

Preplanned Studies

A Cross-Sectional Survey of Iodized Salt Usage in Dining Establishments — 13 PLADs, China, 2021–2022

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Summary

What is already known about this topic?

The National Iodine Deficiency Disease Surveillance system is exclusively focused on monitoring cooking salt used within households. Currently, there is a lack of nationally representative data on the use of iodized salt in dining establishments.

What is added by this report?

This study evaluated 7,889 salt samples obtained from dining establishments located in 13 provincial-level administrative divisions across China. The findings indicated that coverage rate of iodized salt (CRIS) and the consumption rate of adequately iodized salt (CRAIS) were found to be 95.2% and 90.2%, respectively. Further, 880 samples were classified as iodized salt and 804 as adequately iodized salt. In coastal areas, the CRIS and CRAIS showed a significant decrease to 77.1% and 70.5%, respectively, when compared to the inland regions ($P < 0.01$).

What are the implications for public health practices?

The data compiled could potentially fill the void in the national data concerning the use of iodized salt in dining establishments throughout China. It is of the utmost importance to increase the awareness of restaurant operators, particularly those located in coastal areas, about the benefits of iodine supplementation. Moreover, they should be encouraged to use adequately iodized salt.

Universal salt iodization has been established as a safe and effective method for the control of iodine deficiency disorders (IDDs) (1–2). Despite the annual National Iodine Deficiency Disease Surveillance, which began in 1995, only household cooking salt is analyzed. Yet, as the culture of eating out and ordering takeaway becomes more common, the contribution of household cooking salt to overall salt consumption has declined (3). Furthermore, current “Regulations on Salt Iodization to Mitigate the Risks of Iodine Deficiency” specify only that iodized salt is to be used

in food products made and sold in deficient areas, leaving a gap in guidelines related to restaurant use. Hence, it is vital to scrutinize and assess the use of iodized salt (IS) and adequately IS (AIS) in dining establishments. At this stage, there remains a lack of nationwide, representative data on IS use in such settings. In response to this, the study in question employed a multiple-sampling technique to amass 7,889 salt samples from restaurants across 13 provincial-level administrative divisions (PLADs) in China, aiming to provide a nationally representative snapshot. Findings indicate that the coverage rate of IS (CRIS) and consumption rate of AIS (CRAIS) are 95.2% and 90.2%, respectively. However, when focused on coastal regions, the CRIS and CRAIS dropped to 77.1% and 70.5%, respectively, marking a significant difference from inland regions ($P < 0.01$). This discrepancy suggests a need to enhance IDD awareness training for restaurant personnel in coastal areas to promote the procurement of IS.

This cross-sectional study was carried out from 2021 to 2022 across 13 PLADs of China, which were strategically divided into three regions: East, Central, and West. We executed a random selection of 4–5 PLADs from each region. Further, we subdivided each PLAD into five geographical divisions: east, west, south, north, and central. From each geographical division, two counties were randomly selected to serve as our sampling units. Each chosen county was then further dissected into five sampling areas, also based on geographical orientation. Subsequently, a town or sub-district with low water iodine levels was randomly picked from each particular sampling area. Within each chosen town or sub-district, we randomly selected two institutional canteens (either corporate or public) along with five medium-sized restaurants (MSRs) and five small restaurants (SRs). Ultimately, a total of 60 dining locations per county were selected, culminating in a comprehensive evaluation of 130 counties across China.

A 50-gram salt sample was meticulously extracted from the top, middle, and bottom sections of a salt

package acquired from a selected dining establishment. The extraction process entailed using a moisture-free, airtight plastic bag. The salt iodine content (SIC) was then evaluated following the standards stipulated by the “General Test Method for Salt Industry Determination of Iodine” (GB/T 13025.7-2012). Salt that was iodized with KIO_3 was scrutinized utilizing direct titration, while salt iodized with KI or other compounds was analyzed via redox titration. Salt with an SIC less than 5 mg/kg was termed non-IS (NIS). AIS was characterized as SIC within an allowed fluctuation range, defined as a deviation of $\pm 30\%$ from the average iodine content level in edible salt (4). The term “CRIS” was used to denote the ratio of salt samples boasting an iodine content equal to or greater than 5 mg/kg to the total samples tested, while “CRAIS” denoted the ratio of AIS samples to the total number tested.

The data for this study were inputted into Microsoft Excel 2016 (Microsoft Corporation, Redmond, Washington, USA) and subsequently transferred to SAS 9.4 for Windows (SAS Institute, Cary, NC, USA) to facilitate analysis. A test to verify a normal distribution was carried out on continuous data; data that were skewed were represented via median (quartile range). To compare groups with skewed data, nonparametric tests (including the Wilcoxon and Kruskal-Wallis tests) were utilized. Count and percentage, used to express qualitative data, were tested

for proportional differences using the Chi-squared test. All of the statistical tests used were two-tailed, with $P < 0.05$ being indicative of a statistically significant difference.

This study evaluated 131 counties across 13 PLADs in China, encompassing a population of 75,374,000 individuals with a per capita income of 35,508 Chinese Yuan (CNY). Among these counties, 19 (14.5%) are located along the coast in the PLADs of Liaoning, Fujian, Shandong, and Jiangsu. The details of the sample size are presented in Table 1.

Among the 7,882 salt samples gathered, 95.2% were iodized, with notable variation across PLADs ($\chi^2 = 1592.59$, $P < 0.01$). Of the 376 identified NIS, 58.5% were found in Shandong Province, 16.5% in Hebei Province, and 10.4% in Liaoning Province. A total of 7,107 AIS were discovered, with a consumption rate of 90.2% also showing significant provincial variation ($\chi^2 = 983.73$, $P < 0.01$). The median iodine content of IS was 25.3 mg/kg, presenting significant provincial variation as well ($\chi^2 = 1903.81$, $P < 0.01$; Table 2).

The coastal regions' CRIS and CRAIS were observed to be less than 80%, significantly lower compared to those of inland regions ($P < 0.01$; Table 3). There was a slightly lower CRIS found in MSRs in comparison to canteens and SRs, although the difference was not statistically significant ($P = 0.30$). In canteens, SRs, and MSRs, the CRAIS exceeded 90% with no significant

TABLE 1. Characteristics of the surveyed areas and dining establishments.

PLADs	Counties (N)			Residents (million)	Per capita income (thousand CNY/year)	Number of dine-out places	Types of dine-out places			Service type	
	Total	Coastal	Inland				Canteen	MSR	SR	Table meal	Fast food
Anhui	10	0	10	8.4	29.6	610	110	250	250	532	78
Fujian	10	3	7	5.1	36.6	600	100	250	250	394	206
Gansu	10	0	10	3.4	24.7	600	102	198	300	488	112
Hebei	10	0	10	5.0	30.8	600	100	250	250	420	180
Henan	10	0	10	9.0	26.4	601	100	249	252	461	140
Inner Mongolia	10	0	10	3.2	40.1	600	100	242	258	496	104
Jiangsu	10	4	6	9.9	56.8	600	100	250	250	507	93
Liaoning	10	2	8	4.5	37.8	601	100	250	251	500	101
Shandong	10	10	0	6.7	56.2	601	101	253	247	466	135
Shanxi	11	0	11	5.3	28.6	660	112	261	287	584	76
Sichuan	10	0	10	4.6	29.6	600	100	250	250	576	24
Xinjiang	10	0	10	3.7	27.9	603	104	237	262	390	213
Yunnan	10	0	10	6.5	37.1	606	103	223	280	495	111
Total	131	19	112	75.4	35.5	7,882	1,332	3,163	3,387	6,309	1,573

Abbreviation: PLADs=provincial-level administrative divisions; MSR=medium-sized restaurant; SR=small restaurant; CNY=Chinese Yuan.

TABLE 2. Coverage rates for IS and AIS and iodine content at dining establishments by PLAD.

PLADs	IS			AIS	
	N	CR (%)	Median (P25, P75) (mg/kg)	N	CR (%)
Anhui	604	99.0	21.7 (20.1, 23.3)	572	93.8
Fujian	589	98.2	24.2 (23.0, 25.4)	575	95.8
Gansu	600	100.0	26.6 (24.1, 29.6)	562	93.7
Hebei	538	89.7	24.3 (21.9, 26.4)	511	85.2
Henan	592	98.5	25.0 (22.8, 27.7)	555	92.4
Jiangsu	595	99.2	24.5 (21.8, 26.9)	566	94.3
Liaoning	561	93.5	24.5 (21.9, 26.9)	523	87.2
Inner Mongolia	587	97.7	25.2 (23.3, 27.2)	561	93.3
Shandong	381	63.4	23.4 (20.6, 26.0)	334	55.6
Shanxi	656	99.4	27.7 (25.4, 29.8)	599	90.8
Sichuan	597	99.5	26.9 (24.9, 28.8)	583	97.2
Xinjiang	602	99.8	28.1 (25.2, 31.1)	575	95.4
Yunnan	604	99.7	25.8 (24.1, 27.6)	591	97.5
Total	7,506	95.2	25.3 (22.8, 27.7)	7,107	90.2

Abbreviation: PLADs=provincial-level administrative divisions; IS=iodized salt; AIS=adequately iodized salt; CR=coverage rate.

TABLE 3. Coverage rates of IS and AIS based on location, types of dining establishments, and types of services.

Variable	IS				AIS				Total salt sample	
	N	CR (%)	χ^2	P	N	CR (%)	χ^2	P	N	%
Coastal or inland areas			962.6	<0.001			584.2	<0.001		
Coastal	880	77.1			804	70.5			1,141	14.5
Inland	6,626	98.3			6,303	93.5			6,741	85.5
Types of dine-out places			2.4	0.30			0.2	0.93		
Canteen	1,268	95.2			1,202	90.2			1,332	16.9
MSR	2,999	94.8			2,847	90.0			3,163	40.1
SR	3,239	95.6			3,058	90.3			3,387	43.0
Service types			3.0	0.08			0.2	0.66		
Table meal	5,995	95.0			5,684	90.1			6,309	80.0
Fast food	1,511	96.1			1,423	90.5			1,573	20.0

Abbreviation: MSR=medium-sized restaurant; SR=small restaurant; IS=iodized salt; AIS=adequately iodized salt; CR=coverage rate.

differences observed ($P=0.93$). The CRIS and CRAIS in fast food-serving establishments were marginally higher than those providing table meal service, even though the difference was not statistically meaningful ($P>0.05$).

DISCUSSION

The findings of this study indicated that the CRIS and CRAIS in dining-out venues were 95.2% and 90.2%, respectively. It was observed that these measurements were notably lower in coastal regions as compared to inland areas. However, no significant

variance in CRIS and CRAIS was discovered among canteens, MSRs, and SRs. Furthermore, there was no statistically significant distinction in CRIS and CRAIS between establishments offering table meals and those providing fast food.

According to China's "Criteria for Elimination of Iodine Deficiency Disorders (GB16006-2008)" introduced in 2008, a household CRIS of $\geq 95\%$ and a CRAIS $>90\%$ are requisite for IDD elimination. Hence, the values for household CRIS, CRAIS, and SIC have been incorporated into the national IDD control project as critical indicators for monitoring and evaluating iodine nutrition. However, due to rapid

economic progress and increased speed of contemporary life, eating out, buying takeout, and consuming packaged foods are becoming the norm in China. Interestingly, in certain economically advanced areas of the country, household cooking salt no longer significantly influences the population's iodine status (5–7). Two surveys conducted in Shanghai illuminated that household salt iodine intake failed to impact the iodine status of pregnant women (5) and children (6). Further, a monitoring study in Tianjin from 2016 to 2020 unveiled no correlation between the CRIS, CRAIS, and SIC of household cooking salt and iodine status indices within the population (specifically urinary iodine concentration and thyroid volume) once confounding factors were adjusted for (7). The said study's authors proposed that the IDD control project's household salt-related indicators should be amended to accommodate other indicators, such as SIC in school canteens (7). This current study involves an assessment of 7,889 salt samples taken from restaurants nationwide and effectively addresses the deficiency of IS monitoring data on such establishments. Furthermore, this study lays the groundwork for subsequent adjustments of IS monitoring indicators by providing essential data.

Multiple studies (8–9) investigating household salt usage have discovered that the CRIS and the CRAIS in coastal regions were noticeably lower than those in inland areas. A research project in Qingdao City found that household CRIS and CRAIS stood at 88.2% and 86.2%, respectively, failing to meet the elimination criteria for IDD (8). A similar study in Guangxi Zhuang Autonomous Region indicated significantly lower CRIS and CRAIS (75.59% and 63.25%) in coastal households than in their inland counterparts (9).

Given this data, it was important to examine if a substantial difference existed in IS usage between inland and coastal restaurant settings. This study found that the CRIS and CRAIS in coastal restaurants were merely 77.1% and 70.5%, respectively, a marked difference to the 98.3% and 93.5% in inland establishments.

Interviews suggested that missing or inaccurate information may be contributing to this discrepancy, with one such misconception being the unnecessary consumption of iodized salt due to the regular intake of seafood in coastal areas. It should be noted that while coastal residents generally consume more seafood, the iodine content in seafood is only marginally higher than that in land-based animal foods

(10). Thus, the iodine intake tends to be lower in coastal regions.

The highest quantities of iodine in seafood are generally found in specific types of seaweed, but consumption of seaweed is quite minimal. Furthermore, the presence of private salt farms in some coastal regions encourages the use of non-iodized coarse sea salt, resulting in a reduced CRIS.

A study by Mao et al. (11) found that the urinary iodine concentration in pregnant women living in Zhejiang Province's coastal areas was 107.54 µg/L, significantly lower than that of pregnant women in inland areas (152.54 µg/L). It was speculated that this iodine deficiency was linked to the low local CRIS. Similar research by Chen et al. pointed out that the median urinary iodine of pregnant women in rural coastal areas of Fujian (134.9 µg/L) fell short of the World Health Organization's recommendation (12).

To decrease the risk of iodine deficiency among residents of coastal areas, notably pregnant women and lactating mothers, it is crucial to raise not only household CRIS rates but also restaurant operators' awareness of iodine supplementation. Encouraging restaurant operators to purposely purchase and utilize AIS can be a significant step in this direction.

A prior study indicated a higher incidence of CRAIS in large or MSRs compared to SRs (13). This was initially attributed to the deficient regulatory mechanisms within SRs, insufficient food safety awareness and improper management. However, the current study reveals no significant variance in CRIS and CRAIS distribution across diverse dining establishments. This can be reasoned through several factors. First, the recent years have seen an increase in coverage of food safety awareness and educational programs, thus augmenting the health consciousness of individuals responsible for SRs or those involved in procurement. Second, the introduction of efficient regulatory mechanisms has significantly mitigated the circulation of substandard IS in the marketplace.

This study possesses certain limitations. Due to its cross-sectional design, evaluating the temporal relationship between various factors was unattainable, thereby complicating the inference of causation. Additionally, a number of elements influencing the concentration of IS, inclusive of storage methods, purchase dates, and individual health consciousness, were not incorporated in the survey.

To our understanding, this constitutes the first substantial study examining the utilization of IS in dining establishments, thus yielding national-level

representative data. This research scrutinized the usage of IS in 7,882 dining venues across 13 PLADs in China, thereby filling an existing void regarding IS data in such establishments within the country. The employment of IS in China's dining places was deemed satisfactory. Moreover, CRIS and CRAIS in Canteens, MSRs, and SRs matched the criteria set for IDD eradication. Notwithstanding, the CRIS and CRAIS in coastal regions were significantly inferior to those in inland areas. Consequently, augmenting IDD knowledge among restaurant personnel in coastal areas is vital, enhancing their consciousness about purchasing IS. Similarly, it is crucial to bolster local supervision and surveillance mechanisms to suppress the distribution of non-compliant IS in the market.

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