

Original Research Article

Trends and determinants of cesarean deliveries in Tamil Nadu: a comparative analysis of NFHS-4 and NFHS-5

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ABSTRACT

Background: Global evidence shows rising cesarean deliveries, with India also experiencing a notable rise. Tamil Nadu's cesarean rates rose from NFHS-4 to NFHS-5, despite strong maternal services; this study analyses trends and determinants using NFHS-4 and NFHS-5 data.

Methods: Cesarean rates between NFHS 4 and NFHS 5 were compared for Tamil Nadu and its districts. District wise trends and AARI changes were analysed, and survey weighted logistic regression using NFHS-5 data was applied to identify factors influencing cesarean delivery.

Results: The study examined cesarean trends in Tamil Nadu using NFHS-4 and NFHS-5 data. Cesarean rates increased faster in Tamil Nadu (4.7%) than at the national level (3.8%). District-level analysis showed rates above 20% in three districts, 10-20% in eleven districts, 5-10% in twelve districts, and below 5% in six districts, with slight decrease rates observed in a few districts. Cesarean deliveries increased by 9.6% in government hospitals and by 12.7% in private facilities. The likelihood of cesarean delivery was nearly three times higher in private facilities (OR=2.79). First births occurring later in life also increased the likelihood of cesarean delivery (30+: OR=3.02); additionally, certain health conditions, such as thyroid disorders (OR=1.45) and diabetes (OR=3.16), also increased this likelihood.

Conclusions: Cesarean deliveries are continuously increasing in Tamil Nadu, with notable district-level variations. The state's cesarean rate exceeds the national average, highlighting the need for state-specific strategies. Regression analysis identifies place of delivery, maternal age at first birth, and maternal health conditions as key factors, emphasizing the need to monitor trends and strengthen local policy interventions.

Keywords: Cesarean delivery, Logistic regression, NFHS, Tamil Nadu

INTRODUCTION

The main objective of maternal and child health in India is to promote the health and well-being of mothers and new-borns. To decrease maternal and neonatal morbidity and mortality, cesarean sections are a crucial and frequently essential medical procedure. However, the use

of cesarean delivery without clear medical indications has emerged as a public health concern.¹ The World Health Organization (WHO) reports a global rise in cesarean deliveries, projecting that by 2030, around 29% of all births may be via cesarean section if current trends persist.^{1,2} The WHO stated as early as 1985 that cesarean delivery rates above 15% at the population level do not

lead to additional improvements in maternal and new-born health outcomes.³

Since 1990, the number of cesarean deliveries has increased nearly threefold and it varies widely across regions and countries worldwide.^{1,4} Few studies indicate that cesarean delivery does not provide any supplementary benefit to mothers or new-born babies even in the absence of medical reasons, but introduces short- and long-term risks, including surgical complications, adverse effects on new-borns, and complications for future pregnancies.^{2,5,6} This highlights the need for sensible use of cesarean sections in public health systems.

India follows the international trend: as evidenced by data from the National Family Health Survey (NFHS), which indicates that the cesarean delivery rate rose from 17.2% in 2015-16 to 21.5% in 2019-21. This increase is accompanied by notable disparities among different states and between public and private healthcare sectors.^{7,8} The state of Tamil Nadu has strong maternal health services, and has introduced several interventions such as maternal health surveillance systems, Janani Suraksha Yojana (JSY) and Dr. Muthulakshmi Reddy Maternity Benefit Scheme, establishment of midwife-led care units (MLCUs) and extensive public awareness campaigns. Despite these efforts, the state has experienced a noticeable increase in cesarean section rates between NFHS-4 and NFHS-5 surveys.^{8,9}

Research conducted in Tamil Nadu, including “determinants of cesarean section in public health facilities of Tamil Nadu”, published in the Indian Journal of Public Health in 2019 [11], and “increasing trends in cesarean section rates in Tamil Nadu: evidence from National Family Health Surveys”, published in BMC Pregnancy and Childbirth in 2023, have shown that cesarean delivery rates are influenced by a combination of maternal factors such as age, education, and pre-existing health conditions; and geographical and socioeconomic characteristics including place of residence, district, and wealth index; and institutional factors such as the type and location of the delivery.⁹⁻¹¹ Understanding the prevalence of cesarean delivery across these factors is essential for informing planning and strengthening maternal health services.

This study conducted comparative analyses of NFHS-5 (2019-21) and NFHS-4 (2015-16) data to examine the current trends in cesarean delivery rates in Tamil Nadu. To evaluate the differences in key factors including socio-demographic, geographical, and institutional factors. This study provides necessary evidence for the public health policy of the state and the implementation of maternal health programs.

METHODS

The data were drawn from the National Family Health Survey (NFHS), specifically rounds NFHS-4 (2015-2016)

and NFHS-5 (2019-2021).^{7,8} For the analysis, the kids recode (KR) file was used for analysis, which contains information on all children under the age of five, associated with their mothers, including details on birth characteristics, health, nutrition, and survival.

The district-level changes in cesarean delivery rates across India were examined using this dataset. These surveys are representative of the entire nation, encompassing over 99% of the Indian population, and offer reliable estimates for maternal and child health indicators. The analysis aims to compare the rates of cesarean section (CS) between NFHS-4 and NFHS-5 at the district level.

To assess the impact of cesarean deliveries, survey-weighted logistic regression models were applied using NFHS-5 data. The analysis focused on identifying the key factors among mothers who undergo cesarean delivery, including place of delivery, maternal education, family wealth index, respondent's age group at first birth, and presence of comorbidities.

Additionally, the average annual rate of increase (AARI) was computed to measure the changes in cesarean section rates year to year. AARI helps to compare how cesarean delivery rates have changed each year by showing the average annual rate of increase or decrease. It makes it easier to understand which districts are increasing faster or slower over time. The formula for calculating AARI is:

$$AARI = \left[\left(\frac{v_2}{v_1} \right)^{\frac{1}{n}} - 1 \right] \times 100,$$

Here, v_2 – Last year value, v_1 – Base year value, n – No of years.

RESULTS

This study examined the trends in cesarean deliveries between NFHS-4 and NFHS-5 in Tamil Nadu and its districts. The proportion of women undergoing cesarean delivery in Tamil Nadu increased from 34.1% in NFHS-4 to 44.9% in NFHS-5, indicating a substantial rise during the survey period.

Table 1 presents the district-wise proportions of cesarean deliveries from NFHS-4 and NFHS-5, including the percentage gap and the average annual rate of increase (AARI) for both Tamil Nadu and India. The cesarean delivery rate increased by 10.9 percentage points in Tamil Nadu and by 4.3 percentage points at the national level between NFHS-4 and NFHS-5. The AARI for Tamil Nadu (4.7%) is higher than the national AARI (3.8%). Among districts, Tirunelveli recorded the highest increase (22.7%), while Sivaganga showed the lowest increase (0.4%).

Table 1: Percentage of women undergoing cesarean delivery across districts of Tamil Nadu (NFHS-4 versus NFHS-5).

District	Delivery by caesarean section		Gap between NFHS 4 and 5	Average annual rate of increased (AARI)
	NFHS-4	NFHS-5		
Ariyalur	39.9	57.3	17.4	6.2
Chennai	28.8	50.5	21.7	9.8
Coimbatore	41.4	50.9	9.5	3.5
Cuddalore	40.2	51.4	11.1	4.2
Dharmapuri	27.3	29.1	1.7	1.0
Dindigul	30.4	33.3	2.9	1.5
Erode	31.2	48.5	17.3	7.6
Kancheepuram	35.5	40.2	4.7	2.1
Kanniyakumari	51.3	68.3	16.9	4.9
Karur	40.1	47.8	7.7	3.0
Krishnagiri	24.0	31.9	7.9	4.8
Madurai	37.0	43.8	6.8	2.9
Nagapattinam	39.8	49.4	9.7	3.7
Namakkal	32.6	53.7	21.1	8.7
Perambalur	44.9	50.3	5.4	1.9
Pudukkottai	39.9	41.2	1.2	0.5
Ramanathapuram	40.9	47.5	6.5	2.5
Salem	30.5	43.0	12.6	5.9
Sivaganga	42.7	43.2	0.4	0.2
Thanjavur	43.0	51.4	8.4	3.0
The Nilgiris	26.3	42.3	16.0	8.3
Theni	34.8	43.7	8.8	3.8
Thiruvallur	37.1	46.4	9.4	3.8
Thiruvarur	42.0	60.6	18.7	6.3
Thoothukkudi	37.1	52.0	14.9	5.8
Tiruchirappalli	37.3	41.0	3.7	1.6
Tirunelveli	37.5	60.2	22.7	8.2
Tiruppur	35.0	46.4	11.4	4.8
Tiruvannamalai	18.7	27.7	9.0	6.7
Vellore	25.7	42.4	16.7	8.7
Viluppuram	13.3	28.0	14.8	13.3
Virudhunagar	43.2	50.0	6.9	2.5
Tamil Nadu	34.1	44.9	10.9	4.7
India	17.2	21.5	4.3	3.8

Figure 1 illustrates the district-level AARI in cesarean deliveries across Tamil Nadu. Villupuram district recorded the highest AARI (13.3%), whereas Sivaganga had the lowest (0.2%). Overall, six districts experienced rapid increases (AARI>8%), twenty districts showed moderate increases (AARI between 2% and 8%), and six districts had slow increases (AARI<2%).

Table 2 presents the district-wise proportions of cesarean deliveries in urban areas of Tamil Nadu for NFHS-4 and

NFHS-5, along with the percentage change and the average annual rate of increase (AARI). The cesarean section rate in urban Tamil Nadu increased from 36.1% to 47.5%, reflecting an absolute rise of 11.4 percentage points and an AARI of 4.7%. Viluppuram district recorded the highest AARI (16.0%) and the largest percentage increase (28.7%) between NFHS-4 and NFHS-5, while greater Chennai showed the largest absolute increase (21.7%) along with a high AARI of 9.8%.

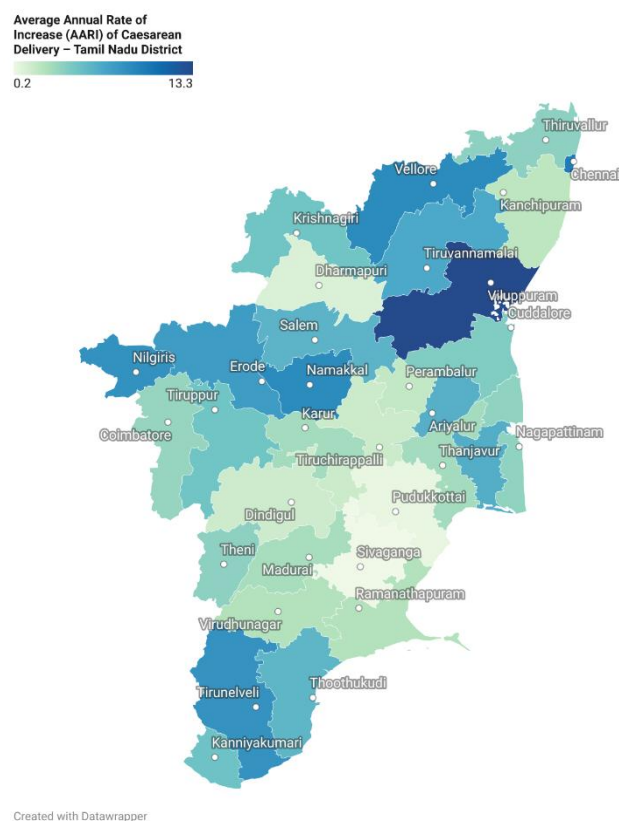


Figure 1: Average annual rate of increase (AARI) for cesarean delivery- Tamil Nadu district.

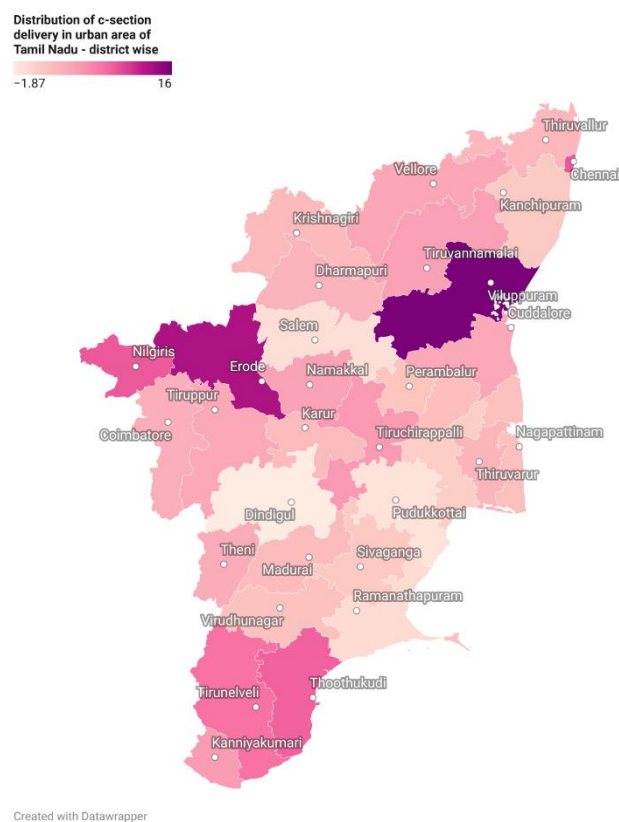


Figure 2: Average annual rate of increase (AARI) for cesarean delivery- urban area of Tamil Nadu districts.

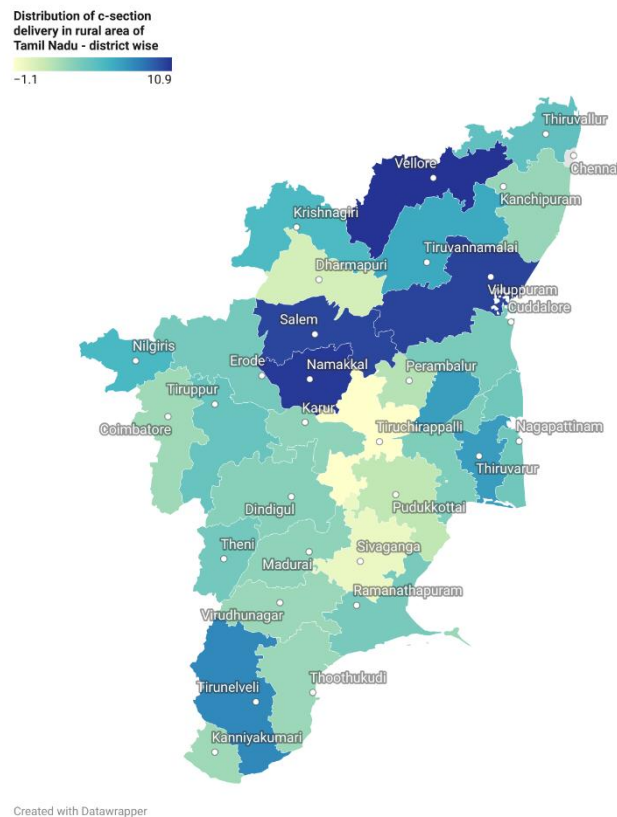


Figure 3: Average annual rate of increase (AARI) for cesarean delivery- rural area of Tamil Nadu districts.

Table 2: Distribution of cesarean section deliveries in urban areas across the districts of Tamil Nadu- comparison between NFHS-4 (2015-16) and NFHS-5 (2019-21).

District	Delivery by cesarean section		Gap between urban area of NFHS 4 and 5	Average annual rate of increased (AARI)
	NFHS-4	NFHS-5		
Ariyalur	58.1	66.6	8.5	2.3
Chennai	28.8	50.5	21.7	9.8
Coimbatore	40.5	50.6	10.1	3.8
Cuddalore	42.0	54.2	12.2	4.4
Dharmapuri	31.1	37.9	6.8	3.3
Dindigul	38.5	34.4	-4.1	-1.9
Erode	30.0	64.1	34.2	13.5
Kancheepuram	39.8	43.0	3.2	1.3
Kanniyakumari	50.0	68.9	18.9	5.5
Karur	41.0	48.1	7.1	2.7
Krishnagiri	37.8	44.6	6.8	2.8
Madurai	36.5	42.4	5.9	2.5
Nagapattinam	41.0	46.6	5.6	2.1
Namakkal	34.7	46.3	11.6	4.9
Perambalur	49.4	54.8	5.4	1.7
Pudukkottai	57.6	53.9	-3.8	-1.1
Ramanathapuram	50.6	49.2	-1.4	-0.5
Salem	32.1	30.8	-1.4	-0.7
Sivaganga	42.2	45.7	3.5	1.3
Thanjavur	40.7	43.2	2.4	1.0
The Nilgiris	25.1	43.6	18.5	9.6
Theni	37.7	48.0	10.3	4.1
Thiruvallur	40.0	47.7	7.7	3.0

Continued.

District	Delivery by cesarean section		Gap between urban area of NFHS 4 and 5	Average annual rate of increased (AARI)
	NFHS-4	NFHS-5		
Thiruvavarur	53.2	64.3	11.1	3.2
Thoothukkudi	34.4	58.3	23.9	9.2
Tiruchirappalli	32.5	45.2	12.7	5.6
Tirunelveli	41.9	67.6	25.7	8.3
Tiruppur	31.9	41.4	9.6	4.5
Tiruvannamalai	23.5	31.7	8.2	5.1
Vellore	25.1	32.7	7.6	4.5
Viluppuram	20.0	48.6	28.7	16.0
Virudhunagar	45.3	50.9	5.6	2.0
Tamil Nadu	36.1	47.5	11.4	4.7

Table 3: Distribution of cesarean section deliveries in rural areas across the districts of Tamil Nadu- comparison between NFHS-4 (2015-16) and NFHS-5 (2019-21).

Districts	Delivery by cesarean section		Gap between urban area of NFHS 4 and 5	Average annual rate of increased (AARI)
	NFHS-4	NFHS-5		
Ariyalur	37.4	56.6	19.2	7.1
Chennai	NA	NA	NA	NA
Coimbatore	44.0	51.5	7.5	2.7
Cuddalore	39.6	49.8	10.3	3.9
Dharmapuri	26.4	27.6	1.2	0.7
Dindigul	26.8	32.8	6.0	3.4
Erode	32.7	41.5	8.8	4.1
Kancheepuram	27.6	32.8	5.2	2.9
Kanniyakumari	56.4	66.1	9.7	2.7
Karur	39.5	47.7	8.2	3.2
Krishnagiri	20.1	28.1	8.0	5.7
Madurai	37.8	45.6	7.8	3.2
Nagapattinam	39.5	50.8	11.3	4.3
Namakkal	31.3	57.6	26.4	10.7
Perambalur	44.1	49.4	5.4	1.9
Pudukkottai	35.3	38.7	3.3	1.5
Ramanathapuram	37.0	46.7	9.7	4.0
Salem	29.3	52.7	23.5	10.3
Sivaganga	42.9	42.0	-0.9	-0.3
Thanjavur	44.2	55.1	10.9	3.7
The Nilgiris	28.6	40.2	11.6	5.8
Theni	30.7	39.3	8.6	4.2
Thiruvallur	32.8	44.0	11.2	5.0
Thiruvavarur	39.5	60.1	20.6	7.2
Thoothukkudi	40.2	47.5	7.3	2.8
Tiruchirappalli	41.3	38.7	-2.7	-1.1
Tirunelveli	34.4	54.9	20.5	8.1
Tiruppur	42.0	55.2	13.2	4.7
Tiruvannamalai	18.1	26.5	8.4	6.6
Vellore	26.4	49.1	22.7	10.9
Viluppuram	12.1	21.8	9.8	10.4
Virudhunagar	41.6	49.2	7.6	2.8
Tamil Nadu	32.3	42.9	10.7	4.9

Figure 2 shows that the district-level AARI in cesarean deliveries across urban areas of Tamil Nadu. The trends were heterogeneous across districts: Viluppuram, Erode,

Chennai, The Nilgiris, Tirunelveli, and Thoothukkudi recorded high AARIs (above 8%). In contrast, several districts (such as Dindigul, Pudukkottai,

Ramanathapuram, and Salem) experienced declines in cesarean delivery proportions between the two survey rounds, resulting in negative AARIs in urban Tamil Nadu.

Table 3 presents district-wise cesarean delivery rates in rural areas of Tamil Nadu for NFHS-4 and NFHS-5, along with the percentage change and the Average Annual Rate of Increase (AARI). The cesarean delivery rate in rural area of Tamil Nadu increased from 32.3% to 42.9%, reflecting an absolute rise of 10.7 percentage points and an AARI of 4.9%.

The largest increase rates were observed in districts such as Namakkal (26.4%), Salem (23.5%), Vellore (22.7%), Thiruvavur (20.6%), and Tirunelveli (20.5%) In contrast, cesarean delivery proportions showed minimal change or slight declines in Sivaganga (-0.9%) and Tiruchirappalli (-2.7%) districts.

Figure 3 shows the district-level average annual rate of increase in cesarean deliveries across rural Tamil Nadu. The highest AARI values were observed in Vellore (10.9%), Namakkal (10.7%), Viluppuram (10.4%), Salem (10.3%), and Tirunelveli (8.1%). In contrast, Sivaganga and Tiruchirappalli districts experienced declines in cesarean delivery proportions between the two survey rounds, resulting in negative AARI values.

Table 4 presents the percentage of cesarean deliveries among institutional deliveries in both public and private sectors across the districts of Tamil Nadu, comparing data from NFHS 4 and NFHS 5, along with the Average Annual Rate of Increase (AARI). At the state level, the cesarean delivery rate increased from 26.4% to 36.0% in the public sector and from 51.2% to 64.0% in the private

sector, with corresponding AARI values of 5.3% and 3.8%, respectively.

In the public sector, the largest increase rate (>20%) in cesarean deliveries was observed in Namakkal, Tirunelveli, Thiruvavur, Vellore, and Salem, while Perambalur, Kancheepuram, Pudukkottai, and Thanjavur recorded minimal increase rates (<2%). Notably, Dharmapuri was the only district to experience a decline in public sector cesarean rates, from 19.3% in NFHS-4 to 17.6% in NFHS-5.

In the private sector, Tiruvannamalai, Chennai, Thoothukkudi, Viluppuram, The Nilgiris, Tirunelveli, and Kanniyakumari had the largest increase rates (>20%) in cesarean deliveries, whereas Dindigul, Thiruvavur, and Pudukkottai recorded the smallest increase rates (<5%). Declines in private sector cesarean rates were observed in Dharmapuri, Salem, Sivaganga, and Theni.

Several districts showed contrasting trends between the public and private sectors. For example, Salem experienced a high increase in the public sector (13.5% AARI) but a decline in the private sector (2.4% AARI). In districts such as Namakkal, Thiruvavur, Tirunelveli, and Vellore, cesarean rates experienced a significant increase in the public sector, whereas the rise in the private sector was more gradual (e.g., Thiruvavur: public AARI 10.9% versus private AARI 0.8%). Conversely, in Tiruvannamalai, Thoothukkudi, and Perambalur, cesarean rates rose moderately in the public sector but increased substantially in the private sector (e.g., Tiruvannamalai: public (3.8% AARI) vs. private (10.4% AARI). No significant changes were observed in Pudukkottai and Thanjavur between NFHS-4 and NFHS-5.

Table 4: Percentage of women undergoing cesarean section among institutional deliveries in public and private sectors across the districts of Tamil Nadu (NFHS-4 and NFHS-5).

District	NFHS-4 (2015-2016)		NFHS-5 (2020-2021)		AARI- public sector	AARI- private sector
	C-section in public sector	C-section in private sector	C-section in public sector	C-section in private sector		
Ariyalur	35.1	60.5	49.1	78.3	5.8	4.4
Chennai	25.5	33.6	42.5	62.5	8.9	10.9
Coimbatore	29.6	64.3	35.5	74.6	3.1	2.5
Cuddalore	37.4	52.9	47.1	64.5	3.9	3.4
Dharmapuri	19.3	63.8	17.6	61.0	-1.5	-0.7
Dindigul	24.8	50.6	28.1	54.6	2.1	1.3
Erode	23.2	55.7	29.6	68.5	4.1	3.5
Kancheepuram	31.5	43.0	31.7	59.4	0.1	5.5
Kanniyakumari	39.8	57.0	53.3	78.0	5.0	5.4
Karur	28.3	58.8	35.4	64.1	3.8	1.4
Krishnagiri	16.5	51.4	23.4	59.7	6.0	2.5
Madurai	29.1	54.2	34.3	66.1	2.7	3.4
Nagapattinam	32.2	61.0	38.7	74.2	3.1	3.3
Namakkal	21.8	52.5	44.8	67.2	12.8	4.2
Perambalur	37.6	56.0	39.3	75.4	0.7	5.1

Continued.

District	NFHS-4 (2015-2016)		NFHS-5 (2020-2021)		AARI-public sector	AARI-private sector
	C-section in public sector	C-section in private sector	C-section in public sector	C-section in private sector		
Pudukkottai	29.9	62.6	30.0	66.0	0.0	0.9
Ramanathapuram	31.2	51.2	42.1	62.5	5.1	3.4
Salem	17.8	61.0	38.0	52.7	13.5	-2.4
Sivaganga	36.9	53.5	43.4	42.6	2.7	-3.7
Thanjavur	33.8	63.2	33.8	77.1	0.0	3.4
The Nilgiris	23.3	34.5	33.6	56.6	6.3	8.6
Theni	21.6	75.4	40.1	59.5	10.9	-3.9
Thiruvallur	32.2	51.9	39.9	63.8	3.6	3.5
Thiruvarur	26.3	76.7	48.8	80.5	10.9	0.8
Thoothukkudi	34.0	42.0	38.9	70.9	2.3	9.1
Tiruchirappalli	22.7	55.8	29.0	66.4	4.2	3.0
Tirunelveli	28.7	46.3	51.5	68.0	10.2	6.6
Tiruppur	34.6	36.1	42.1	53.3	3.3	6.7
Tiruvannamalai	17.1	38.7	21.5	70.1	3.8	10.4
Vellore	20.6	38.2	42.1	43.9	12.6	2.3
Viluppuram	11.1	26.5	23.3	54.7	13.2	12.8
Virudhunagar	38.1	56.4	44.0	66.7	2.4	2.8
Tamil Nadu	26.4	51.2	36.0	64.0	5.3	3.8

Table 5: Result of survey-weighted logistic regression analysis for determinants of cesarean delivery (n=6,455)- NFHS-5.

Covariate	Odds Ratio	95% CI	P value
Type of place of residence			
Urban	(Ref)	(Ref)	(Ref)
Rural	1.06	(0.90-1.26)	0.46
Place of delivery			
Public health sector	(Ref)	(Ref)	(Ref)
Private health sector	2.79	(2.40-3.24)	0.00
Diabetes			
No	(Ref)	(Ref)	(Ref)
Yes	3.16	(1.37-7.29)	0.01
Hypertension			
No	(Ref)	(Ref)	(Ref)
Yes	1.64	(0.53-5.07)	0.39
Chronic respiratory disease including asthma			
No	(Ref)	(Ref)	(Ref)
Yes	1.23	(0.57-2.66)	0.61
Thyroid disorder			
No	(Ref)	(Ref)	(Ref)
Yes	1.45	(1.05-2.01)	0.02
Heart disease			
No	(Ref)	(Ref)	(Ref)
Yes	0.68	(0.16-2.84)	0.60
Cancer			
No	(Ref)	(Ref)	(Ref)
Yes	0.44	(0.02-10.6)	0.61
chronic kidney disorder			
No	(Ref)	(Ref)	(Ref)
Yes	0.87	(0.27-2.85)	0.82
Highest educational level			
No education	(Ref)	(Ref)	(Ref)

Continued.

Covariate	Odds Ratio	95% CI	P value
Primary	1.81	(0.97-3.38)	0.06
Secondary	1.66	(0.93-2.95)	0.08
Higher	1.61	(0.89-2.91)	0.11
Wealth index			
Poor	(Ref)	(Ref)	(Ref)
Middle	1.15	(0.93-1.41)	0.20
Rich	1.14	(0.93-1.4)	0.21
Age group at 1st birth			
Below 20	(Ref)	(Ref)	(Ref)
20–24	1.24	(1.04-1.49)	0.02
25–29	1.72	(1.38-2.15)	0.00
30+	3.02	(2.04-4.47)	0.00

Table 6: Distribution of cesarean deliveries by wealth index and health sector (NFHS-4 versus NFHS-5).

Wealth Index	NFHS - 4 (2015-2016)		NFHS - 5 (2020-2021)	
	Public Health Sector	Private Health Sector	Public Health Sector	Private Health Sector
Poor	21.8	5.4	18.1	5.3
Middle	36.1	19.8	35.2	17.7
Rich	42.1	74.8	46.7	77.1
Total	100.0	100.0	100.00	100.00
Pearson chi ² P value	0.00		0.00	

NFHS- National Health

Table 5 the findings from a survey-weighted logistic regression analysis using NFHS-5 data (n=6,455) to identify significant factors associated with cesarean delivery. The strongest predictor was place of delivery, with private health facilities associated with nearly three times the likelihood of cesarean delivery compared to public facilities (OR=2.79; p=0.001).

Certain medical conditions were also significant contributors: diabetes (OR=3.16; p=0.01) and thyroid disorders (OR=1.45; p=0.02) were associated with higher odds of cesarean delivery. Maternal age at first birth showed a strong positive correlation; women aged 30 years and above having more than three times increased likelihood of having a cesarean section compared to those under 20 years (OR=3.05; p=0.001).

Several factors did not reach statistical significance, including wealth index, education level, respiratory disease, heart disease, cancer, kidney disorders, hypertension, and rural residence.

Table 6 illustrates the distribution of cesarean deliveries by wealth index and place of delivery in NFHS-4 and NFHS-5. There is strong evidence of an association between socioeconomic status and place of delivery among women undergoing cesarean delivery (p<0.001).

In the private sector, cesarean deliveries were highest among wealthy women, increasing from 74.8% in NFHS-4 to 77.1% in NFHS-5. In contrast, the rates among

middle-income and poor women declined slightly over the same period (middle-income: 19.8% to 17.3%; poor: 5.4% to 5.3%).

In the public sector, wealthy women also had the highest cesarean delivery rates, rising from 42.1% in NFHS-4 to 46.7% in NFHS-5. The rates among middle-income and poor women decreased slightly: middle-income from 36.1% to 35.2%; poor from 21.8% to 18.1%.

The findings indicate a distinct socioeconomic gradient in cesarean deliveries, showing that women with higher wealth are more likely to undergo cesarean sections in both public and private healthcare settings.

DISCUSSION

This study showed the trends in cesarean section rates and identifies key factors contributing to the rise in cesarean deliveries. This is consistent with previous reports from the state and other parts of India, particularly regarding private hospitals. According to NFHS-5 data, the rate of cesarean deliveries performed in private hospitals in some districts of Tamil Nadu is over 50 percent, whereas this rate is considerably lower in government hospitals. The fact that Tamil Nadu's AARI is higher than the national AARI shows that the state needs a policy focus that is different from the national level.¹³

Several studies have examined the factors contributing to the high rates of cesarean deliveries in the private sector

in Tamil Nadu. A study by Varghese et al reported that the greatest increase in cesarean deliveries occurred in wealthier urban districts, with most of these surgeries being performed in private hospitals.⁹ This highlights the role of institutional practices in shaping delivery outcomes.¹¹ In their 2018 study, Singh et al. show that women who choose private hospitals, regardless of medical risk, are more likely to undergo cesarean section. This shows that socioeconomic status, patient preferences, and incentives for medical staff influence the method of delivery.¹⁰

A district level analysis in Tamil Nadu highlights significant variations in cesarean section practices, underscoring a growing concern for maternal and child health. The sharp increases seen in districts such as Viluppuram and Tirunelveli may reflect rapid expansion of facility capacity, or institutional pressures within private hospitals that encourage cesarean delivery. Evidence from NFHS 4 and NFHS 5 consistently shows that private facilities report significantly higher cesarean rates than public hospitals, raising questions about financial motives, scheduling convenience, and medico legal considerations driving these decisions. In contrast, districts with smaller increases or even declines may point to stronger support for vaginal births and wider availability of private providers.^{12,13} These findings call for urgent, district specific policy responses. Strengthening facility level audits and clinical reviews in urban districts with high AARI, requiring second opinions for non-emergency elective cesareans, closely monitoring private sector incentives, and expanding evidence-based labour support across both public and private facilities are critical steps to protect mothers and new-borns.^{12,13}

The increase in rural cesarean births in Tamil Nadu shows that this is not just a problem in cities or the private sector. More and more people in rural areas are undergoing cesarean sections. The sharp increases in a few districts like Namakkal, Vellore, and Salem suggest that cesarean sections are increasing rapidly in those areas. Several factors may be driving this trend, including the growth of private and upgraded rural hospitals, shifting preferences among women and families, and providers who lean toward caesarean delivery.¹²

The increase in cesarean deliveries in Tamil Nadu reflects the contribution of both government and private hospitals. However, in many districts, the increase is more prevalent in the public sector, suggesting that private sector expansion alone does not explain the trend. This shift highlights changes in clinical decision-making, referral practices, and the growing capacity of government facilities. Investments in public infrastructure, the availability of more surgical units, referral of complex pregnancies to government hospitals, and evolving provider behaviour may be the drivers of the sharp increases observed in districts such as Namakkal, Tirunelveli, Thiruvallur, Vellore and Salem. Meanwhile,

districts with a strong presence of private hospitals, such as Tiruvannamalai, Chennai, Thoothukudi, Villupuram, Nilgiris, Tirunelveli, and Kanyakumari, indicate either a continued growth in private maternity services or a societal preference for private care. Therefore, it is recommended to carry out facility level analyses that adjust for patient risk and case mix to distinguish medically necessary cesareans from those driven by other factors. Furthermore, conducting interviews and focus groups with providers and women is essential to understand how delivery decisions are actually made in each sector. Finally, evaluating whether expanding public sector surgical capacity improves access, health outcomes, and the financial burden on families is crucial.^{12,13}

The findings of this study show that the type of healthcare facility is the most significant factor affecting cesarean deliveries in Tamil Nadu. Women delivering in private hospitals are almost three times more likely to have a cesarean section than those delivering in government hospitals. This aligns with earlier studies conducted in India and various other middle-income nations, where private healthcare facilities are often associated with higher rates of cesarean deliveries due to financial incentives, practices of healthcare providers, and institutional regulations that favor interventional obstetric care.^{10,14} The elevated incidence of cesarean sections in private hospitals underscores the need for policy interventions such as hospital-level audits, adherence to evidence-based guidelines, and obtaining a second medical opinion for non-emergency planned surgeries.

Maternal age is another significant factor; women aged 30 and older are over three times more likely to have a cesarean delivery than those under 20. This is consistent with research indicating that advanced maternal age correlates with increased obstetric complications, a perception of high-risk pregnancies, and a greater preference among physicians for cesarean deliveries.^{6,15} Particularly in districts where the age of mothers at first delivery is increasing, the rise in cesarean section rates with age highlight the importance of targeted counseling and monitoring for older pregnant women.

Certain medical conditions, particularly diabetes and thyroid disorders, were associated with a higher likelihood of cesarean delivery. These findings are consistent with medical guidelines, as these conditions can complicate pregnancy and may necessitate surgical intervention to reduce risks to the mother or the new-born.^{16,17} However, evidence from systematic reviews indicates that women with respiratory disorders such as asthma have a higher rate of cesarean delivery, often due to concerns related to maternal hypoxia, fetal distress, and complications during labour.¹⁸ Heart disease during pregnancy is consistently associated with an increased rate of cesarean deliveries. A cesarean section is often preferred to reduce the circulatory stress during labour and childbirth.¹⁹ Similarly, gestational hypertensive

disorders, particularly severe preeclampsia, fetal distress, or placental complications, are well-established medical reasons for a cesarean delivery.²⁰

The results of the logistic regression analysis emphasize the importance of specific clinical examination, the need for policy focus on non-medical factors, and the impact of maternal age, place of delivery, and certain medical conditions on the probability of cesarean sections. Continuous monitoring of district-level trends and mixed-methods research are essential to guide appropriate localized policies and clinical practices.^{12,13}

Importantly, the determination of this socioeconomic disparity across NFHS-4 and NFHS-5 rounds indicates that the increasing cesarean section rates in the private sector cannot be attributed solely to demographic shifts over time. At the same time, the rising cesarean section rates observed in government hospitals, despite serving a large proportion of women from middle and lower wealth quintiles, point to the presence of additional systemic factors.

CONCLUSION

There is an urgent need for district-specific monitoring and policy action to reduce cesarean sections throughout Tamil Nadu, as they are particularly concentrated in a few districts. The fact that Tamil Nadu's AARI is higher than the national average highlights the necessity of a state-level approach that deviates from national models. Instead of using a uniform, state-wide approach, differentiated interventions are needed due to the wide variation in district patterns.

In Tamil Nadu, cesarean section rates vary widely across districts. This reflects differences in the expansion of medical facilities, surgical expertise, referral practices, and maternity care models. The rapid increases observed in districts like Vilupuram and Tirunelveli contrast with the more moderate trends seen elsewhere. At the same time, the rising rates in rural districts, including Namakkal, Vellore, and Salem, indicate that cesarean sections are no longer confined solely to urban or private sector settings. These trends highlight the need for district-level strategies, strengthened medical audits, and close monitoring of both public and private healthcare facilities to ensure that cesarean sections are performed based on medical necessity and in accordance with evidence-based maternity care.

Both the public and private sectors are driving the overall increase, but in many districts the public sector has shown a higher relative increase. This trend reflects the growing medicalization of childbirth, evidenced by concerns for safety leading to higher c-section rates even without clinical need, and the expansion of capacity and accessibility of well-equipped healthcare facilities within both public and private sectors in regions like Tamil Nadu districts like Namakkal, Tirunelveli, Thiruvallur, Vellore

and Salem are likely to experience growth due to improved infrastructure and increased surgical capacity. Meanwhile, the higher concentration of the private sector in districts across Tamil Nadu, including Tiruvannamalai, Chennai, Thoothukudi, Vilupuram, Nilgiris, Tirunelveli and Kanyakumari, is associated with a significantly greater likelihood of cesarean section, reflecting the prevalent role of the private sector in driving these rates. Findings from logistic regression analysis reinforce the importance of delivery setting, maternal age at first birth, and selected health conditions in shaping the likelihood of cesarean section, and highlight the need to address non-medical drivers through targeted review and policy reform.

Recommendations

To promote safe and equitable delivery practices in Tamil Nadu, policy actions should prioritize district-specific surveillance and audits in areas with high AARI, introduce second-opinion protocols for non-emergency, elective cesareans, and strengthen clinical accountability across both public and private facilities. Districts with rapidly increasing cesarean rates may require enhanced monitoring mechanisms. Differences across districts suggest the need for location-specific strategies rather than uniform state-wide interventions. Expanding evidence-based workforce support across urban facilities, conducting qualitative research with women and providers in hotspot districts, assessing the impact of public-sector surgical expansion, and strengthening data systems through case-mix-adjusted analyses are essential to ensure clinically relevant and patient-centred care.

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