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People's Knowledge and Practice of Salt Iodization, as Well as the Assessment of Iodine Content in Salt in the Cumilla Region of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To evaluate the household iodine content and knowledge, attitude, and behavior regarding salt iodization among the residents of Cumilla, Bangladesh.
Subjects and Methods: We conducted a cross-sectional survey of 700 inhabitants in Cumilla's urban and rural areas to determine the iodine concentration of salt they consume. The participants were asked about what they know about iodine deficiency and salt iodization as well as how their salt was packaged and stored. Among them, 338 people provided a sample of salt to be tested of its iodine content by the titrimetric method.
Results: 46.57% of people knew that iodization was the best way to prevent iodine deficiency while 35.14% considered salt iodization during purchasing. Most people stored salt in plastic boxes (89.7%) and closed containers (84.14%).Among all participants, only 37.14% of people were aware of the iodine requirement during pregnancy.

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In urban regions, the median iodine content was 36.76 ppm (OR=0.658, 95% CI, 0.469-0.925), while in rural areas, the median iodine content was 40.92 ppm (OR=1.188, 95% CI, 1.022-1.380). Iodine levels were less than 15 ppm (minimum limit) in 6.8% of samples and greater than 40 ppm (maximum limit) in 56.5%. Only 36.7% of the salt samples contained adequate iodine.
Conclusion: An effective and consistent approach for controlling iodine concentration in distributed salt is required at Cumilla, Bangladesh.

Keywords: Iodine deficiency; salt iodization; knowledge; practices; titrimetric method.

ABBREVIATIONS

PPM : Parts Per Million;
WHO : World Health Organization;
CI : Confidence Interval;
OR : Odd Ratio;
H_2SO_4 : Sulfuric Acid;
SPSS : Statistical Package for the Social Sciences.

1. INTRODUCTION

Iodine is an essential nutrient that is vital for regular metabolic activity. Despite the fact that other tissues contain 70% of the body's iodine, the thyroid gland is the most germane organ to the iodine effect [1]. Iodine is a microelement found in some foods naturally and is also offered as a nutritional supplement. Before being absorbed throughout the gastrointestinal tract, iodine from the meal is transformed into the iodide ion [2]. Iodide is actively transported by the sodium/iodide symporter (NIS) on the basolateral membrane of thyroid follicular cells resulting in a highly efficient iodine utilization system [3].

In general, the daily dietary iodine requirement is 100–150 lg. However, it is increased to at least 200 lg/day during pregnancy [4]. The ocean is the primary source of iodine in the environment [5]. Seafood and vegetables have the highest median iodine contents, according to a study of food composites by category. Fruits, as well as bread and cereals, had the lowest iodine contents [6]. In developed countries with advanced technological infrastructure, milk and dairy products are the most common sources of iodine [7].

Iodine deficiency disorders (IDDs) are a group of symptoms caused by a lack of thyroid hormone production [8]. IDDs include goiter (enlarged thyroid gland), stillbirths and miscarriages, neonatal and juvenile thyroid deficiency, dwarfism, mental disorders, deaf-mutism, spastic weakness and paralysis, along with smaller degrees of physical and mental function loss [9]. Iodine deficiency is the leading preventive cause of brain impairment on a global scale [10].

Iodized salt is thought to be the most effective form of iodine supplementation [8]. It is necessary to ensure the availability of salt that is sufficiently iodized (>15 ppm and 40 ppm) at the household level [10]. The two kinds of iodine that can be used to iodize salt are iodide and iodate, which are commonly in the potassium salt form. Iodate is preferable for tropical wet environments since it is less soluble and more stable than iodide. Solar evaporation of seawater and salt mines are the major sources of iodized salt [11]. The Prevention of Food Adulteration Act (PFA) was updated in 1988 to define iodized salt to have a minimum iodine content of 30 ppm at retail [12].

In consideration of the terrible and irreversible health consequences of iodine deficit, the World Health Organization (WHO) advised that the universal salt iodization (USI) program be implemented to assist in eliminating this nutritional deficit [13]. Bangladesh, which is a South Asian country on the Bay of Bengal, east of India, issued the Iodine Deficiency Disease Prevention Act in 1989, making it mandatory for all salt produced for human consumption to be iodized [14]. There have only been a few studies that looked into the availability of iodized salt in Bangladeshi households. Only 57.6% of Bangladeshi householders use appropriately iodized salt, implying that roughly 68 million people still consume inadequately iodized salt, placing them at risk of iodine deficiency ailments [15]. According to the 2015 Bangladesh National Salt Iodization Survey (NSIS), only 50.5% of Bangladeshi households had access to sufficiently iodized salt, while only 65% have access to iodized salt [16]. To the best of our knowledge, no research specifically investigated the context of iodized salt availability at the household level in Cumilla by examining people's attitudes and knowledge about iodized salt. The goal of this research was to understand the

knowledge, attitude, and practice of residents of Cumilla as well as to determine how much iodine is in the salt that is consumed in household of the concerned District.

2. METHODS AND MATERIALS

2.1 Subjects and Data Collection

The present study involved a survey that evaluated the individuals' knowledge, attitudes, and practices related to iodine nutrition and iodized salt. The study was performed in Cumilla; a district of Bangladesh located in the southeastern part of Bangladesh with a total population of 4595557 [17]. According to Banglapedia, 11.65% of Cumilla district live in urban areas, while 88.35% live in rural regions. People of Cumilla district have a literacy rate of 45.99%.

All households of Cumilla district living were eligible for the study. The study's objective and procedures were explained during house visits. A minimum sample size of 385 residents of Cumilla was required at a 95% confidence interval and within 5% of the total population. Our study received 700/1572 respondents yielding a 44.53% response rate who completed data in an interviewer-administered questionnaire. The questionnaire was designed based on reviewed literature of previous studies [18,19].

2.2 Salt Sample Collection

Among 700 participants only 338 people (48.29%) gave the salt samples which were further analyzed to determine iodine content. The salt sample was accompanied by a sheet of information that contained the date of sample collection, sample code, and kind of salt, as well as packing material, batch number if applicable, date of production, expiry date, and the name and signature of the data collector. In this study volumetric iodometric titration was adapted to determine iodine content.

2.3 Measurements of Iodine in Salt

Salt samples were tested for iodine levels using iodometric titration. Free iodine was liberated from the salt sample through the addition of H_2SO_4 in the presence of excess potassium iodide (10% KI) for the ease of solubilization. The salt sample was titrated by sodium thiosulfate whose amount was directly proportional to the amount of free liberated iodine. Starch was used as an indicator to mark the end-point of the titration by producing a blue color [20].

Calculation: Iodine mg/kg (ppm) = titration volume in ml x (21.15) x normality of sodium thiosulfate x 1000/ salt sample weight in gram [20].

2.4 Data Analysis

The amount of iodine of the salt was expressed as median content. Statistical analysis (descriptive statistics and frequency tables, with a further analysis comparing relative frequencies between different groups using chi-squared tests and risk ratios) were performed with SPSS statistics software, version 25, and $p<0.05$ was considered to indicate a significant difference.

3. RESULTS

3.1 Attitudes & Knowledge Assessment

Among 700 people interviewed, approximately 674 (96%) people had heard about iodine deficiency and 580 (83%) people claimed that they knew about the preventive ways of iodine deficiency.

In the survey, most of the people believed that using iodized salt and eating seafood is the most important way to prevent iodine deficiency. Some people also considered that vegetable is the best source of iodine.

Among these 580 participants, 326 people think that the best strategy to avoid iodine deficiency is to eat iodized salt while 209 people suggest eating seafood or seaweed and 45 people prefer taking iodine as a supplement (Fig. 1).

Many individuals are unaware of the benefits of iodized salt and the need of utilizing it. Some people learn about iodine, iodized salt, and the significance of taking iodized salt through their health care providers, while others learn from newspapers, television, and radio (Fig. 2). These media help in the dissemination of information on iodine, iodized salt, the importance of iodized salt, and iodine deficiency disorders. Iodine and iodized salt were familiar to a number of people through family or friends.

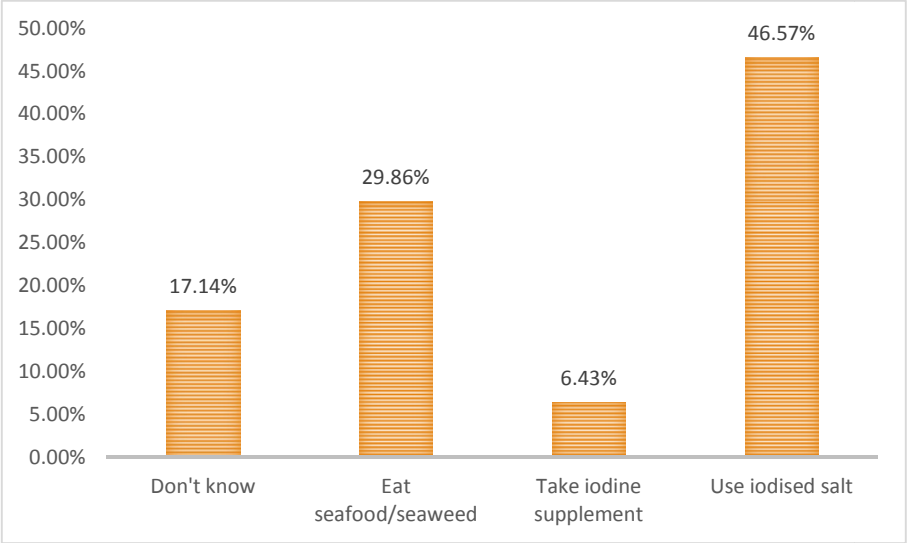

Fig. 1. Ways to prevent iodine deficiency

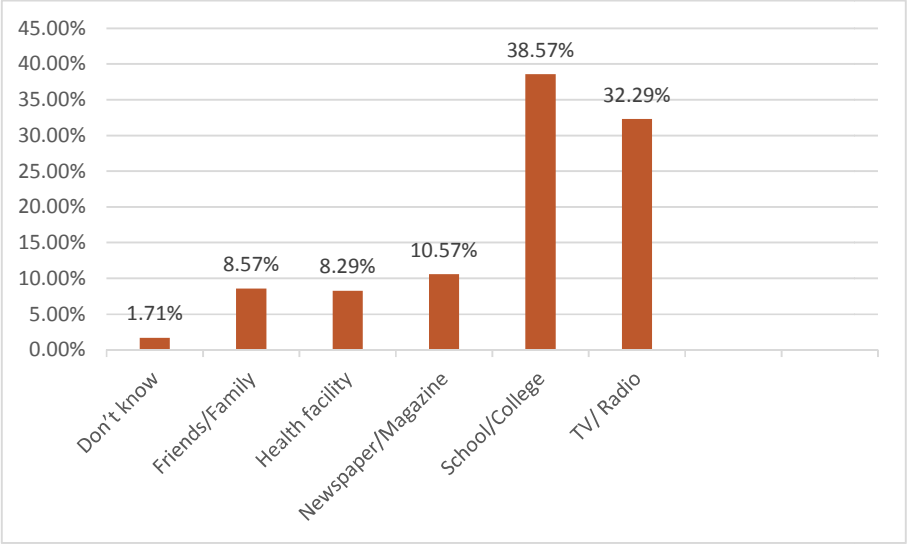

Fig. 2. Sources to know about iodine and iodized salt

Fig. 3 shows that the majority of people (64.57%) recognize goiter improvement as a benefit of iodized salt, but most people are unaware of other important advantages such as improved brain development, pregnancy outcomes, children's health, and intelligence, or the prevention of cretinism.

3.2 Salt Usage Pattern

The following questions (Table 1) were asked to assess the pattern of salt usage in the household among the people of Cumilla, which revealed that the vast majority of household folks use salt that is labeled as iodized salt (93.1%) and also in sealed packages (95.1%). Approximately half of those respondents expressed concern about iodized salt by inquiring about it during the purchase.

During buying salt, a larger portion (48.86%) of people emphasize brand value while 35.14% consider if it has been iodized. On the other hand, a number of people take into account several other factors like price (8.86%) packaging material (7.14%) (Fig. 4).

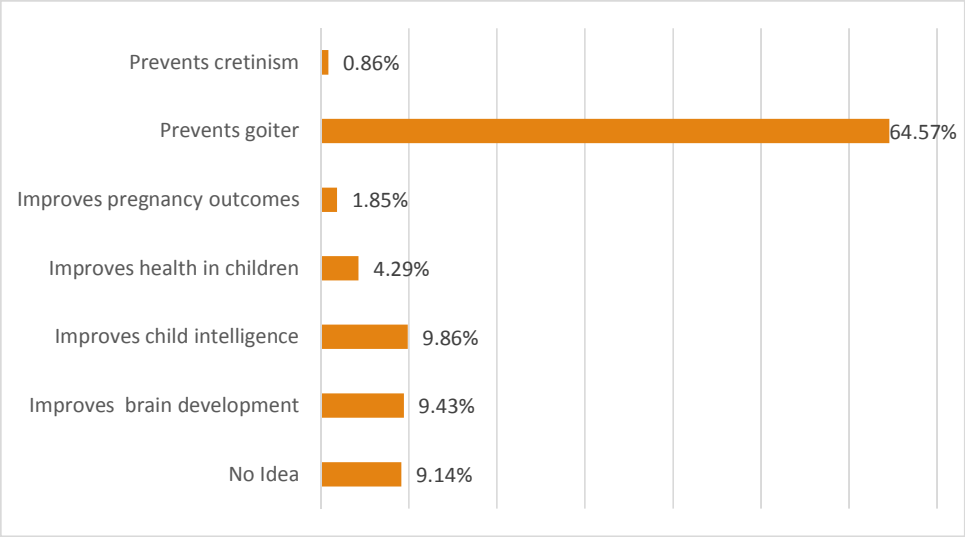

Fig. 3. Benefits of consuming iodized salt

Table 1. Pattern of salt used in the household purpose

Questions	Yes Number (percentage of total)	No Number (percentage of total)	No Idea Number (percentage of total)
Is the salt currently used for cooking in your household obtained in a sealed package?	666(95.1%)	34(4.9%)	-
Is the salt in your household labelled as iodized salt (logo or labelled as iodized)?	652(93.1%)	32(4.6%)	16(2.3%)
When the salt in your household was obtained, did you ask for iodized salt?	344(49.1%)	356(50.9%)	-

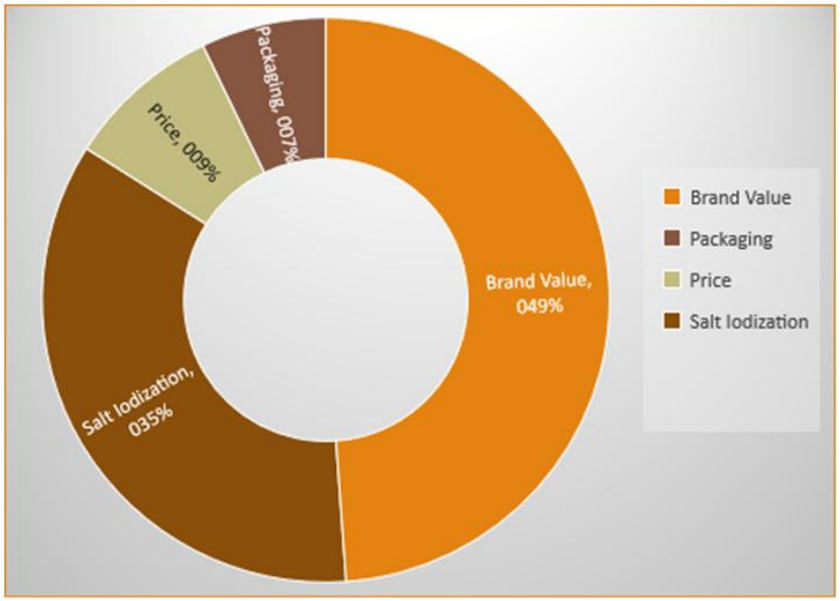

Fig. 4. Factors considered during buying salt

Table 2. Types of containers for storage of salt

Types of containers	Number of participants	Percentages
Cellulose Papers	32	4.57%
Glass Jars	6	0.86%
Metal Boxes	24	3.43%
Plastic	628	89.71%
Porcelain Dishes	10	1.43%

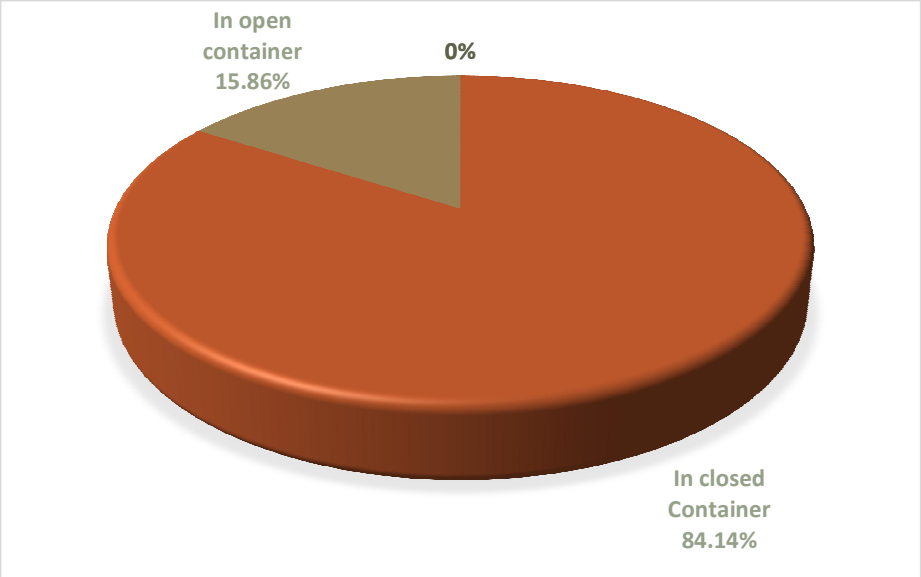

Fig. 5. Condition of container for storage

According to Table 2, almost all of the salt was stored in plastic containers (89.7%), the rest of the salt was stored in glass jars (0.9%), porcelain dishes (1.4%), metal boxes (3.4%), or cellulose papers (4.6%). Moreover, 15.86% of salt among the surveyed sample was not stored in a container with a lid (Fig. 5).

3.3 Iodization during Pregnancy

The majority (62.86%) of those who took part in the survey were either unaware or misguided about the importance of iodine in the diet of pregnant women. However, many people (37.14%) believed that pregnant women require more iodine than non-pregnant women, while others believe that requirements are the same or less (Fig. 6).

3.4 Ways to Raise Public Awareness

To overcome iodine deficiency, several steps need to be performed. People's awareness is critical in the fight against iodine-deficient disorders. According to participants of this study, consciousness can be raised in a variety of ways, including television, radio, newspapers, magazines, seminars, healthcare providers, or dissemination of information through textbooks, or social media (Fig. 7).

3.5 Iodine Content of Edible Salt at Household Level at Cumilla District

The iodine concentration of the sample salt showed a lot of variation after the titrimetric procedure. There were 338 samples in total, with 27.8% from urban households and 72.2% from rural families. The iodine level of the salt samples ranged from 5.64 to 59.23 ppm. Fig. 8 shows that 6.8% of 338 salts had an iodine level below 15 ppm (iodine-poor salt) and 56.5% had an iodine value above 40 ppm (iodine-rich salt). Only 36.7% of the samples were within the required iodine limit (15-40 ppm).

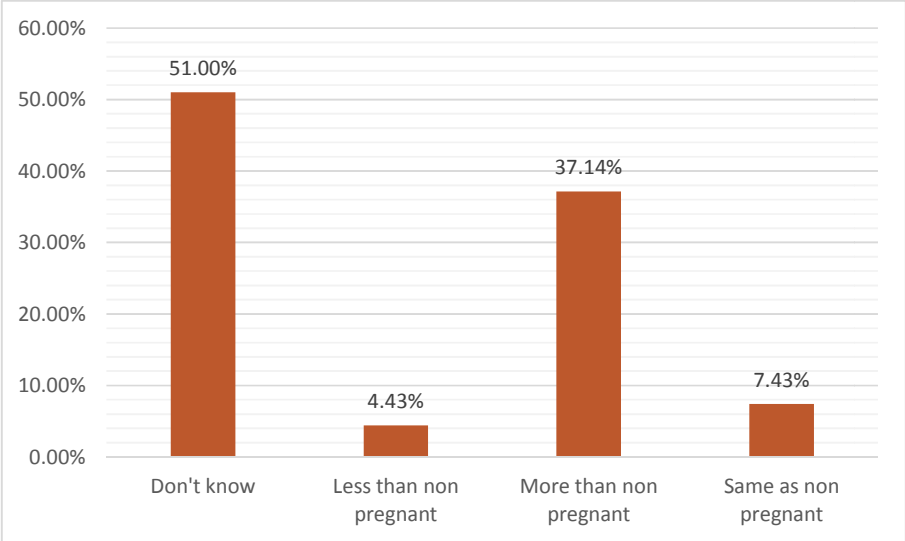

Fig. 6. Opinion regarding requirement of iodine among pregnant women

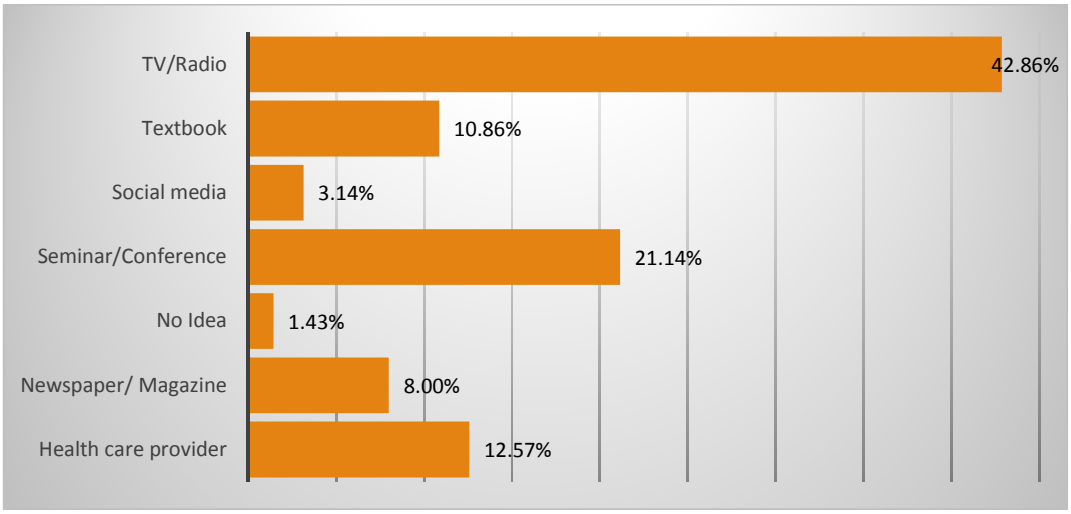

Fig. 7. Ways to conscious the people about iodine deficiency

3.6 Factors Associated with Edible Salt Iodine Content

The median iodine content was 36.76ppm (OR=0.658, 95% CI, 0.469-0.925) for household salt samples in the urban area and 40.92 ppm (OR=1.188, 95% CI, 1.022-1.380) for samples in the rural zone. The salt iodization differences between these two types of Cumilla zones were statistically significant (*P*=0.0003).In the urban zone, 46.81% of families had enough iodine in their salt (between 15 and 40 ppm), compared to 32.79% in the rural area. In the urban zone, the proportion of residents utilizing non-iodized salt was greater (9.57%) than in the rural zone (5.74%), and the number of iodine-rich salt samples also differed between rural (61.48) and urban (43.62%) areas. (Fig. 9).

From Table 3, the median iodine concentration of household salt varies depending on the material and condition used to store the salt. Metal boxes had a higher median iodine concentration than other containers, but the differences were not statistically significant. The median iodine content for closed container was 40.92 ppm (OR=1.115, CI=95%, 0.991-1.254) and open container was ppm (OR=0.654, CI=95%, 0.426-1.005) respectively(*P*=0.03).

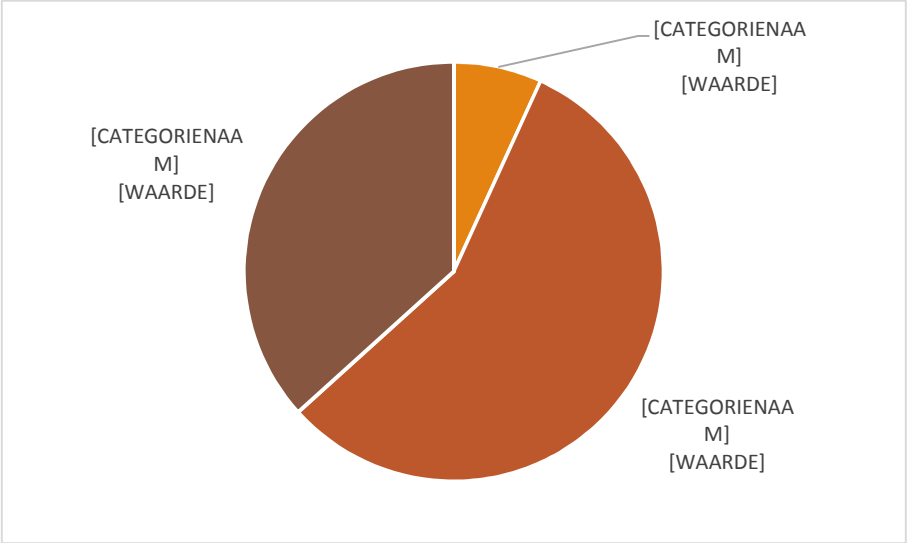

Fig. 8. Distribution of iodine content in salt from 338 households in Cumilla

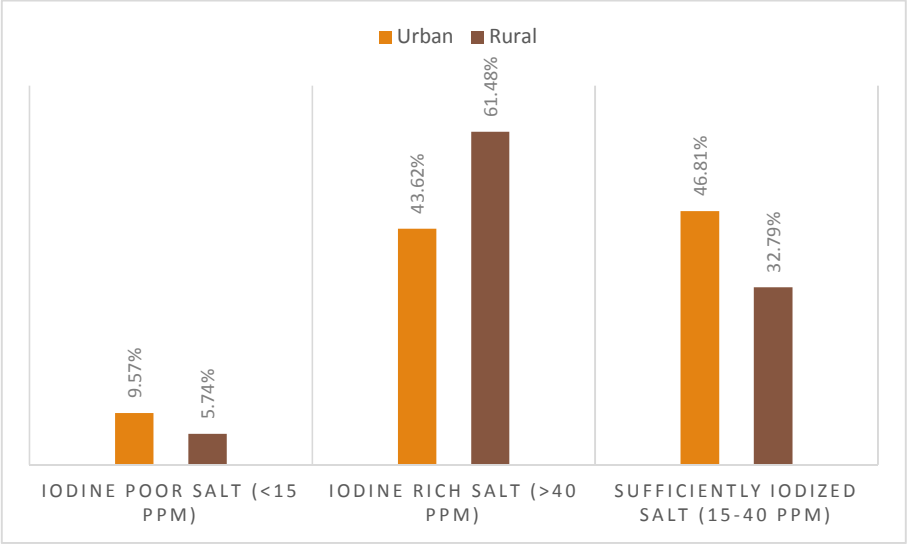

Fig. 9. Coverage of iodized salt in urban and rural zones of Cumilla, Bangladesh

Table 3. Iodine content in salt according to method of storage of salt at 338 homes in Cumilla, Bangladesh

Variable	Number (percentages)	Median Iodine Content in ppm	P value
Storage Box Material			
Cellulose Paper	10 (2.96%)	34.55	*P*=0.11
Glass Jar	4 (1.18%)	22.65	
Metal Boxes	22 (6.51%)	47.39	
Plastic	298 (88.17%)	40.92	
Porcelain Dishes	4 (1.18%)	31.78	
Conditions of Container			
Closed Container	272 (80.47%)	40.92	*P*=0.03
Open Container	66 (19.53%)	34.55	

4. DISCUSSION

On the basis of responses to the questions of the survey study, only 46.57% of people answered iodized salt as the best way to prevent iodine deficiency. For the participants in this study, various mediums such as academic tools and television/radio shows were the primary sources of information on iodized salt. A huge section of the populace is also unaware of the multiple benefits of iodized salt, apart from goiter prevention. These findings suggest that a campaign to raise public awareness about the benefits of iodized salt in terms of health is urgently needed.

During purchase, apart from salt iodization (35.14%) almost half of the participants (48.86%) were concerned about salt brand value. They said that this salt, which had a higher brand value for them, was packed in packaging. The majority number of salts is claimed as iodized by the manufacturing companies demonstrating that they are concerned about public health as well.

Based on the response by the participants, the highest amount of salt was kept in a closed plastic container to prevent exposure to dust and sunlight. The iodine molecule is sensitive to sunlight, moisture, and heat because it is a volatile element. In a Cameroon research of iodized salt consumption, percentage losses between production and distribution chain were 41.3% and 82.3% amid distribution chain and households. In the study conducted in Ivory Coast which was similarly based on household data, losses between the distribution system and homes totaled roughly 84% [21]. So, the majority of individuals questioned in our study do not deviate much from standard procedure when it comes to salt storage.

Unfortunately, the majority of those interviewed are ignorant that the daily iodine need for pregnant women differs from that for non-pregnant women. According to the trimester of pregnancy, the requirement for iodine is increased by iodine clearance and the transfer of maternal iodine to the fetus [22]. Therefore, numerous strategies can be implemented to raise awareness based on the entire scenario of knowledge and practices about salt iodization among the people of Cumilla, as suggested by the participants such as broadcasted programs, print media, seminars, healthcare providers, or dissemination of information through textbooks, or social media.

Only 338 people out of 700 were persuaded to contribute a salt sample for iodine content measurement, indicating that more than half of the population was indifferent to a scientific evaluation in the realm of public health. Of the 338 salt samples, all of them indicated the presence of iodine in salt in households. In the survey sites, nearly 6 out of 10 households (56.51%) consumed salt with a high iodine content (> 40 ppm). In contrast, 6.8% were consuming salt with an insufficient iodine content (<15 ppm). Only 36.69% of samples had enough iodized salt. Excessive iodine consumption may contribute to a rise in the prevalence of hyperthyroidism in the population.

According to the findings of this research, iodine was not present in 63.31% of 338 samples of at an acceptable range which were mostly from rural areas. The absence of sufficiently iodized salt could be attributed to the oxidation of the iodized form (iodate) of iodine due to improper packaging of the salt in nonwatertight material or to practices like the use of an open container that affected the iodine content. Another explanation is that the practice of markets and stores to sell handmade, non-iodized, or iodine-rich commercial diverted salt for consumption surreptitiously which are more prevalent in the rural areas than of urbans. The commercial competition also contributes to the absence of iodine as iodization raises the price of salt. So, people may tend to choose the salt that is less expensive but tastes and performs equally well. Based on the socio-economic condition of Bangladesh these tendencies appear to be more prominent among rural residents.

Residents of Cumilla may suffer from both hypothyroidism and hyperthyroidism as a result of improper practices of iodine and iodized salt consumption. Given the importance of iodine in neonatal brain development, particularly in pregnant women, educational activities to raise community understanding and contribute actively to iodine profile in high-risk populations, especially among rural people, are needed. Continuous modifications and regular inspections are required at all stages of the distribution chain to make large quantities of salt with acceptable iodine content available. Such measures will help to improve the population's health by meeting the population's daily iodine demands. Data from field studies at various stages of the distribution chain are needed to determine the factors of consumption of inadequately or excess iodized salt.

5. LIMITATIONS

Non-responses were a drawback, but they did bring culturally sensitive issues.

6. CONCLUSION

Bangladesh's government has passed the Iodized Salt Bill, 2021 on June 14, making the iodization of edible salts mandatory. Violators of the new law who produce, import, or sell non-iodized salt will have to face severe legal and monetary penalties [23]. The presence or absence of iodine content can be determined using the titrimetric method, which can be adapted to put this rule into practice. This research, which assessed the iodine concentration of 338 people's salt in Cumilla, only 36.69% of people in Cumilla used adequately iodized salt, 6.8% used insufficiently iodized salt, and 56.51% used salt with high iodine content. We do not have any information about the risks of taking salt that is not properly iodized in Cumilla. Nevertheless, non-iodized or inadequately iodized salt may perpetuate the problem of iodine-deficiency syndromes in Cumilla. To improve the efficiency of the program against iodine deficiency problems in Cumilla, Bangladesh, the iodine content of salt should be scrutinized at all stages of the distribution chain.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

We are gathering data about the salt iodization knowledge and practices of salt usage. To do this we are asking residents of Cumilla to help us by answering the following questions. All information collected will be anonymous, with no names, or personal data involved. You are free to refuse to participate in the whole survey, or not answer some particular questions.

1. How old are you? (Please circle)
   18-21 22-30 31-50 50+

2. What is your gender? (Please circle)
   Male Female Other

3. Are you here as a single adult or as part of a family? (Please circle)
   Alone Family

4. Where are you currently staying? (Please circle)
   Urban Rural

5. Have you heard about iodine deficiency? (Please circle)
   Yes No

6. Most effective way to prevent iodine deficiency (Please circle)
   Use iodized salt Take iodine supplement Eat seafood/seaweed Don't Know

7. Where did you hear about iodized salt?(Please circle)
   Friends/Family Health Facility Newspaper/Magazine School/College
   TV/Radio Don't Know

8. Can you give one or more benefits of consuming iodized salt?(Please circle)
   Prevents Cretinism Prevents Goiter Improves pregnancy outcomes Improves health in children
   Improves child intelligence No idea

9. Which factor do you consider during choosing salt? (Please circle)
   Brand Value Packaging Material Salt iodization Price

10. How do you usually store salt? (Please circle)
    In a container with lid In a container without lid

11. Which type of container you use for salt?(Please circle)
    Cellulose papers Glass jars Metal boxes
    Plastic Porcelain dishes

12. In your opinion, do pregnancy women need dietary iodine? (Please circle)

    Same as non-pregnant More than non-pregnant
    Less than non-pregnant Don't Know

13. How can we conscious the people about iodine deficiency? (Please circle)

    Healthcare provider Textbook Seminar/Conference Social media
    TV/Radio Newspaper/Magazine Don't know

14. Can you give the sample of salt that you consume please? (Please circle)

    Yes No

Peer-review history:
The peer review history for this paper can be accessed here:
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