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Original Research Article

STUDY OF IODINE DEFICIENCY, THYROID DISORDERS AND FETO- MATERNAL OUTCOME AMONG PREGNANT WOMEN IN A TERTIARY CARE HOSPITAL IN THE NILGIRIS

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ABSTRACT

Background: Iodine deficiency and thyroid dysfunction during pregnancy are important public health concerns, particularly in low- and middle-income settings. This study aimed to assess iodine status, thyroid disorders, and their associations with maternal and neonatal outcomes among pregnant women attending a tertiary care hospital. **Materials and Methods:** This prospective observational study included 400 pregnant women who attended their first antenatal visit at Nilgiris Medical College between November 2024 and October 2025. Urinary iodine concentration (UIC) was measured using the Sandell–Kolthoff method, and thyroid function was assessed by serum TSH, free T3, and free T4 levels using chemiluminescence immunoassay. Maternal and neonatal outcomes were recorded until the time of delivery. **Results:** Among 400 pregnant women, the mean age was 24.6 ± 4.2 years; 53.3% were aged 18–25 years, and 60% were primigravida. Mild iodine deficiency occurred in 49%, moderate deficiency in 7%, and adequate iodine status in 44%; median urinary iodine concentration was 135 µg/L (IQR 110–165). Most women were euthyroid (75%), while 21.3% had subclinical hypothyroidism. Thyroid status varied with iodine status, with higher subclinical hypothyroidism among iodine-adequate women and overt hypothyroidism in moderate deficiency ($p=0.001$). Iodine status differed by age, trimester, and parity ($p< 0.05$). Anaemia increased with worsening iodine deficiency and remained independently associated with moderate deficiency (AOR 13.2; 95% CI 5.8–30.1). Subclinical hypothyroidism was more common in women aged 26–30 years and in the first trimester ($p< 0.001$). **Conclusion:** Iodine deficiency and subclinical hypothyroidism are common during pregnancy and are strongly associated with anaemia. Routine screening and targeted nutritional interventions should be integrated into antenatal care programs.

INTRODUCTION

Iodine is required for thyroid hormone synthesis. These hormones regulate maternal metabolism and foetal growth. During pregnancy, the iodine requirement increases because of increased thyroid hormone production, higher renal iodine loss, and transfer of iodine to the foetus. In early pregnancy, the foetus depends entirely on maternal thyroid hormones because the foetal thyroid gland is not yet functional.[1,2] When iodine intake is inadequate, maternal thyroid hormone synthesis decreases. Reduced hormone availability during early gestation can affect foetal brain development and growth.3 Iodine deficiency continues to occur in specific geographic regions, even after long-standing salt iodisation programmes. Hilly and mountainous areas are vulnerable because iodine is lost from the soil due to heavy rainfall and erosion. Locally produced food often contains low iodine levels. Limited availability of adequately iodised salt, inconsistent iodisation practices, and iodine loss during storage and cooking further reduce intake.[4,5] Pregnant women are particularly susceptible because iodine intake that is marginal before conception may not meet the increased demands of pregnancy.[6]

Thyroid disorders are common during pregnancy, with subclinical and overt hypothyroidism being more frequently reported than hyperthyroid conditions. Thyroid dysfunction has been associated

with adverse outcomes such as miscarriage, preterm birth, hypertensive disorders of pregnancy, and impaired neurodevelopment in the foetus.[7,8] The relationship between iodine status and thyroid function is not consistent among pregnant women. Thyroid abnormalities can occur in iodine-sufficient individuals due to autoimmune thyroid disease or other non-nutritional causes.[9,10] This lack of direct overlap means that the assessment of iodine status alone may not accurately reflect thyroid function during pregnancy.

In India, iodine nutrition varies widely from region to region. Hill districts have repeatedly shown lower iodine sufficiency than the plains.[4,5] However, most Indian studies on iodine deficiency and thyroid disorders during pregnancy have been conducted in urban or rural settings. However, these findings cannot be directly applied to hilly populations because of differences in geography, dietary patterns, and healthcare access. Studies examining iodine status, thyroid function, and pregnancy outcomes within the same cohort from hill regions are limited. Data on trimester-wise iodine status and its association with maternal anaemia and metabolic outcomes are also scarce across different trimesters of pregnancy. The relationship between iodine status and common maternal outcomes, such as anaemia and gestational diabetes mellitus (GDM), is not clearly defined in hill populations.

The Nilgiris district is a hilly region where pregnant women may face combined nutritional and endocrine risk. Data collected from this setting can guide clinicians in recognising region-specific patterns of iodine insufficiency and thyroid dysfunction, enabling more targeted screening, counselling, and management strategies during antenatal care. This study aimed to assess iodine status and thyroid function among pregnant women in a hilly region and examine their association with selected maternal outcomes. To determine the prevalence of iodine deficiency and thyroid disorders and assess their association with important maternal outcomes, particularly anaemia and GDM.

MATERIALS AND METHODS

This prospective observational study was conducted at Nilgiris Medical College from November 2024 to October 2025 among 400 pregnant women who presented for their first antenatal visit. Ethical committee approval was obtained (IRB No. IRBGMC0051), and written informed consent was obtained from all the participants.

Inclusion and exclusion criteria

Women were included if they were pregnant at any gestational age, irrespective of parity, and agreed to participate in the study.

Women were excluded if they had a diagnosed thyroid disorder before pregnancy and were on treatment, were using drugs that interfered with thyroid function, had recently taken iodine-containing medications, had multiple pregnancies, or had a known foetal anomaly at enrolment.

Methods

The data collected included maternal age, gestational age at enrolment, parity, medical history, and current medication use, along with maternal outcomes such as anaemia, GDM, and preeclampsia, and neonatal outcomes including birth weight, stillbirth, respiratory distress, hypothermia, and early neonatal death. Maternal height and weight were measured at enrolment using standard equipment, and the body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. These data were obtained using a structured questionnaire at enrolment and by reviewing antenatal, delivery, and postnatal records.

Of the 437 pregnant women screened for eligibility, 27 were excluded (18 with pre-existing thyroid disease on treatment, 2 using medications affecting thyroid function, 5 with multiple pregnancies, and 2 who declined consent). A total of 410 women were enrolled, and complete maternal and neonatal outcome data were available for 400.

Spot urine samples were collected at enrolment and stored at −20°C until analysis. Urinary iodine concentration was measured using the ammonium persulphate digestion method followed by the Sandell–Kolthoff reaction, with samples analysed in duplicate. Iodine status was classified using the World Health Organisation pregnancy cut-offs. Blood samples were collected for serum thyroid-stimulating hormone (TSH), free triiodothyronine (free T3), and free thyroxine (free T4) estimation using chemiluminescence immunoassay, applying trimester-specific upper reference limits for the TSH. Thyroid status was categorised as euthyroid, subclinical hypothyroidism, overt hypothyroidism, subclinical hyperthyroidism, or overt hyperthyroidism based on TSH and free T4 levels. Thyroid peroxidase antibody levels were not routinely measured.

Anaemia was defined using trimester-specific haemoglobin thresholds, GDM using the IADPSG criteria, and preeclampsia according to the ACOG definitions. Women diagnosed with thyroid disorders were initiated on levothyroxine as per the American Thyroid Association guidelines with trimester-specific treatment targets, and therapy was continued throughout follow-up. Women with confirmed moderate iodine deficiency received oral iodine supplementation at a dose of 150 µg/day. Participants were followed until delivery and the immediate postpartum period, with in-hospital deliveries documented from records and external deliveries followed through telephone contact and record verification.

Statistical Analysis

Data were analysed using SPSS version 29. Descriptive statistics were used to summarise baseline characteristics and outcome variables. Continuous variables were expressed as mean ± standard deviation or median with interquartile range,

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and categorical variables as frequencies and percentages. Bivariate associations between categorical variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. Multivariate logistic regression analysis was performed to identify independent predictors. Variables with $p < 0.10$ in bivariate analysis were entered into the multivariate model. A p value < 0.05 was considered statistically significant.

RESULTS

Most participants were aged 18–25 years (n = 213, 53.3%), with a mean age of 24.6 ± 4.2 years. The majority were enrolled during the second trimester of pregnancy, 198(49.5%), and primigravida women constituted the largest proportion of the study population, 240(60%), with a BMI of 22.8 ± 3.4 kg/m². [Table 1]

Table 1: Baseline characteristics

Variable	Category	N (%) /OR (Odds ratio)
Age (years)	Mean ± SD	24.6 ± 4.2
	18–25 years	213 (53.3%)
	26–30 years	107 (26.8%)
	31–35 years	80 (20%)
Trimester at enrolment	1st	26 (6.5%)
	2nd	198 (49.5%)
	3rd	176 (44%)
Parity	Primigravida (G1)	240 (60%)
	Second gravida (G2)	120 (30%)
	Third gravida (G3)	40 (10%)
BMI	Mean ± SD (kg/m²)	22.8 ± 3.4

Nearly half of the women had mild iodine deficiency (49%), 44% had adequate iodine status, and 7% had moderate iodine deficiency. The median UIC was 135 µg/L with an interquartile range of 110–165 µg/L. Most patients were euthyroid (75%), subclinical hypothyroidism was present in 21.3%, overt hypothyroidism in 2.8%, and subclinical hyperthyroidism in 1%. [Table 2]

Table 2: Prevalence of iodine status and thyroid disorders

Variable	Category	N (%)
Iodine status	Adequate (150–249 µg/L)	176 (44%)
	Mild deficiency (100–149 µg/L)	196 (49%)
	Moderate deficiency (50–99 µg/L)	28 (7%)
	Median UIC (µg/L)	135 (110–165)
Thyroid status	Euthyroid	300 (75%)
	Subclinical hypothyroid	85 (21.3%)
	Overt hypothyroid	11 (2.8%)
	Subclinical hyperthyroid	4 (1%)

Mild iodine deficiency was most frequent among women aged 18–25 years (57.7%), moderate iodine deficiency was highest in women aged 26–30 years (15.0%) ($p = 0.001$). Iodine deficiency was more common in the second and third trimesters ($p = 0.001$). Primigravida women had the highest prevalence of moderate iodine deficiency (9.6%), and third gravida women had only mild deficiency (50%, $p = 0.044$). [Table 3]

Table 3: Association of obstetric factors with iodine status

Obstetric factors	Category	Adequate (150-249 µg/L)	Mild (100-149 µg/L)	Moderate (50-99 µg/L)	P value
Age	18-25 years	78 (36.6%)	123 (57.7%)	12 (5.6%)	0.001
	26-30 years	60 (56.1%)	31 (29%)	16 (15%)	
	31-35 years	38 (47.5%)	42 (52.5%)	0	
Pregnancy period	1st trimester	22 (84.6%)	4 (15.4%)	0	0.001
	2nd trimester	85 (42.9%)	100 (50.5%)	13 (6.6%)	
	3rd trimester	69 (39.2%)	92 (52.3%)	15 (8.5%)	
Parity	G1	109 (45.4%)	108 (45%)	23 (9.6%)	0.044
	G2	47 (39.2%)	68 (56.7%)	5 (4.2%)	
	G3	20 (50%)	20 (50%)	0	

Subclinical hypothyroidism was most frequent among women aged 26–30 years (46.7%; $p = 0.001$) and among those enrolled during the first trimester (61.5%; $p = 0.001$). Euthyroid status was common in the second (81.3%) and third trimesters (73.3%). Thyroid status did not differ significantly according to parity ($p = 0.13$). Subclinical hypothyroidism was most frequent among women with adequate iodine status (30.1%), while overt hypothyroidism was highest in those with moderate iodine deficiency (10.7%, $p = 0.001$). [Table 4]

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Table 4: Association of maternal factors with thyroid disorders

Variable	Category	Euthyroid	Subclinical hypothyroid	Overt hypothyroid	Subclinical hyperthyroid	p value
Age	18–25 yrs	182 (85.4%)	23 (10.8%)	8 (3.8%)	0	0.001
	26–30 yrs	50 (46.7%)	50 (46.7%)	3 (2.8%)	4 (3.7%)	
	31–35 yrs	68 (85%)	12 (15%)	0	0	
Trimester	1st	10 (38.5%)	16 (61.5%)	0	0	0.001
	2nd	161 (81.3%)	32 (16.2%)	5 (2.5%)	0	
	3rd	129 (73.3%)	37 (21%)	6 (3.4%)	4 (2.3%)	
Parity	G1	180 (75%)	50 (20.8%)	6 (2.5%)	4 (1.7%)	0.13
	G2	84 (70%)	31 (25.8%)	5 (4.2%)	0	
	G3	36 (90%)	4 (10%)	0	0	
Iodine deficiency	Adequate (150-249 µg/L)	114 (64.8%)	53 (30.1%)	5 (2.8%)	4 (2.3%)	0.001
	Mild (100-149 µg/L)	165 (84.2%)	28 (14.3%)	3 (1.5%)	0	
	Moderate (50-99 µg/L)	21 (75.0%)	4 (14.3%)	3 (10.7%)	0	

Anaemia occurs most often in women with moderate deficiency (67.9 %), followed by mild deficiency (40.8 %, $p < 0.001$). GDM was more frequent among women with moderate iodine deficiency (7.1%, $p = 0.034$). Other maternal and neonatal outcomes, including preeclampsia, low birth weight, stillbirth, preterm birth, respiratory distress, and hypothermia, did not differ meaningfully across iodine status categories ($p > 0.05$ for all). [Table 5]

Table 5: Association of iodine status with maternal and neonatal outcomes

Outcome	Adequate	Mild	Moderate	p value
Anaemia	21 (11.9%)	80 (40.8%)	19 (67.9%)	<0.001
GDM	5 (2.8%)	28 (4.1%)	2 (7.1%)	0.034
Preeclampsia	5 (2.8%)	12 (6.1%)	2 (7.1%)	0.267
Low birth weight	4 (2.3%)	9 (4.6%)	3 (10.7%)	0.142
Stillbirth	1 (0.6%)	3 (1.5%)	0	0.621
Preterm birth	6 (3.4%)	8 (4.1%)	1 (3.6%)	0.894
Respiratory distress	2 (1.1%)	10 (5.1%)	1 (3.6%)	0.098
Hypothermia	8 (4.5%)	7 (3.6%)	0	0.453

Table 5: Association of iodine status with maternal and neonatal outcomes

Outcome	Adequate	Mild	Moderate	p value
Anaemia	21 (11.9%)	80 (40.8%)	19 (67.9%)	<0.001
GDM	5 (2.8%)	28 (4.1%)	2 (7.1%)	0.034
Preeclampsia	5 (2.8%)	12 (6.1%)	2 (7.1%)	0.267
Low birth weight	4 (2.3%)	9 (4.6%)	3 (10.7%)	0.142
Stillbirth	1 (0.6%)	3 (1.5%)	0	0.621
Preterm birth	6 (3.4%)	8 (4.1%)	1 (3.6%)	0.894
Respiratory distress	2 (1.1%)	10 (5.1%)	1 (3.6%)	0.098
Hypothermia	8 (4.5%)	7 (3.6%)	0	0.453

Anaemia occurred mostly in women with overt hypothyroidism (36.4%), followed by euthyroid women (35.7%), and subclinical hypothyroidism (9.4%; $p < 0.001$). Other maternal and neonatal outcomes, including GDM, preeclampsia, low birth weight, stillbirth, preterm birth, respiratory distress, and hypothermia, did not vary significantly across the thyroid status categories ($p > 0.05$ for all). [Table 6]

Table 6: Association of thyroid status with maternal and neonatal outcomes

Outcome	Euthyroid	Subclinical hypothyroid	Overt hypothyroid	Subclinical hyperthyroid	p value
Anaemia	107 (35.7%)	8 (9.4%)	4 (36.4%)	1 (25%)	<0.001
GDM	12 (4.0%)	3 (3.5%)	0	0	0.872
Preeclampsia	16 (5.3%)	2 (2.4%)	1 (9.1%)	0	0.412
Low birth weight	13 (4.3%)	3 (3.5%)	0	0	0.894
Stillbirth	4 (1.3%)	0	0	0	0.752
Preterm birth	13 (4.3%)	1 (1.2%)	1 (9.1%)	0	0.156
Respiratory distress	12 (4.0%)	1 (1.2%)	0	0	0.334
Hypothermia	12 (4.0%)	3 (3.5%)	0	0	0.982

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Moderate and mild iodine deficiency was strongly associated with anaemia ($p < 0.001$). Younger maternal age (18–25 years) was independently associated with anaemia ($p = 0.012$). A higher BMI was associated with GDM ($p = 0.021$). Adequate iodine status was associated with higher odds of subclinical hypothyroidism ($p = 0.001$). Subclinical hypothyroidism has a high chance of occurring among women aged 26–30 years ($p < 0.001$) and those enrolled in the first trimester ($p < 0.001$). [Table 7]

Table 7: Multivariate analysis of factors associated with anaemia, gestational diabetes, and subclinical hypothyroidism

Variable	Category	Anaemia (n=120) AOR (95% CI)	p value	GDM (n=15) AOR (95% CI)	p value	Subclinical Hypothyroidism (n=85) AOR (95% CI)	p value
Iodine Status	Adequate	Reference	-	Reference	-	2.6 (1.5-4.5)	0.001
	Mild deficiency	4.8 (2.5-9.2)	<0.001	1.5 (0.5-4.6)	0.489	Reference	-
	Moderate deficiency	13.2 (5.8-30.1)	<0.001	2.1 (0.7-6.3)	0.183	1.0 (0.3-3.1)	0.961
Age	18–25 years	2.3 (1.2-4.4)	0.012	0.8 (0.2-2.9)	0.712	0.6 (0.3-1.3)	0.201
	26–30 years	1.6 (0.8-3.2)	0.178	1.2 (0.3-4.5)	0.789	4.8 (2.4-9.6)	<0.001
	31–35 years	Reference	-	Reference	-	Reference	-
Parity	G1	1.4 (0.6-3.1)	0.423	0.9 (0.2-3.8)	0.876	2.1 (0.7-6.4)	0.188
	G2	1.2 (0.5-2.9)	0.681	1.1 (0.3-4.6)	0.891	2.4 (0.8-7.5)	0.125
	G3	Reference	-	Reference	-	Reference	-
Trimester at enrolment	1st trimester	Reference	-	-	-	6.2 (2.4–16.0)	<0.001
	2nd trimester	1.1 (0.4–3.2)	0.845	-	-	0.7 (0.4–1.2)	0.189
	3rd trimester	0.9 (0.3–2.7)	0.823	-	-	Reference	-
BMI (per kg/m²)	Continuous	0.98 (0.92–1.04)	0.512	1.12 (1.02–1.23)	0.021	-	-

DISCUSSION

Iodine deficiency and thyroid dysfunction during pregnancy are important health concerns, particularly in regions such as hilly areas where soil iodine depletion is common. This study evaluated iodine status and thyroid function among pregnant women in a hilly region and examined their association with maternal outcomes. The findings show a high prevalence of mild iodine deficiency, a predominance of euthyroid status followed by subclinical hypothyroidism, significant trimester-specific variations, and a strong association between iodine deficiency and maternal anaemia, while most other maternal and neonatal outcomes showed no significant variation.

In our study, most participants were aged 18–25 years (213, 53.3%), enrolled during the second trimester (198, 49.5%), and primigravida (240, 60.0%). Similarly, Sonowal et al. found that most women were in the younger reproductive age group of 21–30 years, accounting for 162 participants (40.5%), comprising 99 euthyroid and 59 subclinical hypothyroid cases, indicating that the cohort was largely composed of young pregnant women.[11] Therefore, both studies included predominantly young pregnant women, indicating similar reproductive age profiles and supporting the comparability of maternal characteristics.

In this study, iodine status varied by age, trimester, and parity, with greater deficiency among younger and primigravida women and better adequacy in early pregnancy ($P < 0.05$). Similarly, Pan et al. found that iodine status varied by maternal factors: median urinary iodine concentration was adequate in the first trimester (156.3 µg/L), lowest in the second trimester (146.2 µg/L), and nulliparous women showed higher iodine insufficiency (62.4% vs. 41.9%, $p < 0.05$).[12] Jauhari et al. found that iodine status differed across maternal factors: younger women showed higher iodine insufficiency, adequacy was most evident in the first trimester with a median UIC of 252.5 µg/L, and nulliparous women had greater vulnerability to low iodine status ($p < 0.05$).[13] These findings show that iodine status changes with pregnancy stage and maternal characteristics, particularly younger age and nulliparity, and suggest their influence on iodine sufficiency during pregnancy.

Our study shows that euthyroid status predominated, with subclinical hypothyroidism more common in women aged 26–30 years and early pregnancy, independent of parity. Overt hypothyroidism was highest among women with moderate iodine deficiency, while subclinical hypothyroidism was more frequent in women with adequate iodine status ($p = 0.001$). Similarly, Mainali et al. found that among 160 pregnant women, most were euthyroid (92.5%), while hypothyroidism was present in 4.4%

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(subclinical 3.1%, overt 2.5%) and hyperthyroidism in 3.1% (subclinical 1.9%, overt 1.3%).[14] Dhanwal et al. reported using trimester-specific TSH cut-offs; hypothyroidism was most common in the first trimester (44.3%), compared with the second (32.0%) and third trimesters (34.0%), and the study did not report any significant variation in thyroid status by parity.[15] Wu et al. reported that thyroid dysfunction was more frequent with iodine deficiency, with isolated hypothyroxinemia highest in women with UIC <150 µg/L (7.4%; p = 0.033).[16] These studies support our findings by showing euthyroid predominance, higher hypothyroidism in early pregnancy, and minimal parity influence, highlighting the role of iodine status, age, and gestational stage in thyroid function. The higher prevalence of subclinical hypothyroidism among women with adequate iodine status in our study may be due to non-iodine-mediated thyroid dysfunction, including autoimmune thyroiditis or physiological TSH variation in early pregnancy, as thyroid autoantibodies were not assessed.

In our study, anaemia was significantly associated with iodine deficiency and overt hypothyroidism, while other maternal and neonatal outcomes showed no significant variation. Similarly, Sonowal et al. found that anaemia increased with worsening iodine deficiency, from 9.5% in adequate iodine to 38.6% in mild and 86.4% in moderate deficiency (p = 0.00). GDM (p = 0.02) and preeclampsia (p = 0.04) were also higher with lower iodine, while foetal and neonatal outcomes showed no significant differences.[11] Singh et al. reported that anaemia differed significantly by thyroid status, occurring in 61% of euthyroid women, 35% with subclinical hypothyroidism, and 4% with overt hypothyroidism (p = 0.007). Anaemia severity and red cell indices showed no significant association with TSH or FT4 levels (p > 0.05).[17] Thus, both studies show anaemia rising with iodine deficiency and thyroid dysfunction, while most foetal and neonatal outcomes remain unaffected, supporting our findings.

In our study, iodine deficiency and younger maternal age were independently associated with anaemia, whereas subclinical hypothyroidism was independently associated with age 26–30 years and first-trimester enrolment. Similarly, Simpong et al. found that the median urinary iodine concentration was significantly lower in pregnant women during the second and third trimesters (p = 0.033 each), and anaemia was more common among younger women, especially those aged 16–19 years, while gestational weight was also significantly lower in anaemic participants (p < 0.05).[18] This study supports our findings by showing that lower iodine status and younger age independently increase the risk of anaemia, particularly in later pregnancy.

Limitations: This was a single-centre study conducted in a hilly region, which limits generalisability, and there was no comparison group from non-hilly areas. Iodine status was assessed using a single spot urinary iodine concentration, which shows recent intake rather than long-term status. The relatively small number of certain outcomes, including moderate iodine deficiency and overt thyroid dysfunction, may have reduced statistical power. Thyroid antibody levels were not measured, preventing mechanistic differentiation between iodine-related and autoimmune thyroid dysfunction. Treatment initiated for identified thyroid disorders and iodine deficiency may have influenced outcome associations. Long-term neurodevelopmental follow-up of infants was not performed. Outcomes from external deliveries were partly obtained through telephonic follow-up, causing possible information bias.

CONCLUSION

Most of the pregnant women in this hilly region suffer from iodine deficiency and thyroid disorders, with clear trimester-specific patterns and a significant association between iodine deficiency and maternal anaemia. Although most women were euthyroid, subclinical hypothyroidism was common, including among those with adequate urinary iodine levels, suggesting possible roles of autoimmune thyroid disease, reverse causation, or measurement variability. Integrating routine iodine status assessment and thyroid function testing into antenatal care is necessary. Future multicentre longitudinal studies should evaluate dietary iodine intake, thyroid autoimmunity, and long-term maternal and neonatal outcomes to inform preventive strategies.

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