey-5 State Fact Sheet- Uttarakhand. Mumbai. International Institute for Population Sciences; 2022. Available from: http://rchiips.org/nfhs/NFHS-5_FCTS/COMPENDIUM/Uttarakhand.pdf. [Last accessed on 2022 Nov 14].
26. National Family Health Survey-5 State Fact Sheet- Kerala. Mumbai. International Institute for Population Sciences; 2022. Available from: http://rchiips.org/nfhs/NFHS-5_FCTS/Kerala.pdf. [Last accessed on 2022 Nov 14].
27. Noh JW, Kim YM, Akram N, Yoo KB, Cheon J, Lee LJ, *et al*. Determinants of timeliness in early childhood vaccination among mothers with vaccination cards in Sindh province, Pakistan: A secondary analysis of cross-sectional survey data. BMJ Open 2019;9:e028922. Available from: https://bmjopen.bmj.com/content/bmjopen/9/9/e028922.full.pdf. [Last accessed on 14 Nov 2022].
28. Bassoum O, Kimura M, Tal Dia A, Lemoine M, Shimakawa Y. Coverage and timeliness of birth dose vaccination in Sub-Saharan Africa: A systematic review and meta-analysis. Vaccines (Basel) 2020;8:301. Available from: https://www.mdpi.com/2076-393X/8/2/301. [Last accessed on 14 Nov 2022].