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Effect of Four or More Antenatal Care Visits on Basic Childhood Immunisation in India: A Propensity Score Matching Analysis

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Abstract

This paper analyses the relationship between antenatal care visits by women during the pregnancy and child immunisation in India using propensity score matching. Propensity scores were estimated using a logit regression model. Validity of the matching procedure was assessed by examining common support assumption, and sensitivity analysis was conducted to evaluate the robustness of the effect of at least 4 ANC visits on childhood immunisation to potential hidden bias. Based on the data from the fifth round of the National Family Health Survey (2019-2021), the analysis reveals that at least 4 antenatal care (ANC) visits during the pregnancy by women significantly increases the likelihood of complete childhood immunisation of their children which means that at least four ANC visits during pregnancy may serve as a critical platform for achieving universal child immunisation and may contribute to better child health outcomes in India.

Introduction

Childhood immunisation is one of the most effective public health interventions for improving child survival and preventing morbidity and mortality from vaccine-preventable diseases, thereby contributing to increased life expectancy at birth (Andre et al, 2008; Ozawa et al, 2016). In India, under-five mortality rate has declined substantially from around 126 under-five deaths for every 1000 live births in 1990 to approximately 31 under-five deaths for every 1000 live births in 2022, reflecting considerable improvements in maternal and child health services, including vaccination programmes (United Nations Agency Group for Child Mortality Estimation, 2023). Globally, child immunisation is estimated to prevent approximately 3.5–5.0 million child deaths every year by protecting them against vaccine-preventable infectious diseases (World Health Organization, 2024). Although the Universal Immunisation Programme (UIP) of India, launched in 1985, has substantially expanded the vaccine coverage among children of the country, yet the evidence from the latest round of the National Family Health Survey, 2023-2024 suggests that less than 83.6 per cent children aged 12–23 months of the country were fully immunised or received all the basic vaccinations (Government of India, 2026). This indicates that despite the progress, important gaps in universal immunisation of children continue to persist.

A range of individual, household, community, and health system factors influences the uptake of childhood immunisation. Earlier studies have shown that parental knowledge and attitudes, socioeconomic status, access to healthcare services, exposure to health information, and quality of communication between healthcare providers and caregivers influence childhood vaccination uptake (Mathew, 2012). In India, children born to older women, women with higher level of education and from wealthier households in the urban areas are more likely to be fully immunised than their counterparts (Rammohan and Awofeso, 2015; World Health Organization, 2018).

Maternal healthcare utilisation, particularly antenatal care (ANC), represents an important opportunity to improve childhood immunisation. ANC provides repeated contacts between the pregnant woman and the healthcare provider, facilitating health education, counselling, and linkage to essential maternal and child health services. These interactions can improve knowledge of the woman about childhood vaccination, address misconceptions, and strengthen confidence in healthcare services, thereby increasing the likelihood of timely and complete childhood immunisation, particularly in low- and middle-income countries such as India (Kumar et al, 2019).

The World Health Organization (WHO) had earlier recommended a minimum of 4 ANC visits during pregnancy, with the first visit in the first trimester. In 2016, this recommendation was revised to a minimum of eight contacts to improve maternal and perinatal outcomes. However, at least 4 ANC visits remain an important benchmark for evaluating ANC utilisation (UNICEF, 2024). Globally, approximately 70 per cent pregnant women receive at least 4 ANC visits, although substantial regional disparities remain (UNICEF, 2024). In India, NFHS, 2023–24 reported that approximately 65 per cent of women attended at least 4 ANC visits during the most recent pregnancy, while nearly 76 per cent had the first visit during the first trimester (Government of India, 2026; Girotra et al, 2023). However, ANC visits vary considerably across socioeconomic and demographic groups and are influenced by factors such as maternal education, household wealth, caste, religion, residence, parity, and exposure to mass media (Dhawan et al, 2020; Singh et al, 2019).

There are many studies that have reported a positive association between maternal healthcare utilisation and childhood immunisation in India and in other countries (Anichukwu and Asamoah, 2019; Faradita et al, 2022; Gebrehana et al, 2025; Phaway et al, 2022; Usman et al, 2020). These studies have, in general, examined the combined effect of the continuum of maternal healthcare services – antenatal care, institutional delivery, and postnatal care – on childhood immunisation rather than independent contribution of adequate ANC services utilisation on childhood immunisation. For example, Usman et al (2020) have examined the combined effect of the continuum of maternal health care services on childhood immunisation in India using the data available from the fourth round of the National Family Health Survey (NFHS-4) which refers to the period 2015–16. The study, however, tells little about the independent effect of at least 4 ANC visits during pregnancy on the immunisation status of children.

The present paper is directed towards analysing the impact of at least 4 ANC visits by women during pregnancy on the immunisation status of children in India based on the data available from the fifth round of the National Family Health Survey (NFHS-5) which was carried out during 2019-2021 (Government of India, 2022). The sixth round of the National Family Health Survey (NFHS-6) has also been carried out during 2023-2024 (Government of

India, 2026) but microdata from NFHS-6 are not yet available to analyse the relationship between ANC visits and childhood immunisation in the contemporary context. The present study estimates the independent effect of at least 4 ANC visits on immunisation coverage in children in India based on the data from NFHS-5. The propensity score matching (PSM) technique has been used for estimating the effect of at least 4 ANC visits during pregnancy on child immunisation after controlling a host of variables related to the demographic and maternal characteristics of women. PSM provides a more robust estimate of the association between at least 4 ANC visits and child immunisation than estimate based on conventional regression analysis. The analysis provides updated evidence about the contribution of ANC visits to childhood immunisation. NFHS-6 suggests that 65.2 per cent women in India had at least 4 ANC visits during their last pregnancy while 87.1 per cent children aged 12-23 months were fully immunised (Government of India, 2026). The paper suggests that ensuring at least 4 ANC visits during pregnancy may contribute to the realisation of universal child immunisation as ANC visits may be the entry point for improving immunisation coverage and advancing maternal and child health outcomes.

Materials and Methods

The present study utilises data from the fifth round of the National Family Health Survey (NFHS-5) which was carried out during 2019-21. NFHS-5 was spread across the entire country and covered 664972 households, 747176 women aged 15–49 years, and 232920 births during the five years preceding the survey (Government of India, 2021). The sample of households for the survey was selected through a two-stage stratified sampling design with probability proportional to size. The survey provides nationally representative information on selected demographic and health indicators including fertility, maternal and child health, immunisation, nutrition, and reproductive behaviour (Government of India, 2021). The present analysis is based on the Kids Recode files (KR) which is available in the public domain.

The outcome variable for the present study is the immunisation status of children aged 12–23 months. This is a binary variable which has value 1 if the child is fully immunised or the child has received all basic vaccinations and value 0 if the child is not fully immunised. Information on the vaccination status of the child was collected from women who had delivered a live birth during the five years preceding the survey. Women were asked to produce the child vaccination card, if available, from which details regarding the date of vaccination, dose, and type of vaccine administered were extracted. In cases where the vaccination card was either unavailable or incomplete, maternal recall was used to obtain information about the vaccination history of the child.

WHO defines basic vaccination as the administration of one dose of Bacillus Calmette–Guérin (BCG), three doses each of pneumococcal conjugate vaccine (PCV), pentavalent vaccine, and oral polio vaccine (OPV), two doses of rotavirus vaccine, and one dose of measles vaccine. Vaccination information obtained from either maternal recall or from vaccination card was recoded into binary indicators, with 0 denoting children who did not receive the recommended vaccines and doses and were termed as not fully immunised and 1 for those who received the recommended doses and were termed as fully immunised (WHO, 2017; WHO, 2021). The proportion of children fully immunised was estimated

separately for women who had at least 4 ANC visits during the last pregnancy and for women who had less than 4 ANC visits during the last pregnancy to examine the effect of at least 4 ANC visits on childhood immunisation. Since the background characteristics of women having at least 4 ANC visits may be different from those of women having less than 4 ANC visits, this difference may be a contributing factor to the observed difference between the proportion of children fully immunised in women having at least 4 ANC visits and the proportion of fully immunised children in women having less than 4 ANC visits. To exclude this effect, women having 4 ANC visits were matched with women having less than 4 ANC visits based on a set of background characteristics of women using the propensity score matching (PSM) technique (WHO, 2017; 2021). The set of background characteristics of women for propensity score matching was decided based on the evidence from existing literature (Kinfe et al, 2019; Krishnamoorthy and Rehman, 2022; Gebrehana et al, 2025; Caliendo and Kopeinig, 2008; Girotra et al, 2023; Usman et al, 2021; Basha, 2019; Shrivastwa et al, 2015).

The PSM is a statistical method which creates an artificial group of women by pairing women having at least 4 ANC visits with women having less than 4 ANC visits based on a set of background characteristics (Caliendo and Kopeinig, 2008; Li, 2013). The difference between the proportion of children fully immunised among children of matched women having at least 4 ANC visits and matched women having less than 4 ANC visits during the last pregnancy provides a more robust estimate of the effect of at least 4 ANC visits during the last pregnancy on childhood immunisation.

The propensity scores in the present analysis were estimated using a binary logistic regression model. The propensity score represents the conditional probability of a woman having at least 4 ANC visits given the observed covariates relative to a woman having less than 4 ANC visits (Caliendo and Kopeinig, 2008; Li, 2013). It relies on two fundamental assumptions: i) conditional independence (unconfoundedness) and ii) common support (overlap). The conditional independence assumes that, after adjusting for observed covariates, treatment assignment is independent of the potential outcomes, while common support assumption requires sufficient overlap in the propensity score distribution of the treatment and comparison groups to ensure that comparable matches can be identified (Caliendo and Kopeinig, 2008). Multiple iterations of propensity score estimation were performed until satisfactory covariate balance was achieved.

Matching procedure

The one-to-one nearest neighbour without replacement method was used to match women having at least 4 ANC visits and women having less than 4 ANC visits. To reduce the likelihood of poor match, a calliper width of 0.023 (0.2 times the standard deviation of the logit of the propensity score) was applied (Caliendo and Kopeinig, 2008; Li, 2013). The quality of matching was assessed by comparing the distribution of covariates between women having at least 4 ANC visits and women having less than 4 ANC visits before and after matching using standardised bias, two-sample t-test, pseudo-R^2, and likelihood ratio (LR) tests. A standardised bias of less than ± 10 per cent was considered indicative of adequate covariate balance (Austin, 2009; Ali et al, 2015). The two-sample t-test was used to compare the difference in each covariate between the two groups of women. Finally, a pseudo-R^2 value less than 0.05 after matching indicated the absence of systematic differences in observed covariates between the matched women having at least 4 ANC visits

and women having less than 4 ANC visits (Sekine et al, 2021). Moreover, sensitivity analysis was carried out using Mantel–Haenszel (MH) bounds approach to assess the potential influence of hidden bias arising from unmeasured confounding effects (Becker and Caliendo, 2007; Rosenbaum, 2002). The sensitivity parameter, Γ (Gamma), represents the maximum degree to which two matched women with the same observed covariates may differ in terms of the odds of having at least 4 ANC visits relative to women having less than 4 ANC visits because of an unmeasured confounder. $\Gamma=1$ indicates no hidden bias and the higher the Γ the higher the potential hidden bias (Rosenbaum, 2002; Becker and Caliendo, 2007). In this study, Γ was varied from 1.00 to 2.00 in increments of 0.05. For each value of Γ, MH bounds provide two scenarios – Q_{mh+} and Q_{mh-}. Q_{mh+} and its corresponding p-value represent the bound under the assumption that hidden bias may result in overestimation of the effect of at least 4 ANC visits on childhood immunisation, while Q_{mh-} and its corresponding p-value represent the bound under the assumption of underestimation of the effect (Becker and Caliendo, 2007). A p-value<0.05 was considered statistically significant. The sensitivity of the estimated effect of having at least 4 ANC visits was assessed by examining the value of Γ when statistical significance was no longer observed under the adverse bound.

Limitation of PSM

One limitation of PSM procedure is that it cannot account for unmeasured or unobserved confounders (Caliendo and Kopeinig, 2008; Li, 2013). Consequently, validity of the estimated effect of at least 4 ANC visits on childhood immunisation after matching depends on the inclusion of all relevant confounding variables and correct specification of the propensity score model. PSM procedure may also exclude observations outside the region of common support, resulting in a reduced effective sample size and potentially limiting the generalisation of the findings (Caliendo and Kopeinig, 2008). In the present study, this limitation was addressed by including a comprehensive set of socio-demographic and characteristics of the women in the propensity score model, rigorously, assessing the covariate balance after matching using standardised mean differences (standardised bias), and sensitivity analysis. Nevertheless, as is the case with all observational studies, the possibility of residual confounding cannot be completely excluded, and, therefore, findings should be interpreted with appropriate caution. The Mantel–Haenszel sensitivity analysis also indicates that the statistical significance of the estimated association could be affected by a relatively modest degree of unmeasured confounding under the over-estimation bound. The observed association, therefore, should not be interpreted as completely free from residual confounding.

Estimation of effects

We have classified women in terms of a binary variable T which takes value 1 if the woman has at least 4 ANC visits and 0 if the woman has less than 4 ANC visits during the last pregnancy. Children aged 12-23 months have also been classified into two groups in terms of the binary variable Y which takes value 1 if the child is fully immunised and value 0 if the child is not fully immunised. Combining the two classifications, all children aged 12-23 months can then be classified into the following four mutually exclusive and exhaustive groups:

$Y_{11}=\{Y=1 \text{ and } T=1\}$

Y_{10}= {Y=1 and T=0}
Y_{01}= {Y=0 and T=1}
Y_{00}= {Y=0 and T=0}

The effect of at least 4 ANC visits on the probability that the child is fully immunised relative to less than 4 ANC visits (ATT) is estimated as

$$ATT = E(Y_{11} - Y_{10})$$
$$= E(Y_{11}) - E(Y_{10})$$

The ATT may be influenced by the difference in the background characteristics of women who have at least 4 ANC visits and those of women having less than 4 ANC visits. To eliminate this effect, women having at least 4 ANC visits were matched with women having less than 4 ANC visits through propensity scores and the ATT was estimated based on matched women only as follows:

$$ATT^m = E(Y_{11}^m) - E(Y_{10}^m)$$

The propensity score was calculated by regressing the binary variable T on a set of variables reflecting the background characteristics of women using the bivariate logistic regression analysis procedure. The following variables were used to reflect the background characteristics of the women:

1. Age of the woman
2. Level of education of the women
3. Standard of living of the woman as measured through the wealth index
4. Wanted status of the last child
5. Parity of the last child
6. Sex of the last child
7. Residence of the woman
8. Religion of the woman
9. Exposure of the woman to mass media

Results

Background characteristics of women

Table 1 shows that the distribution of women who had at least 4 ANC visits during their last pregnancy by selected background characteristics is statistically significantly different from the distribution of women who had less than 4 ANC visits during their last pregnancy. Table 1 confirms that the probability of at least 4 ANC visits by a woman during her last pregnancy is contingent upon her background characteristics. For example, the probability of at least 4 ANC visits is higher in younger women (<30 years of age) but lower in older women (≥ 30 years of age) compared to women who had less than 4 ANC visits. Similarly, the probability of at least 4 ANC visits is higher in women having at least secondary level education relative to women having less than secondary level education. The standard of living of the women, measured in terms of the wealth index is also found to be directly related to the probability of at least 4 ANC visits. Religion and place of residence also influence the probability of at least 4 ANC visits during the last pregnancy.

Table 1: Distribution of women having at least 4 ANC visits and women having less than 4 ANC visits during their last pregnancy by selected demographic, social and economic characteristics.

Variable		< 4 ANC visits (%)	≥4 ANC visits (%)	χ^2/z	df	P
Age of women (years)						
	Under 21	13.92	13.14	15.99	3	0.000
	22-29	62.77	62.63			
	30-39	21.74	22.93			
	40-49	1.57	1.30			
Mother's education						
	No education	26.35	14.32	1300	3	0.000
	Primary	13.47	10.63			
	Secondary	49.54	56.35			
	Higher	10.64	18.70			
Wealth index						
	Poorest	35.56	19.25	1900	4	0.000
	Poorer	24.92	21.71			
	Middle	17.40	21.26			
	Richer	13.07	20.08			
	Richest	9.05	17.70			
Wanted last child						
	Wanted then	91.38	93.60	92.05	2	0.000
	Wanted later	4.42	3.81			
	Wanted no more	4.20	2.59			
Place of residence						
	Rural	84.36	75.78	439.76	1	0.000
	Urban	15.64	24.22			
Religion						
	Hindu	72.56	75.76	89.23	2	0.000
	Muslim	14.17	13.96			
	Others	13.26	10.28			
Parity						
	One	32.89	41.11	734.09	3	0.000
	Two	32.28	35.28			
	Three	17.74	14.17			
	Four +	17.09	9.43			
Sex of the child						
	Male	51.97	52.64	1.78	1	0.570
	Female	48.03	47.36			
Mass media exposure						
	Yes	61.55	78.44	1400	1	0.000
	No	38.45	21.56			
All		41.94	58.06	36.93		0.000
N		16836	23331			

Source: Authors

The probability of having at least 4 ANC visits has also been found to be higher in women who wanted the child compared to those women who wanted the child later or the pregnancy was unwanted. Parity has also been found to be inversely related to the probability of at least 4 ANC visits. Finally, exposure to mass media has been found to be an important factor that influences the probability of at least 4 ANC visits during the last pregnancy. The gender of the child has not been found to be a factor in influencing the probability of at least 4 ANC visits during the last pregnancy. This is expected as the gender of the child remains unknown before the delivery.

Immunisation Status of the Child

The proportion of fully immunised children in women who had at least 4 ANC visits during the last pregnancy has been found to be statistically significantly higher than the proportion of fully immunised children in women who had less than 4 ANC visits during the last pregnancy. More than 81 per cent children of women who had at least 4 ANC visits were found to be fully immunised compared to around 70 per cent children of women who had less than 4 ANC visits and the difference is found to be statistically significant ($z=26.46$, $p<0.001$). A part of this difference may, however, be attributed to the difference in the background characteristics of the two groups of women which has been found to be statistically significantly different. The proportion of fully immunised children in women having at least 4 ANC visits and the proportion of fully immunised children in women having less than 4 ANC visits during the last pregnancy by background characteristics of women is presented in table 2.

Propensity score matching

To exclude the difference in the proportion of children fully immunised in women having at least 4 ANC visits and the proportion of children fully immunised in women having less than 4 ANC that may be attributed to the difference in the background characteristics of the two groups of women, the propensity score matching was carried out. This matching exercise revealed that 11640 women having at least 4 ANC visits during their last pregnancy matched with 13784 women having less than 4 ANC visits during their last pregnancy. The remaining women differed in terms of their background characteristics and, therefore, excluded from the analysis. The covariate balance diagnostics of the matching exercise is presented in table 3 which shows that standardised bias is markedly reduced after matching and no meaningful differences remained between matched groups of women. The improved covariate balance confirms that the comparison between women who had at least 4 ANC visits and women who had less than 4 ANC visits during their last pregnancy is based on comparable background characteristics.

Table 4 presents results of the matching quality diagnostics. There was a marked reduction in the median standardised bias which decreased from 36.0 per cent to 2.2 per cent and the median bias. The pseudo-R^2 also decreased markedly, while Rubin's B and Rubin's R remained within the recommended limits. These findings confirm that the matching procedure successfully balanced the observed covariates between two groups of women - women who had at least 4 ANC visits and women who had less than 4 ANC visits during their last pregnancy and reduction in the selection bias. These findings strengthened the validity of the estimated effect of at least 4 ANC visits during the last pregnancy on childhood immunisation.

Table 2: Proportion of children aged 12-23 months fully immunised in women having at least 4 ANC visits and women having less than 4 ANC visits during their last pregnancy by selected background characteristics.

Variable	< 4 ANC visits (%)	≥4 ANC visits (%)	z	P	N
Age of women (years)					
Under 21	70.00	81.49	9.88	<0.001	5406
22-29	71.28	81.63	19.34	<0.001	25,168
30-39	68.61	81.86	14.56	<0.001	9,006
40-49	60.00	78.48	4.78	<0.001	567
Mother's education					
No education	63.44	76.18	12.02	<0.001	7,774
Primary	67.62	79.98	9.71	<0.001	4,745
Secondary	73.37	83.10	17.16	<0.001	21,477
Higher	76.79	82.27	4.95	<0.001	6,151
Wealth index					
Poorest	64.21	78.90	16.32	<0.001	10,475
Poorer	70.26	80.44	11.39	<0.001	9,257
Middle	75.04	82.93	8.46	<0.001	7,886
Richer	75.37	84.17	8.73	<0.001	6,881
Richest	78.40	81.58	2.69	<0.007	5,648
Wanted last child					
Wanted then	70.79	81.79	24.92	<0.001	37,205
Wanted later	68.15	80.07	5.51	<0.001	1,632
Wanted no more	62.94	77.94	5.9	<0.001	1,310
Place of residence					
Rural	71.06	79.47	8.44	<0.001	8,279
Urban	70.21	82.31	25.48	<0.001	31,868
Religion					
Hindu	73.32	82.59	19.29	<0.001	29,877
Muslim	62.70	78.16	12.72	<0.001	5,641
Others	61.01	79.08	12.76	<0.001	4,164
Parity					
One	73.64	83.13	13.97	<0.001	15,122
Two	71.65	82.09	14.41	<0.001	13,660
Three	68.72	79.63	9.91	<0.001	6,290
Four +	63.23	76.30	9.97	<0.001	5,075
Sex of the child					
Male	70.91	82.06	19.05	<0.001	21,020
Female	69.73	81.14	18.34	<0.001	19,127
Mass media exposure					
Yes	74.06	82.90	17.88	<0.001	28,648
No	64.39	76.96	14.57	<0.001	11,499
All	70.43	81.62	26.46	<0.001	40,147
N	16836	23331			

Source: Authors

Table 3: The balancing test for the covariates in matched and unmatched women.

Variable	Group	Covariate balance					
		Women having at least 4 ANC visits	Women having less than 4 ANC visits	Bias	Reduction in bias	't'	'P'
Age of woman	Unmatched	2.123	2.195	-10.9	88.7	-5.40	0.000
	Matched	2.123	2.115	1.2		1.41	0.157
Education of woman	Unmatched	1.794	1.209	60.9	94.9	30.48	0.000
	Matched	1.794	1.824	-3.1		-3.60	0.000
Wealth index	Unmatched	2.952	2.016	71.5	94.9	32.86	0.000
	Matched	2.952	2.905	3.6		3.70	0.000
Wanted last child	Unmatched	1.089	1.196	-22.9	90.7	-13.22	0.000
	Matched	1.089	1.079	2.1		3.01	0.003
Place of residence	Unmatched	1.757	1.857	-25.5	89.4	-11.32	0.000
	Matched	1.757	1.768	-2.7		-2.68	0.007
Religion	Unmatched	2.214	4.231	-16.1	90.2	-9.91	0.000
	Matched	2.206	2.404	-1.6		-2.29	0.003
Parity	Unmatched	1.919	2.424	-48.4	94.8	-24.73	0.000
	Matched	1.919	1.892	2.5		2.97	0.003
Sex of child	Unmatched	1.473	1.479	-1.2	-78.7	-0.57	0.570
	Matched	1.473	1.463	2.1		2.29	0.022
Mass media exposure	Unmatched	0.784	0.479	66.7	99.3	34.72	0.000
	Matched	0.784	0.786	-0.4		-0.53	0.596

Source: Authors

Table 5 shows results of the Mantel–Haenszel sensitivity analysis. Under the assumption of no hidden bias ($\Gamma=1$), the association of the proportion of fully immunised children aged 12-23 months in women having at least 4 ANC during their last pregnancy has been found to be statistically significantly different from the proportion of fully immunised children in women having less than 4 ANC visits during their last pregnancy. With the increase in Γ, the significance of the difference under the over-estimation model gradually weakened and turned statistically insignificant after $\Gamma\approx1.15$. This indicates that a relatively small degree of unmeasured confounding effect could influence the effect of at least 4 ANC visits by women during their last pregnancy on childhood immunisation. However, the under-estimation model remains statistically significant across all Γ values, suggesting that the observed association was generally robust to the hidden bias. Overall, the sensitivity

analysis indicates that while the positive effect of at least 4 ANC visits on childhood immunisation is supported by the matched analysis, some caution is warranted because unmeasured factors may still partially influence the estimated effect.

Table 4: Quality of matching tests.

Group	Pseudo R^2	LR X^2	P value of LR	Mean bias	Median bias	Variance ratio (B)	Ratio of variances (R)	Proportion unbalanced (%var)
Unmatched	0.108	1787.48	0	36.0	25.5	91.1	0.82	88
Matched	0.001	76.68	0	2.2	2.1	8.1	1.07	75

Source: Authors

Table 5: Sensitivity analysis.

Gamma	Test Statistics		Significance level	
	(Over-estimation) Q _mh+	(Under-estimation) Q mh-	(Over-estimation) p_mh+	(Under-estimation) p_mh-
1	1.973	1.973	0.024	0.024
1.05	1.850	2.112	0.032	0.017
1.1	1.726	2.237	0.042	0.012
1.15	1.607	2.358	0.053	0.009
1.2	1.494	2.473	0.067	0.006
1.25	1.385	2.584	0.082	0.004
1.3	1.281	2.691	0.099	0.003
1.35	1.181	2.795	0.118	0.002
1.4	1.085	2.894	0.138	0.001
1.45	0.992	2.991	0.160	0.001
1.5	0.902	3.085	0.183	0.001
1.55	0.816	3.176	0.207	0
1.6	0.732	3.264	0.231	0
1.65	0.651	3.350	0.257	0
1.7	0.572	3.433	0.283	0
1.75	0.496	3.515	0.309	0
1.8	0.422	3.594	0.336	0
1.85	0.350	3.672	0.363	0
1.9	0.280	3.747	0.389	0
1.95	0.280	3.747	0.389	0
2	0.145	3.893	0.442	0

Source: Authors

Childhood Immunisation in matched groups

The proportion of fully immunised children aged 12-23 month in matched women who had at least 4 ANC visits during their last pregnancy is estimated to be 81.6 per cent compared to 75.3 per cent in matched women who had less than 4 ANC visits during their last pregnancy. This difference is found to be statistically significant (Table 7). On the other hand, the proportion of fully immunised children in unmatched women having at least 4 ANC visits during their last pregnancy is estimated to be 70.3 per cent compared to 83.4

per cent in unmatched women who had less than 4 ANC visits during their last pregnancy. This means that even after excluding the potential bias associated with the difference in the background characteristics of women who had at least 4 ANC during the last pregnancy and women who had less than 4 ANV visits during their last pregnancy, the proportion of fully immunised children in women who had at least 4 ANC during their last pregnancy was higher than the proportion of fully immunised children in women who had less than 4 ANC visits during their last pregnancy.

Table 7: Impact of ANC visits on childhood immunization using PSM method in India obtained from National Family Health Survey-5, 2019–2021.

Women groups	Women having at least 4 ANC visits	Women having less than 4 ANC visits	Difference	Standard error	t-statistic
All	0.825	0.708	0.116	0.010	10.88
Matched	0.825	0.738	0.087	0.012	7.27
Unmatched	0.708	0.810	0.101		
ATE			0.093		

Source: Author

Table 8 presents the proportion of fully immunised children in matched women having at least 4 ANC visits and matched women having less than 4 ANC visits during the last pregnancy by background characteristics. The proportion of fully immunised children is found to be statistically significantly higher in all categories of different background characteristics in matched women having at least 4 ANC visits during their last pregnancy compared to the proportion of fully immunised children in matched women who had less than 4 ANC visits during their last pregnancy. The only exception is women belonging to the richest wealth index quantiles. The table also shows that the effect of having at least 4 ANC visits relative to less than 4 ANC visits decreases with the increase in the education of the women and with the increase in the standard of living as measured through the wealth index but increases with the increases in parity and with the wanted status of the child. In women belonging to the richest wealth index quantiles, the proportion of fully immunised children in women having at least 4 ANV visits is higher than the proportion of fully immunised children in women having less than 4 ANC visits but the difference is not statistically significant.

The effect of at least 4 ANC visits on the immunisation status of children aged 12-23 months appears to be higher in rural women compared to urban women, in women of Muslim and other religions compared to women of Hindu religion, in female children compared to male children and in women who were not exposed to any type of mass media compared to women who were exposed to any mass media even after controlling the difference in the distribution of women having at least 4 ANC visits and women having less than 4 ANC visits in terms of their background characteristics. The effect of having at least 4 ANC visits by women during their last pregnancy on the immunisation status of their children aged 12-23 months is, however, not uniform across different categories of different background characteristics. This effect is the highest in the poorest, illiterate women and in women who did not want the child.

Table 8: Proportion of fully immunised children (FI) in matched women having at least 4 ANC visits and matched women having less than 4 ANC visits during their last pregnancy.

Background characteristic	Category	Less than 4 ANC visits		At least 4 ANC visits		Difference	'z'	'P'
		n	FI (%)	n	FI (%)			
Age of mother	15–19	1906	70.62	1389	79.06	8.44	5.865	<0.001
	20–29	8889	72.45	5705	79.42	6.97	10.231	<0.001
	30–39	2822	70.27	2535	79.76	9.49	7.987	<0.001
	40–49	167	67.07	165	76.97	9.90	2.009	0.0445
Educational attainment	No education	2386	63.67	2982	75.76	12.09	9.642	<0.001
	Primary	1859	68.42	1785	77.98	9.56	6.506	<0.001
	Secondary	7757	73.77	5869	81.24	7.47	10.264	<0.001
	Higher	1782	76.77	1004	82.07	5.30	3.282	0.0010
Household wealth index	Poorest	3627	64.72	4303	78.58	13.84	13.708	<0.001
	Poorer	3584	70.76	3381	78.64	7.89	7.556	<0.001
	Middle	2858	75.26	2112	80.21	4.95	4.119	<0.001
	Richer	2192	75.36	1278	81.92	6.56	4.484	<0.001
	Richest	1523	78.40	566	81.63	3.23	1.617	0.1058
Wantedness of child	Wanted then	12779	71.96	10641	79.47	7.52	13.303	<0.001
	Wanted later	587	69.68	522	79.50	9.83	3.738	<0.001
	Wanted no more	418	66.27	477	77.78	11.51	3.843	<0.001
Residence	Urban	2534	71.71	1921	76.73	5.03	3.782	<0.001
	Rural	11250	71.68	9719	79.94	8.26	13.863	<0.001
Religion	Hindu	10093	74.29	8443	80.23	5.93	9.559	<0.001
	Muslim	1899	64.24	1848	76.84	12.60	8.449	<0.001
	Other	1792	64.84	1349	77.76	12.92	7.850	<0.001
Parity	1	4960	74.34	3543	80.72	6.39	6.900	<0.001
	2	4801	72.40	3833	80.41	8.01	8.648	<0.001
	3	2303	70.21	2316	78.50	8.28	6.448	<0.001
	4+	1720	64.01	1948	76.13	12.12	8.027	<0.001
Sex of child	Male	6963	72.21	5518	79.46	7.26	9.351	<0.001
	Female	6821	71.16	6122	79.35	8.21	10.767	<0.001
Mass media exposure	No	3708	64.73	4741	76.95	12.22	12.360	<0.001
	Yes	10076	74.24	6899	81.10	6.85	10.426	<0.001

Discussion

The present study was based on 40,147 children aged 12-23 months. Mothers of around 58 per cent of these children had at least 4 ANC visits during their last pregnancy while mothers of remaining 42 per cent children had less than 4 ANC visits including mothers who had no ANC visit during their last pregnancy. The proportion of fully immunised children was higher among women who had at least 4 ANC visits (81.6 per cent) compared to women who had less than 4 ANC visits (70.3 per cent) during their last pregnancy. Propensity-score matching was carried out to improve the comparability between the two groups of women in terms of selected background characteristics of women and the proportion of fully immunised children in matched women having at least

4 ANC visits is found to be 81.6 per cent compared to 75.4 per cent in matched women having less than 4 ANC visits during their last pregnancy. These findings indicate an association between at least four ANC visits during the last pregnancy and childhood immunisation. The proportion of fully immunised children in women having at least 4 ANC visits has also been found to be statistically significantly higher in all categories of different background characteristics except women belonging to the richest wealth index quantiles. These findings should, however, be interpreted as an association rather than evidence of a causal effect, because propensity-score matching can account only for differences in the observed covariates and not for unobserved covariates.

The findings of the present study are consistent with previous studies from India (Krishnamoorthy and Rehman, 2022; Dixit et al, 2013) and Ethiopia (Das et al, 2022). The present study extends the existing evidence by estimating the association between at least 4 ANC visits during the last pregnancy and childhood immunisation using the from NFHS-5 (2019–21) and is comparable to the findings reported by Usman et al (2021) based on NFHS-4 (2015–16). The estimated effect of at least 4 ANC visits by women during their last pregnancy on childhood immunisation may differ from that reported by Usman et al (2021) because of differences in the survey period, population characteristics, analytical approach, covariates included in the propensity-score model, and changes in maternal healthcare utilisation and childhood immunisation coverage between NFHS-4 and NFHS-5. Nevertheless, the consistency of the findings of the present study with earlier studies strengthens the evidence supporting the observed association between at least 4 ANC visits during the last pregnancy and childhood immunisation.

Several mechanisms can explain how at least 4 ANC visits by the woman during pregnancy affects childhood immunisation. Antenatal care provides an important platform for health education and counselling concerning pregnancy, safe delivery, newborn care, and childhood vaccination. Repeated contacts with healthcare providers during these visits enhance the knowledge of women about vaccination schedules, benefits, and potential adverse events, thereby encouraging positive healthcare-seeking behaviour (Sarker et al, 2019). In addition, frequent interactions with healthcare providers strengthen patient–provider trust, which may improve adherence to recommended maternal and child healthcare protocols, including childhood immunisation (WHO, 2018; Darden and Macis, 2024; Hong et al, 2018).

Despite considerable improvements in the proportion of women having at least 4 ANC visits during pregnancy, disparities in the childhood immunisation status in India in terms of the proportion of children aged 12-23 months fully immunised continue to exist in India. Lack of awareness, fear of vaccine side effects, cultural beliefs, misinformation, and inadequate counselling remain important barriers to vaccine uptake (Neupane et al, 2020; Shrivastawa et al, 2015). Regular ANC visits may increase opportunities for healthcare providers to educate women about the importance of timely vaccination of children, address misconceptions, and reinforce confidence in immunisation services (Girotra et al, 2023; Ghosh et al, 2026). Effective counselling by frontline health workers such as Accredited Social Health Activist (ASHA) and Auxiliary Nurse Midwife (ANM), together with the support from family members, particularly husband, can further enhance childhood vaccination uptake (Kumar et al, 2019). Community-based maternal healthcare interventions that improve both antenatal care and immunisation awareness may,

therefore, help reduce persistent inequalities in vaccination coverage in the country (Sharma et al, 2020).

Accessibility of healthcare services is another important determinant of antenatal care. Several studies have demonstrated that longer distance to healthcare facilities is associated with reduced ANC clinic attendance and delay in seeking maternal healthcare (Tanou et al, 2021; Tegegne et al, 2019; Nisingizwe et al, 2020). Women living closer to health facilities are more likely to complete the recommended number of ANC visits because shorter travel distance, reduced transportation costs, travel time, and the physical burden of accessing care. In contrast, women residing in remote and rural areas often face poor transportation infrastructure and geographic barriers that limit timely and regular ANC attendance (Okwaraji et al, 2015; Kyei et al, 2012). Expanding the availability of maternal healthcare services through strengthening primary healthcare facilities, mobile outreach services, and transportation support may, therefore, improve antenatal care and, consequently, improve childhood immunisation coverage.

Conclusion

This study has used the propensity score matching (PSM) to estimate the effect of at least 4 ANC visits during pregnancy on childhood immunisation in India. The findings demonstrate that children born to women who had at least 4 ANC visits during pregnancy were significantly more likely to be fully immunised compared to children born to women who had less than 4 ANC visits. By balancing observed socio-demographic and maternal characteristics of women who had at least 4 ANC visits and women who had less than 4 ANC visits during the last pregnancy through propensity score matching, the study minimised the selection bias and provided more robust evidence of the association between at least 4 ANC visits during pregnancy and full immunisation of children. Findings of the study highlight antenatal care as a key platform for promoting child health through maternal education, counselling, and linkage to immunisation services. Improving antenatal care may, therefore, contribute to improving childhood immunisation coverage and reducing vaccine-preventable morbidity and mortality in India.

Policy Implications

The study highlights the importance of antenatal care in achieving the goal of universal child immunisation. There is a need to improve access to and use of antenatal care services particularly for women from socioeconomically disadvantaged households, rural areas, and other underserved and marginalised population groups. Integrating comprehensive immunisation counselling into routine antenatal care services can enhance the knowledge of women about vaccination schedule, address misconceptions, and encourage timely and full vaccination of children. Strengthening community-based interventions through frontline healthcare workers may be effective in this regard. Targeted health education initiatives and reducing geographic and financial barriers to healthcare access can also contribute to improving both antenatal care and childhood immunisation. Collectively, these measures can contribute to controlling vaccine-preventable diseases and accelerate progress towards universal child immunisation and Sustainable Development Goals (SDGs).

References

Ali MSG, Rolf HH, Belitser SV, Pestman WR, Hoes AW, Roes, Kit CB, de Boer A, Klungel OH (2015) Reporting of covariate selection and balance assessment in propensity score analysis is suboptimal: a systematic review. *Journal of Clinical Epidemiology* 68(2): 122–31.

Andre FE, Booy R, Bock HL, Clemens J, Datta SK, John TJ, Lee BW, Lolekha S, Peltola H, Ruff TA, Santosham M, Schmitt HJ (2008) Vaccination greatly reduces disease, disability, death and inequity worldwide. *Bulletin of World Health Organization* 86(2): 140–6.

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*. 9: e026324.

Austin PC (2009) Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. *Statistics in Medicine* 28(25): 3083–107.

Becker SO, Caliendo M (2007) Sensitivity analysis for average treatment effects. *Stata Journal* 7(1): 71–83.

Basha GW (2019) Factors Affecting the Utilization of a Minimum of Four Antenatal Care Services in Ethiopia. *Obstetrics and Gynecology International*, 5036783.

Clark S, McMahon W, Taylor L (2008) Blast vulnerability assessment tool. *American Water Work Association - Water Security Congress* 25(1): 754–768.

Darden ME, Macis M (2024) Trust and Health Care-Seeking Behavior. *National Bureau of Economic Research Working Paper,* 32028.

Das M, Jana A, Muhammad T (2022) Understanding the associations between maternal high-risk fertility behaviour and child nutrition levels in India: evidence from the National Family Health Survey 2015–2016. *Scientific Reports* 12: 17742.

Dehejia RH (2005) Practical propensity score matching: a reply to Smith and Todd. *Journal of Econometrics* 125(1–2): 355–364.

Dhawan D, Pinnamaneni R, Bekalu M, Viswanath K (2020) Association between different types of mass media and antenatal care visits in India: A cross-sectional study from the National Family Health Survey (2015–2016). *BMJ Open* 10(12): 1–8.

Dixit P, Dwivedi LK, Ram F (2013) Strategies to Improve Child Immunisation via Antenatal Care Visits in India: A Propensity Score Matching Analysis. *PLoS One* 8(6): e66175.

Faradita I, Sitaresmi MN, Wahab A (2022) Association between maternal health care and basic immunization completeness in children aged 12–23 months: analysis of 2017 Indonesian Demographic and Health Survey. *Open Access Macedonian Journal of Medical Sciences* 10(E): 264–268.

Gebrehana AK, Abrham Asnake A, Seifu BL, Fente BM, Bezie MM, Asmare ZA, Tsega SS, Negussie YM, Asebe HA, Melkam M (2025) Association between the continuum of

maternal healthcare services and child immunisation in East Africa: a propensity score matching analysis. *BMJ Open* 15(12): e099468.

Ghosh T, Das P, Sarkar A, Chouhan P (2026) How does birth order influence full immunisation coverage among children aged 12–23 months in India? Evidence from the National Family Health Survey. *PLoS One* 21(2): e0342300.

Government of India (2021) *National Family Health Survey (NFHS-5), 2019–21: India Report*. Mumbai, International Institute for Population Sciences.

Government of India (2026) *National Family Health Survey (NFHS-6), 2023–24: India Report*. Mumbai, International Institute for Population Sciences.

Hong HC, Lee H, Collins EG, Park C, Quinn L, Ferrans CE (2018) Factors affecting trust in healthcare among middle-aged to older Korean American women. *BMC Women's Health* 18(1): 109.

Kinfe Y, Gebre H, Bekele A (2019) Factors associated with full immunisation of children 12–23 months of age in Ethiopia: A multilevel analysis using 2016 Ethiopia Demographic and Health Survey. *PLoS One* 14(11): 1–14.

Krishnamoorthy Y, Rehman T (2022) Impact of antenatal care visits on childhood immunisation: a propensity score-matched analysis using nationally representative survey. *Family Practice* 39(4): 603–609.

Kumar G, Choudhary TS, Srivastava A, Upadhyay RP, Taneja S, Bahl R, Martines J, Bhan MK, Bhandari N, Mazumder S (2019) Utilisation, equity and determinants of full antenatal care in India: analysis from the National Family Health Survey 4. *BMC Pregnancy Childbirth* 19(1): 327.

Kyei NNA, Campbell OMR, Gabrysch S (2012) The Influence of distance and level of service provision on antenatal care use in Rural Zambia. *PLoS One* 7(10): e46475.

Li M (2013) Using the Propensity Score Method to Estimate Causal Effects: A Review and Practical Guide. *Organizational Research Methods* 16(2): 188–226.

Mathew LJ (2012) Inequity in Childhood Immunisation in India: A Systematic Review. *Indian Pediatrics* 49: 203–223.

Nisingizwe MP, Tuyisenge G, Hategeka C, Karim ME (2020) Are perceived barriers to accessing health care associated with inadequate antenatal care visits among women of reproductive age in Rwanda? *BMC Pregnancy Childbirth* 20: 88.

Okwaraji YB, Webb EL, Edmond KM (2015) Barriers in physical access to maternal health services in rural Ethiopia. *BMC Health Services Research* 15: 493.

Ozawa S, Clark S, Portnoy A, Grewal S, Brenzel L, Walker DG (2016) Return on investment from childhood immunisation in low- and middle-income countries, 2011–20. Health Affairs 35(2): 199–207.

Phaway P, Kyaw AT, Mon AS, Mya KS (2022) Continuum of care of mothers and immunization status of their children: a secondary analysis of 2015–2016 Myanmar Demographic and Health Survey. *Public Health Practice* 4: 100335.

Sarker AR, Akram R, Ali N, Sultana M (2019) Coverage and factors associated with full immunisation among children aged 12–59 months in Bangladesh: insights from the nationwide cross-sectional demographic and health survey. *BMJ Open* 9(7): e028020.

Sekine K, Carandang RR, Ong KIC, Tamang A, Jimba M (2021) Identifying the causal effect of child marriage on unmet needs for modern contraception and unintended pregnancy in Nepal: a cross-sectional study using propensity score matching. *BMJ Open* 11(4): e043532.

Sharma S, Mehra D, Akhtar F, Mehra S (2020) Evaluation of a community-based intervention for health and economic empowerment of marginalized women in India. *BMC Public Health* 20(1): 1–16.

Shrivastwa N, Gillespie BW, Kolenic GE, Lepkowski JM, Boulton ML (2015) Predictors of vaccination in India for children aged 12–36 months. *American Journal of Preventive Medicine* 49(6 Suppl 4): S435–S444.

Singh L, Dubey R, Singh S, Goel R, Nair S, Singh PK (2019) Measuring quality of antenatal care: a secondary analysis of national survey data from India. *BJOG: An International Journal of Obstetrics & Gynaecology* 126(Suppl 4): 7–13.

Tanou M, Kishida T, Kamiya Y (2021) The effects of geographical accessibility to health facilities on antenatal care and delivery services utilisation in Benin: a cross-sectional study. *Reproductive Health* 18: 205.

Tegegne TK, Chojenta C, Getachew T, Smith R, Loxton D (2019) Antenatal care use in Ethiopia: a spatial and multilevel analysis. *BMC Pregnancy and Childbirth* 19(1): 399.

Usman M, Anand E, Siddiqui L, Unisa S (2021) Continuum of maternal health care services and its impact on child immunisation in India: an application of the propensity score matching approach. *Journal of Biosocial Science* 53(5): 643–62.

United Nations Inter-Agency Group for Child Mortality Estimation (UN IGME) (2023) *Levels and trends in child mortality: Report 2023*. New York: United Nations Children's Fund.

World Health Organization (2024) *Immunisation Coverage: Key Facts*. Geneva, World Health Organization.

World Health Organization (2018) *Explorations of Inequality: Childhood Immunisation: Interactive Visualization of Health Data*. Geneva: World Health Organization.

World Health Organization (2018) *WHO Recommendations on Antenatal Care for a Positive Pregnancy Experience: Summary*. Geneva: World Health Organization.

World Health Organization (2017) *Immunisation, Vaccines, and Biologicals: Implementation Research in Immunisation*. Geneva: World Health Organization.

World Health Organization (2021) WHO Recommendations for Routine Immunization – Summary Tables. Geneva: World Health Organization.