



Urinary Iodine Status and Associated Factors among Children Aged 3–5 Years and the Elderly in Thailand, 2023–2025

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Abstract

Objectives: To assess the iodine status and identify associated dietary factors among children aged 3–5 years and adults aged ≥60 years in Thailand within the context of current national fortification policies.

Methods: A national cross-sectional survey from 2023 to 2025 was conducted using multi-stage cluster sampling across 77 provinces. Spot urinary iodine concentrations (UIC) were measured in 11,028 children and 11,183 older adults. Dietary behaviors were assessed via questionnaires and analyzed using multivariable linear regression to identify independent predictors of UIC while adjusting for socioeconomic and demographic confounders.

Results: The national median UIC level for children aged 3–5 years was 222.0 ug/L (interquartile range (IQR) 204.4–238.9) and for older adults was 111.4 ug/L (IQR 96.2–136.0). Among children, processed food consumption was associated with higher UIC (adjusted regression coefficients (adjusted β) 17.55, 95% confidence interval (CI) 0.68 to 34.43). In older adults, a positive trend was observed between the consumption of iodine-fortified condiments and iodine status (adjusted β 10.66, 95% CI –0.24 to 21.56). Lower UIC was independently associated with advanced age (≥81 years: adjusted β –18.76, 95% CI –33.12 to –4.39), and history of kidney disease (adjusted β –27.30, 95% CI –50.76 to –3.83) and diabetes mellitus (adjusted β –10.72, 95% CI –19.94 to –1.50).

Public Health Recommendations: Adequate population-level iodine status for both groups (according to UNICEF/ICCIDD and WHO criteria), underscores the importance of universal salt iodization programs and iodine fortification policies for condiments in Thailand. Addressing regional and clinical vulnerabilities requires strict enforcement of fortification standards to ensure the consistent delivery of sufficient iodine to the population. Policies promoting dietary patterns aligned with national guidelines should also be strengthened to safeguard population-wide iodine security.

Keywords: iodine deficiency, urinary iodine concentration, universal salt iodization, older adults, preschool children, Thailand



Introduction

Iodine deficiency remains a critical global public health concern as iodine is an essential nutrient for thyroid hormone synthesis. Thyroid hormones are essential for physical growth, brain development, and various physiological functions, particularly during early life stages.¹ At the population level, insufficient iodine intake can impair cognitive development, reduce intellectual potential, and adversely affect overall health and long-term quality of life.²

Over the past decades, substantial global progress has been achieved in controlling iodine deficiency disorders through mandatory salt iodization policies recommended by the World Health Organization (WHO).³ According to the Iodine Global Network (IGN), the number of iodine-deficient countries declined from 113 in 1993 to 21 in 2021, underscoring universal salt iodization as the cornerstone strategy for population iodine nutrition.⁴

In Thailand, iodine control policies began in 1989. The current National Action Plan for the Control and Prevention of Iodine Deficiency Disorders (2022–2027) prioritizes universal salt iodization, supplemented by mandatory seasoning fortification under the notification of the Ministry of Public Health (No. 331) B.E. 2554 (2011), targeting dietary staples such as fish sauce, soy protein seasoning, and cooking brine.^{5–7} This framework mandates iodized salt production while promoting iodine-rich foods through public health education. Population iodine status is evaluated via the median urinary iodine concentration (MUIC), the standard WHO indicator.^{11,12} National surveillance involves annual monitoring for pregnant women and cyclic monitoring for children aged 3–5 years and older adults, which was established during 2014–2016 and most recently conducted between 2023 and 2025. Notably, 2022 data among pregnant women revealed a sub-optimal MUIC of 149.7 µg/L (recommended threshold ≥ 150 µg/L) alongside persistent regional deficiencies, particularly in the Northeast, while household iodized salt coverage reached only 84%, falling short of the 90% national target.^{13,14}

Although the 2014–2016 Cyclic Monitoring System indicated adequate MUIC levels among Thai children aged 3–5 years and older adults (≥ 60 years), these findings predate recent dietary shifts, including increased processed food consumption and altered iodine sources.^{15–17} Up-to-date evidence on iodine status and its dietary determinants remains limited.¹⁸ Therefore, this study was conducted to assess the urinary iodine status and identify associated dietary

factors among children aged 3–5 years and older adults in Thailand, providing evidence to strengthen national surveillance and support targeted interventions under the National Action Plan for the Control and Prevention of Iodine Deficiency Disorders.^{5,6}

Methods

Study Design

This study was conducted as a national survey using a multi-stage cluster sampling design as part of the cyclic monitoring system (2023–2025) to assess urinary iodine levels among children aged 3–5 years and older adults in Thailand. The surveillance aims to support national and provincial planning for iodine deficiency disorder control. Over the three-year cycle, all 77 provinces were included.

Study Population and Eligibility Criteria

The study population comprised children aged 3–5 years and adults aged 60 years and above registered in the Bureau of Registration Administration database under the Department of Provincial Administration, Ministry of Interior, and residing in the selected villages during the study period. At the village level, five participants per age group were randomly selected from local registries using simple random sampling, yielding 150 participants per age group per province. Participants were excluded if they had clinical disorders interfering with thyroid function or urinary iodine levels, incomplete essential data preventing comprehensive analysis, or if consent was voluntarily withdrawn at any point.

Sampling and Sample Size Calculation

A stratified multi-stage sampling procedure was conducted. At the first stage, provinces were selected using stratified random sampling based on the jurisdictions of the 12 Regional Health Centers and the Bangkok Metropolitan Administration to ensure geographic representation. Within each stratum, provinces were randomly selected using computer-generated randomization. Between 24 and 29 provinces were surveyed annually during 2023–2025 (Table 1). At the second stage, within each selected province, thirty villages were sampled using probability proportionate to size using population data from Department of Provincial Administration, Ministry of Interior. At the third stage, within each village, individuals were randomly selected from official population lists using simple random sampling. Two cohorts were included: children aged 3–5 years and adults aged ≥ 60 years.

Table 1. List of provinces randomly selected for sampling among children aged 3–5 years and older adults aged ≥60 years, 2023.

Regional Health Promotion Center	Year		
	2023	2024	2025
Regional Health Promotion Center 1 Chiang Mai	Lamphun, Phayao	Chiang Rai, Nan, Mae Hong Son	Chiang Mai, Phrae, Lampang
Regional Health Promotion Center 2 Phitsanulok	Phitsanulok, Phetchabun	Tak, Sukhothai	Uttaradit
Regional Health Promotion Center 3 Nakhon Sawan	Kamphaeng Phet, Uthai Thani	Phichit, Chai Nat	Nakhon Sawan
Regional Health Promotion Center 4 Saraburi	Sing Buri, Ang Thong	Pathum Thani, Saraburi, Phra Nakhon Si Ayutthaya	Lopburi, Nonthaburi, Nakhon Nayok
Regional Health Promotion Center 5 Ratchaburi	Samut Songkhram, Ratchaburi	Nakhon Pathom, Samut Sakhon, Prachuap Khiri Khan	Suphan Buri, Kanchanaburi
Regional Health Promotion Center 6 Chonburi	Sa Kaeo, Chanthaburi	Chachoengsao, Trat, Rayong	Prachin Buri, Chon Buri, Samut Prakan
Regional Health Promotion Center 7 Khon Kaen	Kalasin, Roi Et	Maha Sarakham, Khon Kaen	-
Regional Health Promotion Center 8 Udon Thani	Udon Thani, Nong Khai	Nakhon Phanom, Sakon Nakhon	Nong Bua Lamphu, Bueng Kan, Loei
Regional Health Promotion Center 9 Nakhon Ratchasima	Buriram, Surin	Chaiyaphum, Nakhon Ratchasima	-
Regional Health Promotion Center 10 Ubon Ratchathani	Si Sa Ket, Amnat Charoen	Yasothon, Ubon Ratchathani	Mukdahan
Regional Health Promotion Center 11 Nakhon Si Thammarat	Surat Thani, Chumphon	Ranong, Krabi	Nakhon Si Thammarat, Phang Nga, Phuket
Regional Health Promotion Center 12 Yala	Phatthalung, Songkhla	Yala, Satun	Trang, Narathiwat, Pattani
Metropolitan Health and Wellness Institution		Bangkok	

The provincial sample size was calculated using the population proportion formula adjusted for cluster sampling:

$$n = \frac{Z_{\alpha/2}^2 P(1 - P) \times DEFF}{d^2}$$

Based on 2011 surveillance data, an expected proportion (P) of 0.10 was applied to both cohorts. Incorporating a 95% confidence level (Z=1.96), a margin of error (d) of 0.06, and a design effect (DEFF) of 1.5 to account for clustering, the required sample size was determined to be 150 participants per age group per province.^{19,20} Since 30 villages were chosen from each province, five individuals from each of the two cohorts were selected per village, yielding 10 participants per village.

Data Collection

Separate standardized surveillance questionnaires, validated by five experts with an Index of item-objective congruence of 0.89 and pilot-tested for reliability, were administered to adults ≥60 years and caregivers of children aged 3–5 years. The tools captured demographics, household iodine practices, and a 7-day food frequency record. Trained personnel across the 12 Regional Health Centers followed standardized protocols to collect spot urine samples and interview participants. UIC was quantified using ammonium persulfate digestion with a microplate kinetic assay. All data were centrally managed and audited for quality prior to analysis.

Dietary data were collected and analyzed at the individual level, while iodine status was aggregated for regional estimates, utilizing a 5-point scale to score food consumption frequency: non-consumption=0, 1–3 days/month=1, 1–3 days/week=2, 4–6 days/week=3, and daily=4, without quantifying portions or amounts.

Iodine-rich foods were classified into five distinct groups, with raw frequency scores summed and converted into a percentage of the maximum possible score to standardize comparison: iodine-fortified condiments (four items including iodized salt, fish sauce, soy sauce/seasoning sauce, and cooking brine; maximum 16 points); seafood (five items including fish, shrimp, crab, squid, and seaweed; maximum 20 points); eggs (one item including all egg types; maximum four points); milk (one item including all milk; maximum four points); and processed foods (five items including sausages/meatballs, savory snacks, instant noodles, fermented foods, and dried foods; maximum 20 points).

All survey and laboratory data were integrated into a central database and audited for consistency. Missing data were handled using complete-case analysis.

Statistical Analysis

Descriptive statistics including frequencies, percentages, medians, and interquartile ranges (IQR) were used to summarize urinary iodine status. National and regional estimates of MUIC were calculated. The population iodine status was assessed using the United Nations Children's Fund (UNICEF), and the International council for control of iodine deficiency disorders (ICCIDD) criteria for children (adequate 100–299 µg/L) and WHO criteria for older adults (adequate 100–199 µg/L). Regional differences in MUIC and UIC <100 µg/L were assessed using the Kruskal–Wallis and Pearson chi-square tests, respectively. To identify independent predictors of UIC, data from the 2023 dietary behavior survey conducted as part of the national iodine survey 2023–2025 was analyzed due to its availability. Multivariable linear regression was performed to identify independent predictors of individual-level UIC, focusing on specific iodine-rich food groups (including iodine-fortified condiments, seafood, milk, eggs, and processed foods). For food consumption, percentage scores of each food group were

dichotomized into two levels: never/rarely (<20%) as the reference group, and occasional and above (20% and above) as the comparison group.

The regression models systematically adjusted for key socioeconomic, demographic, and health-related confounders, including age, gender, household income, geographic region, and residential area for both cohorts, with the inclusion of primary food preparer and food preparation for children and specific underlying medical conditions for older adults. Statistical significance level was set at *p*-value <0.05. Analyses were performed using IBM SPSS Statistics version 23.

Results

Demographic Characteristics

The study sample consisted of 11,028 children and 11,183 older adults (Figure1). The regional distribution of both cohorts was relatively consistent, with the highest proportion residing in the Central region of Thailand followed by the Northeast, North, and South respectively (Table 2). For the 2023 dietary behavior sub-analysis, 3,237 children and 3,367 older adults were included. Among the children, the gender distribution was nearly equal, and approximately 61.8% lived in non-municipal areas. Notably, parents were the primary food preparers in the Central and Southern regions, while grandparents predominated in the North and Northeast (Table 3). Among the older adults, the majority were female (75.1%) and aged between 60–70 years (63.7%). Furthermore, 63.2% reported having chronic conditions, primarily hypertension (Table 3).

Urinary Iodine Status

The national MUIC for children aged 3–5 years was 222.0 µg/L (IQR 204.4–238.9). Regionally, the North recorded the highest MUIC at 226.0 µg/L, while the Northeast recorded the lowest at 206.0 µg/L. 10.2% of children had urinary iodine concentrations below 100 µg/L (Table 2).

Among older adults, the national MUIC was 111.4 µg/L (IQR 96.2–136.0). The highest MUIC was seen in the South at 131.1 µg/L, whereas the Northeast recorded the lowest at 90.2 µg/L. At the individual level, 40.8% of older adults had a UIC below 100 µg/L (Table 2).

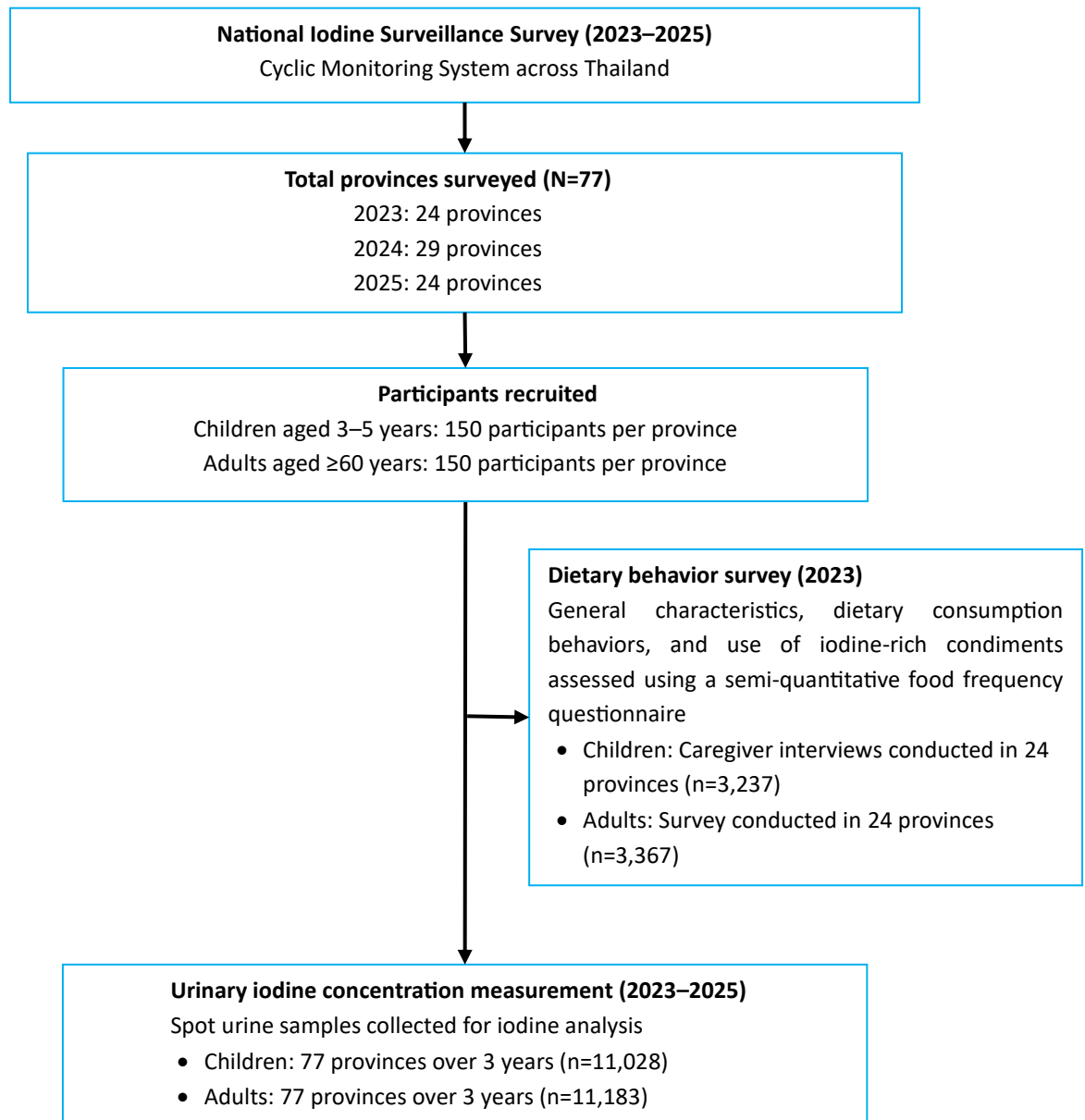


Figure 1. Study flowchart for assessing urinary iodine concentration and associated factors among children aged 3–5 years and older adults aged ≥60 years in Thailand, 2023–2025.

Table 2. Median and inadequate urinary iodine concentrations among children aged 3–5 years and older adults aged ≥60 years in Thailand stratified by region, 2023–2025.

Cohort	Region					P-value
	National	Central	Southern	Northern	Northeastern	
Children, n	11,028	3,652	2,007	2,635	2,734	
UIC (µg/L), median (IQR)	222.0 (204.4, 238.9)	222.0 (214.8, 234.1)	219.5 (212.6, 235.0)	226.0 (195.4, 243.0)	206.0 (191.6, 260.3)	0.382*
Inadequate UIC [§] , n (%)	1,124 (10.2)	348 (9.5)	139 (6.9)	263 (10.0)	374 (13.7)	<0.001 [†]
Older adults, n	11,183	3,659	2,045	2,662	2,817	
UIC (µg/L), median (IQR)	111.4 (96.2, 136.0)	128.5 (104.5, 136.0)	131.1 (122.9, 148.6)	111.4 (97.0, 128.2)	90.2 (81.1, 136.0)	0.004*
Inadequate UIC [§] , n (%)	4,564 (40.8)	1,371 (37.5)	623 (30.5)	1,127 (42.3)	1,443 (51.2)	<0.001 [†]

*P-values were calculated using the Kruskal–Wallis test. [†]P-values were calculated using Pearson chi-square test. [§]<100 µg/L. UIC: Urinary iodine concentration. IQR: Interquartile range.

Table 3. General characteristics of children aged 3–5 years and older adults aged ≥60 years included in the survey of iodine-rich food consumption behaviors, 2023.

Characteristics	National n (%)	Central n (%)	Southern n (%)	Northern n (%)	Northeastern n (%)
Children	N=3,237	N=824	N=533	N=871	N=1,009
Gender					
Male	1,674 (51.7)	440 (53.4)	274 (51.4)	461 (52.9)	499 (45.4)
Female	1,556 (48.1)	382 (46.4)	256 (48.0)	409 (47.0)	509 (46.3)
Age (years)					
3	1,189 (36.7)	307 (37.3)	201 (37.7)	300 (34.4)	381 (34.7)
4	1,189 (36.7)	299 (36.3)	222 (41.7)	330 (37.9)	338 (30.8)
5	859 (26.5)	218 (26.5)	110 (20.6)	241 (27.7)	290 (26.4)
Place of residence					
Municipal area	1,164 (36.0)	320 (38.8)	240 (45.0)	336 (38.6)	268 (26.6)
Non-municipal area	2,002 (61.8)	457 (55.5)	278 (52.2)	531 (61.0)	736 (72.9)
Not reported	71 (2.2)	47 (5.7)	15 (2.8)	4 (0.5)	5 (0.5)
Primary caregiver responsible for meal preparation					
Parents	1,632 (50.4)	430 (52.2)	362 (67.9)	391 (44.9)	449 (40.9)
Grandparents	1,484 (45.8)	359 (43.6)	158 (29.6)	444 (51.0)	523 (47.6)
Siblings/relatives	85 (2.6)	22 (2.7)	9 (1.7)	23 (2.6)	31 (2.8)
Others	29 (0.9)	10 (1.2)	2 (0.4)	16 (1.8)	4 (0.4)
Older adults	N=3,367	N=831	N=546	N=891	N=1,099
Gender					
Male	837 (24.9)	219 (26.4)	126 (23.1)	237 (26.6)	255 (23.2)
Female	2,530 (75.1)	612 (73.6)	420 (76.9)	654 (73.4)	844 (76.8)
Age group (years)					
60–70	2,145 (63.7)	513 (61.7)	342 (62.6)	598 (67.1)	692 (63.0)
71–80	959 (28.5)	254 (30.6)	153 (28.0)	242 (27.2)	310 (28.2)
≥81	236 (7.0)	56 (6.7)	51 (9.3)	51 (5.7)	78 (7.1)
Not reported	27 (0.8)	8 (1.0)	0 (0)	0 (0)	19 (1.7)
Place of residence					
Municipality	1,281 (38.0)	361 (43.4)	271 (49.6)	342 (38.4)	307 (27.9)
Non-municipality	2,077 (61.7)	467 (56.2)	270 (49.5)	549 (61.6)	791 (72.0)
Not reported	9 (0.3)	3 (0.4)	5 (0.9)	0 (0)	1 (0.1)
History of chronic disease					
No	1,215 (36.1)	246 (29.6)	182 (33.3)	294 (33.0)	493 (44.9)
Yes	2,129 (63.2)	585 (70.4)	353 (64.7)	597 (67.0)	594 (54.0)
Goiter	32 (1.0)	7 (0.8)	5 (0.9)	8 (0.9)	12 (1.1)
Kidney disease	82 (2.4)	18 (2.2)	13 (2.4)	26 (2.9)	25 (2.3)
Hypertension	1,557 (46.2)	452 (54.4)	250 (45.8)	453 (50.8)	402 (36.6)

Dietary Behaviors and Associated Factors

Using data from the 2023 Dietary Behavior Survey of the National Iodine Surveillance Survey (2023–2025), multivariable analysis revealed that among children aged 3–5 years, processed food consumption was the sole independent dietary predictor of higher UIC. Compared with children aged 3–5 years who never or rarely consumed process foods, those with occasional or more frequent consumption had a UIC that was 17.55 ug/L higher, after controlling for all confounding

variables included in Table 4 (adjusted regression coefficients (adjusted β) 17.55, 95% CI 0.68 to 34.43). Geographic region also strongly predicted pediatric iodine status; relative to the Central region, children in the South had significantly higher UIC (adjusted β 29.61, 95% CI 11.42 to 47.81), whereas those in the North exhibited significantly lower levels (adjusted β –22.33, 95% CI –38.43 to –6.22). Other whole-food categories, including milk, eggs, and seafood, lost statistical significance on multivariable analysis.

Table 4. Multivariable linear regression of factors associated with iodine nutrition status among children aged 3–5 years.

Variables	Urinary iodine concentration (µg/L)	
	Adjusted β	95% confidence interval
Region		
Central	reference	
Northern	–22.33	–38.43, –6.22
Northeastern	–0.59	–15.22, 16.40
Southern	29.61	11.42, 47.81
Age (years)		
3	reference	
4	–3.52	–16.65, 9.60
5	–18.30	–32.62, –3.98
Area of residence		
Rural	reference	
Urban	–12.87	–24.73, –1.02
Food preparation		
Food prepared similarly to adult meals	reference	
Food prepared separately for children	10.94	–0.81, 22.68
Convenience food consumption	–24.90	–94.42, 44.62
Consumption of iodine-rich foods		
Iodine-fortified condiments*		
Never/rarely	reference	
Occasionally and above	–13.66	–31.40, 4.08
Seafood[†]		
Never/rarely	reference	
Occasionally and above	–10.84	–23.81, 2.13
Milk		
Never/rarely	reference	
Occasionally and above	5.79	–40.47, 52.05
Eggs		
Never/rarely	reference	
Occasionally and above	8.46	–32.17, 49.08
Processed foods*		
Never/rarely	reference	
Occasionally and above	17.55	0.68, 34.43

The model was also adjusted for gender, income and food preparer. *Food group definitions: seafood includes fish, shrimp, crab, squid, and seaweed; processed foods include sausages or meatballs, savory snacks, instant noodles, fermented foods, and dried foods; iodine-fortified condiments include iodized salt, fish sauce, soy sauce/seasoning sauce, and cooking brine. Adjusted β : adjusted regression coefficients.

As shown in Table 5, among older adults, residing in the Northern (adjusted β –14.83, 95% CI –24.97 to –4.68) and Northeastern regions (adjusted β –27.93, 95% CI –37.79 to –18.07) was significantly associated with lower UIC. Advanced age (≥ 81 years: adjusted β –18.76, 95% CI –33.12 to –4.39) and a clinical history of kidney disease (adjusted β

–27.30, 95% CI –50.76 to –3.83) or diabetes mellitus (adjusted β –10.72, 95% CI –19.94 to –1.50) were also significantly associated with lower UIC. The use of iodine-fortified condiments demonstrated a positive trend, although the association was not statistically significant (adjusted β 10.66, 95% CI –0.24 to 21.56).

Table 5. Multivariable linear regression of factors associated with iodine nutrition status among older adults aged ≥60 years.

Variables	Urinary iodine concentration (µg/L)	
	Adjusted β	95% confidence interval
Region		
Central	reference	
Northern	-14.83	-24.97, -4.68
Northeastern	-27.93	-37.79, -18.07
Southern	-1.80	-13.45, 9.85
Age group (years)		
60–70	reference	
71–80	-7.35	-15.50, 0.80
≥81	-18.76	-33.12, -4.39
Area of residence		
Rural	reference	
Urban	3.79	-3.78, 11.35
Chronic disease		
None	reference	
Goiter	26.99	-9.88, 63.86
Hypertension	-1.58	-9.21, 6.05
Heart disease	5.30	-12.44, 23.03
Kidney disease	-27.30	-50.76, -3.83
Diabetes mellitus	-10.72	-19.94, -1.50
Consumption of iodine-rich foods		
Iodine-fortified condiments*		
Never/rarely	reference	
Occasionally and above	10.66	-0.24, 21.56
Seafood†		
Never/rarely	reference	
Occasionally and above	6.97	-0.92, 14.86
Milk		
Never/rarely	reference	
Occasionally and above	-3.06	-13.05, 6.94
Eggs		
Never/rarely	reference	
Occasionally and above	-10.58	-30.59, 9.43
Processed foods*		
Never/rarely	reference	
Occasionally and above	2.06	-5.59, 9.72

The model was adjusted for gender and income. *Food group definitions: seafood includes fish, shrimp, crab, squid, and seaweed; processed foods include sausages or meatballs, savory snacks, instant noodles, fermented foods, and dried foods; iodine-fortified condiments include iodized salt, fish sauce, soy sauce/seasoning sauce, and cooking brine. Adjusted β : adjusted regression coefficients.

Discussion

The findings of this study demonstrate that Thailand has maintained adequate iodine nutrition at the national level according to UNICEF/ICCIDD and WHO criteria. The iodine sufficiency observed in both children and older adults reflects the sustained impact of long-term iodine deficiency prevention and control

policies. Although national MUIC indicates iodine sufficiency at the population level, a proportion of individuals with insufficient iodine intake remains. Approximately 10% of children aged 3–5 years and more than one-third of older adults had urinary iodine concentrations below 100 µg/L. According to WHO guidelines, MUIC is intended to assess iodine status at the population level rather than diagnose deficiency in

individuals.^{11,12} However, the presence of individuals with low iodine intake suggests that certain subgroups remain vulnerable to iodine insufficiency. These findings highlight the importance of maintaining targeted public health interventions and continued surveillance to ensure iodine sufficiency across population groups.

Among children aged 3–5 years, consumption of processed food was the sole independent dietary risk factor of a higher urinary iodine concentration. This trend aligns with Thailand's shifting food landscape, where there has been heavy penetration of commercial convenience foods that are frequently manufactured using fortified iodized salt into early childhood diets.^{21–23} While this commercial exposure inadvertently maintains population level iodine sufficiency among young children, it runs directly counter to national dietary guidelines that advise limiting ultra-processed products due to risks of childhood obesity and excessive sodium exposure. Geographic variables independently affected pediatric iodine status. Relative to the Central region, children in the South had significantly higher UIC, while those in the North exhibited lower levels. This regional variation underscores disparities in food iodine quality and nutrient density rather than ingestion rates. Coastal populations have direct access to fresh marine organisms that often retain maximal natural iodine, though this varies substantially by species, tissue type, and habitat.²⁴

Among older adults, although the association between the consumption of iodine-fortified condiments and iodine status did not reach statistical significance in the multivariable analysis, a positive trend was evident. These findings support the continued implementation of iodine fortification policies for condiments to help ensure adequate iodine intake in the population. In contrast, the geographical protection of coastal proximity was completely absent among older adults, where living in both the Northern and Northeastern regions, which are far from the coast, were independent predictors of severe UIC deficits. This baseline regional insufficiency suggests that older adults may consume protein-rich seafood less frequently or in smaller proportions due to age-related dietary shifts, obviating protection that geographical proximity to the ocean might afford.²⁵ Although aging is associated with a reduced glomerular filtration rate and may influence urinary iodine excretion, the low UIC in older adults observed in this study suggests that inadequate iodine intake remains a primary cause, but can be exacerbated by reduced kidney function and/or diabetes mellitus.^{26–28}

Overall, these findings emphasize the critical need for sustained policy enforcement within universal salt iodization and seasoning fortification programs. To address regional disparities and clinical vulnerabilities, maintaining rigorous iodine fortification standards for salt and seasonings is essential to ensure the consistent provision of adequate iodine to meet the biological requirements of populations across all age groups. Advancing balanced dietary patterns aligned with Thailand's Food-Based Dietary Guidelines addresses a dual public health challenge; it concurrently discourages excessive processed food consumption and encourages wholefood intake among preschool children while safeguarding adequate iodine security and nutrition for the aging population.²⁹

Limitations

Some limitations of this study warrant consideration. First, spot urine samples were used to calculate MUIC; however, the large sample size ($n > 22,000$) ensures MUIC reliability for population monitoring. Second, self-reported dietary data may introduce recall or social desirability biases, although these biases were mitigated by standardized tools and trained interviewers. Third, while we employed a multivariable analysis to adjust for key confounders, residual confounding from unmeasured variables remains possible. Finally, the cross-sectional design precluded us from making causal inferences.

Public Health Recommendations

To maximize the public health impact, intensified promotion of iodized salt and fortified seasonings should be prioritized, particularly in the North and Northeast regions where iodine deficiency persists among older adults. For areas with limited access to seafood, public health interventions must emphasize the consistent use of these fortified products in all households and community food preparations as the most reliable source of iodine. Furthermore, public health strategies should ensure the alignment of national salt reduction policies with iodine fortification programs to ensure that individuals managing hypertension through sodium reduction continue to receive adequate iodine via high-quality, fortified condiments. Finally, continued cyclic monitoring and surveillance are essential to detect localized iodine imbalances and provide evidence-based data for targeted public health interventions.

Conclusion

National iodine surveillance data from 2023–2025 indicate that Thailand has maintained adequate

iodine status at the population level, with MUIC among children aged 3–5 years and older adults within the UNICEF/ICCIDD and WHO recommended range. However, this overall success masks important regional and demographic disparities, particularly the persistent iodine deficiency observed among older adults in the Northeast and North of the country. The findings reflect a shifting dietary landscape, increased processed food consumption influences pediatric iodine status, whereas older adults face unique vulnerabilities. Specifically, clinical dietary controls for managing kidney disease and diabetes must be carefully structured to ensure adequate iodine intake without compromising therapeutic outcomes. Public health strategies must sustain mandatory salt iodization and seasoning fortification while promoting the consumption of natural iodine-rich foods, strengthening monitoring, and targeting interventions in vulnerable regions to ensure equitable iodine nutrition across all populations.

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Author Contributions

Saipin Chotivichien: Conceptualization, methodology, project administration, supervision, validation, writing—original draft, writing—review & editing. **Wipasri Suwanaphol:** Data curation, formal analysis, writing—original draft. **Jutharat Supanuwat:** Data curation, formal analysis, writing—original draft. **Visaratana Therakomen:** Validation, writing—review & editing. **Panithee Thammawijaya:** Formal analysis, software, validation.

Ethical Approval

The study adhered to the Declaration of Helsinki and was approved by the Research Ethics Committee of the Department of Health, Thailand (Protocol No. 925). Informed consent was obtained for dietary interviews.

Informed Consent

Informed consent was obtained from all participants, or their legal guardians in the case of minors, prior to the dietary behavior interviews. For the collection of urine samples, which was performed as part of the established national routine surveillance (Cyclic Monitoring System) by the Department of Health, the

need for additional individual patient consent was waived as the samples were processed as de-identified data for public health monitoring purposes.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this manuscript.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the authors used Gemini to support literature searching and language editing. All output generated by the tool were carefully reviewed, validated against original sources, and revised by the authors, who assume full responsibility for the final content.

References

1. Bernal J. Thyroid hormones in brain development and function [Internet]. In: Feingold KR, Anawalt B, Boyce A, et al., editors. Endotext. South Dartmouth (MA): MDText.com, Inc.; 2000 [updated 2025 Sep 29, cited 2026 Feb 6]. <<https://www.ncbi.nlm.nih.gov/books/NBK285549/>>
2. Zimmermann MB, Jooste PL, Pandav CS. Iodine-deficiency disorders. *Lancet*. 2008;372(9645):1251–62. doi:10.1016/S0140-6736(08)61005-3.
3. World Health Organization. Salt iodization for the prevention of iodine deficiency disorders [Internet]. Geneva: World Health Organization; 2014 [cited 2026 Feb 6]. <<https://www.who.int/tools/elena/interventions/salt-iodization>>
4. Iodine Global Network. Global scorecard of iodine nutrition [Internet]. Ottawa: Iodine Global Network; [cited 2026 Feb 6]. <<https://ign.org/scorecard/>>

5. Department of Health, Ministry of Public Health. National Action Plan for the Control and Prevention of Iodine Deficiency Disorders 2022–2027. Nonthaburi: Department of Health; 2022. 49 p. Thai.
6. Department of Health, Ministry of Public Health. Guidelines for the Control and Prevention of Iodine Deficiency Disorders 2020 [Internet]. Nonthaburi: Department of Health; [cited 2026 Feb 6]. 53 p. <https://nutrition2.anamai.moph.go.th/web-upload/6x22cac0452648c8dd1f534819ba2f16c/202101/m_document/33015/17967/file_download/55445dd892605d9af9b353cae192351.pdf>. Thai.
7. Ministry of Public Health, Food and Drug Administration. Notification of the Ministry of Public Health Re: Iodized Salt. Royal Thai Government Gazette. Vol. 128, Special Part 41 Ngor; 2011 Apr 7. Thai.
8. Ministry of Public Health, Food and Drug Administration. Notification of the Ministry of Public Health Re: Fish Sauce (No. 2). Royal Thai Government Gazette. Vol. 127, Special Part 115 Ngor; 2010 Oct 1. Thai.
9. Ministry of Public Health, Food and Drug Administration. Notification of the Ministry of Public Health Re: Seasoning from Soybean Protein (No. 2). Royal Thai Government Gazette. Vol. 127, Special Part 115 Ngor; 2010 Oct 1. Thai.
10. Ministry of Public Health, Food and Drug Administration. Notification of the Ministry of Public Health Re: Salted Water for Food Cooking. Royal Thai Government Gazette. Vol. 127, Special Part 115 Ngor; 2010 Oct 1. Thai.
11. World Health Organization. Assessment of iodine deficiency disorders and monitoring their elimination: a guide for programme managers [Internet]. 3rd ed. Geneva: World Health Organization; 2007 [cited 2026 Feb 6]. 99 p. <<https://www.who.int/publications/i/item/9789241595827>>
12. World Health Organization. Urinary iodine concentrations for determining iodine status in populations [Internet]. Geneva: World Health Organization; 2013 [cited 2026 Feb 6]. 5 p. <<https://www.who.int/publications/i/item/WHO-NMH-NHD-EPG-13.1>>
13. Bureau of Nutrition, Department of Health, Ministry of Public Health. Report on urinary iodine surveillance among pregnant women 2022 [Internet]. Nonthaburi: Department of Health; [cited 2026 Feb 6]. <<https://hpci.anamai.moph.go.th/hl/IOD/IodRpt.aspx>>. Thai.
14. Bureau of Nutrition, Department of Health, Ministry of Public Health. Report on the implementation of the iodine deficiency disorders control and prevention program (July 2020–February 2022) [Internet]. Nonthaburi: Department of Health; 2022 [cited 2026 Feb 6]. <https://nutrition2.anamai.moph.go.th/th/iodinemeetingdoc/download?id=91838&mid=33021&mkey=m_document&lang=th&did=28905>. Thai.
15. Monteiro CA, Moubarac JC, Cannon G, Ng SW, Popkin B. Ultra-processed products are becoming dominant in the global food system. *Obes Rev*. 2013;14(Suppl 2):21–8. doi:10.1111/obr.12107.
16. World Health Organization. Guideline: Sodium intake for adults and children [Internet]. Geneva: World Health Organization; 2012 [cited 2026 Feb 6]. 56 p. <<https://www.who.int/publications/i/item/9789241504836>>
17. World Health Organization; United Nations Children's Fund; International Council for Control of Iodine Deficiency Disorders. Indicators for assessing iodine deficiency disorders and their control through salt iodization [Internet]. Geneva: World Health Organization; 1994 [cited 2026 Feb 6]. 66 p. <<https://iris.who.int/handle/10665/70715>>
18. Bureau of Nutrition, Department of Health. Control and prevention of iodine deficiency disorders: A path to sustainability. Nonthaburi: Bureau of Nutrition, Department of Health; 2016. 64 p. Thai.
19. Kish L. Survey sampling. New York: John Wiley & Sons; 1965.
20. Lwanga SK, Lemeshow S. Sample size determination in health studies: a practical manual [Internet]. Geneva: World Health Organization; 1991 [cited 2026 Feb 6]. 80 p. <<https://iris.who.int/handle/10665/40062>>
21. Nerhus I, Odland M, Kjellevoid M, Midtbo LK, Markhus MW, Graff IE, et al. Iodine status in Norwegian preschool children and associations with dietary iodine sources: the FINS-KIDS

- study. *Eur J Nutr.* 2019;58(6):2219–27. doi:10.1007/s00394-018-1768-0.
22. Chongchaithet N, Viriyautsahakul N, Aksornchu P, Supanuwat J. Dietary behavior and iodine status of 3–5 year-old children. *J Nutr Assoc Thai.* 2018;53(2):37–50.
23. Chotivichien S, Chongchaithet N, Aksornchu P, Boonmongkol N, Duangmusik P, Knowles J, et al. Assessment of the contribution of industrially processed foods to salt and iodine intake in Thailand. *PLoS One.* 2021;16(7):e0253590. doi:10.1371/journal.pone.0253590.
24. Sprague M, Chau TC, Givens DI. Iodine content of wild and farmed seafood and its estimated contribution to UK dietary iodine intake. *Nutrients.* 2021 Dec 31;14(1):195. doi:10.3390/nu14010195.
25. Bourre JM, Paquotte P. Seafood (wild and farmed) for the elderly: contribution to the dietary intakes of iodine, selenium, DHA and vitamins B12 and D. *J Nutr Health Aging.* 2008;12(3):186–92. doi:10.1007/BF02982617.
26. Zhang M, Ni H, Lin Y, Wang K, He T, Yuan L, et al. Renal aging and its consequences: navigating the challenges of an aging population. *Front Pharmacol.* 2025;16:1615681. doi:10.3389/fphar.2025.1615681.
27. Gounden V, Bhatt H, Jialal I. Renal Function Tests. In: *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2026 Feb 6]. <<https://www.ncbi.nlm.nih.gov/books/NBK507821/>>
28. Zugravu CA, Petre M, Constantin C. Iodine and Thyroid Dysfunction in Ageing: Nutritional, Pharmacologic, and Microbial Modifiers in Older Adults. *Geriatrics (Basel).* 2026;11(1):12. doi:10.3390/geriatrics11010012.
29. Bureau of Nutrition, Department of Health, Ministry of Public Health. Food-based dietary guidelines for Thai [Internet]. Rome: Food and Agriculture Organization of the United Nations; [cited 2026 Feb 6]. <<https://www.fao.org/nutrition/education/food-dietary-guidelines/regions/countries/thailand/en/>>