Empowering Coastal Communities through the Iodized Salt Awareness Movement: Integrating Marine Resource Utilization and Public Health Efforts in Purworejo

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Abstract. Iodine deficiency continues to pose a major public health challenge in several Indonesian coastal regions, even though these areas possess great potential for salt production. This research sought to design and assess a community-based intervention model, the Iodized Salt Awareness Movement (ISAM), as an integrated strategy that combines nutrition education, simple iodization technology, and local economic empowerment in Purworejo Regency, Central Java. Using a participatory mixed-method approach, the program included health education for key community members, technical mentoring for salt farmers in producing iodized salt through tunnel geomembrane technology, and laboratory testing to ensure compliance with the Indonesian National Standard (SNI 3556:2024). Results indicated a significant improvement in participants' knowledge regarding iodized salt (mean score increased from 71.8 to 82.1; $p < 0.05$) and the establishment of community-based microenterprises producing SNI-compliant salt. Collaboration between local government, academia, and community groups fostered behavioral change and improved access to safe and nutritious salt. This model demonstrates how a multisectoral approach, linking public health, coastal resource utilization, and local economic development, can bolster nutrition resilience and contribute to the sustainable reduction of iodine deficiency disorders in Indonesia.

1 Introduction

Globally, one of the most preventable causes of impaired growth and cognitive development is iodine deficiency disorders (IDD). Insufficient iodine intake contributes to goiter, reduced intelligence, and developmental delays in children, with long-term effects on population health and productivity [1]. In Indonesia, the prevalence of goiter declined from 27.5% in 1990 to 11.1% in 2003, according to national IDD surveys. However, this rate remains above the World Health Organization (WHO) threshold of 5%, indicating that IDD continues to be a public health concern [1].

Salt iodization is widely known as an effective and affordable approach for IDD prevention. The Universal Salt Iodization (USI) program, endorsed by WHO and UNICEF, mandates that all salt intended for both human and animal consumption must contain sufficient levels of iodine. In Indonesia, this policy was strengthened through Presidential Decree No. 69/1994 and the establishment of the Indonesian National Standard (SNI) for iodized salt. The most recent regulation, SNI 3556:2024, specifies an iodine concentration

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of 30–80 ppm and sets strict limits on heavy metal contamination, such as lead and arsenic [2].

Despite these standards, the practical implementation of iodization varies across regions. Small-scale coastal producers often face challenges in meeting SNI requirements due to limited access to iodization tools, inadequate technical knowledge, and weak quality control systems [3]. As a result, many households continue to consume salt with iodine content below the recommended level .

This study addresses those gaps by developing a participatory model that combines community empowerment, nutrition education, and the use of simple iodization technology adapted to local resources. Unlike previous top-down approaches, this model emphasizes local ownership, capacity building, and cross-sector collaboration between government, academia, and community organizations. By focusing on coastal ecosystems as both an economic and nutritional resource, this research also contributes to broader discussions on sustainable coastal resource management, water governance, and food–health security in Indonesia. Specifically, it aims to identify and evaluate the implementation of the Iodized Salt Awareness Movement (ISAM) in Purworejo's coastal communities, focusing on improved knowledge, compliance with SNI standards, and the sustainability of household iodized salt use.

2 Methods

2.1 Study Design and Location

A community-based participatory mixed-method design was adopted to capture both measurable outcomes and contextual community processes influencing iodized salt practices. The research was carried out in Paturejo Village, Grabag Sub-district, Purworejo Regency, Central Java, an area with high potential for marine resource utilization but limited iodized salt production..

2.2 Study Population and Sampling

Participants consisted of salt farmers who were members of the Kelompok Usaha Garam Rakyat (KUGAR) "Pendowo Limo" cooperative, along with key community figures, including village officials, PKK (Family Welfare Movement) members, and local leaders. Respondents were selected purposively to represent various social and occupational backgrounds related to salt production and community health.

2.3 Intervention Activities

The intervention comprised two major components: (1) Nutrition Education and (2) Technical Mentoring. Nutrition education sessions, delivered directly by the research team, covered the role of iodine in health, the consequences of iodine deficiency, and the standards required under SNI 3556:2024 for edible salt. Technical mentoring provided hands-on training in iodized salt production using low-cost tunnel geomembrane technology, emphasizing proper iodization procedures, safe storage, packaging, and compliance monitoring. The intervention was implemented collaboratively with district-level offices of Health and Marine Affairs.

2.4 Data Collection

Quantitative data were obtained through pre–post intervention questionnaires assessing participants' knowledge, attitudes, and practices regarding iodized salt. Laboratory tests were conducted by PT Sucofindo to analyze baseline salt characteristics (NaCl content, moisture, insoluble matter, and heavy metals: Cd, Pb, Hg, As) based on SNI 3556:2024. Post-fortification iodine content was examined by the Magelang Public Health Laboratory using the iodometric titration method. Qualitative data were gathered through semi-structured interviews with KUGAR managers, focusing on production challenges, regulatory requirements, and business sustainability.

2.5 Data Analysis

The assessment of shifts in knowledge was conducted through the implementation of two distinct statistical tests: the McNemar change test and the Wilcoxon signed-rank test. Additionally, participants' narratives concerning the production and consumption of iodized salt were analyzed using thematic content analysis, allowing for the identification of recurring themes and patterns related to their practices and beliefs.

This study received ethical approval from the Ethics Review Board of the Faculty of Public Health, Diponegoro University (No: 7/EA/KEPK-FKM/2025). Participation was entirely voluntary, and informed consent was obtained from every respondent, following ethical research standards and procedures for human subject protection.

3 Result

The Iodized Salt Awareness Movement (ISAM) in Purworejo Regency demonstrated significant improvements in community knowledge, practices, and technical capacity related to iodized salt production. The intervention combined participatory education, technical mentoring, and institutional collaboration with district-level authorities, enabling both behavioral and production-level changes within the coastal community.

As presented in Table 1, most respondents were women in the productive age range (31–60 years), with the majority having completed secondary education. Their occupations varied, including homemakers, farmers, and local entrepreneurs. This demographic composition reflects the socioeconomic diversity of coastal households engaged in salt production and highlights the central role of women in health-related community initiatives.

Table 1. Characteristics of Respondents

Characteristics	n	%
Age (years)		
31–40.	7	25.0
41–50.	12	42.9
51–60.	8	28.6
≥ 61.	1	3.6
Gender		
Female.	17	60.7
Male.	11	39.3
Education		
Elementary School.	1	3.6

Characteristics	n	%
Junior High School.	5	17.9
Senior High School.	10	35.7
Bachelor's Degree or S1.	2	7.1
Master's Degree or S2.	1	3.6
Others.	9	32.1
Occupation		
Farmer.	6	21.4
Village Official.	4	14.3
Teacher.	2	7.1
Laborer.	1	3.6
Entrepreneur.	2	7.1
Housewife.	8	28.6
Trader.	1	3.6
Private Employee.	1	3.6
Other.	3	10.7

Following the intervention, participants' overall knowledge scores on iodized salt improved significantly, from a mean of 71.79 (±15.65) before to 82.14 (±8.76) after the program ($p = 0.001$). Increases were most notable in practical aspects, such as proper storage methods ($p = 0.002$), correct timing of salt use in cooking to minimize iodine loss ($p = 0.021$), and understanding that labels alone do not guarantee iodine adequacy ($p = 0.016$). Additionally, participants showed improved awareness of the inadequacy of naturally produced krosok salt in meeting iodine needs ($p = 0.039$) and the importance of consuming salt in moderation to prevent overuse, even for iodine purposes ($p = 0.001$).

However, knowledge regarding broader health implications, such as the link between iodine deficiency and stunting or intelligence, showed limited change ($p > 0.05$), suggesting the need for more targeted health education components (Table 2). These findings indicate that the intervention effectively strengthened applied knowledge relevant to daily household practices, even though conceptual understanding of IDD impacts may require longer-term reinforcement.

Table 2. Changes in Knowledge Scores Before and After the Intervention

No	Essence of Knowledge	N	Pre		Post		p-value
			Mean	SD	Mean	SD	
1	Quality of iodized salt – Label does not guarantee standard compliance.	28	64.29	48.80	89.29	31.50	0.016a*
2	Reason for choosing salt – Consider iodine content, not just taste.	28	89.29	31.50	100.00	-	0.250a
3	Characteristic of iodized salt – Iodine cannot be identified by taste.	28	64.29	48.80	78.57	41.79	0.289a
4	Krosok salt – Naturally insufficient to meet iodine needs.	28	71.43	46.00	96.43	18.90	0.039a*

No	Essence of Knowledge	N	Pre		Post		p-value
			Mean	SD	Mean	SD	
5	Fortification of *krosok* salt – Iodine must be added before marketing.	28	89.29	31.50	96.43	18.90	0.500a
6	Usage method – Add after cooking to prevent iodine loss.	28	57.14	50.40	85.71	35.63	0.021a*
7	Salt storage – Keep in a closed container to prevent iodine loss.	28	64.29	48.80	100.00	-	0.002a*
8	Salt consumption – Consume adequately; do not overuse even for iodine.	28	60.71	49.73	7.14	26.23	0.001a*
9	Impact of iodine deficiency – Stunting.	28	89.29	31.50	78.57	41.79	0.375a
10	Impact of iodine deficiency – Intelligence.	28	67.86	47.56	89.29	31.50	0.070a
Average score		28	71.79	15.65	82.14	8.76	0.001b
Score increment (test gain)		28			9.65		

SD: Std. Deviation; a=Related-Samples McNemar Change Test; b=Related-Samples Wilcoxon Signed Rank Test; * $p<0.05$.

On the production side, the mentoring component enabled local salt farmers to adopt low-cost tunnel geomembrane technology. This method improved evaporation efficiency and salt purity while minimizing contamination. Laboratory results confirmed that KUGAR's salt before iodization met SNI 3556:2024 standards for NaCl content (94.54%) and moisture (4.72%), with negligible levels of heavy metals (Table 3). After fortification, the iodine content reached 69.13 ppm, well within the required range of 30–80 ppm.

Table 3. Quality test results of salt produced by "KUGAR Pendowo Limo" compared with SNI 3556:2024.

Parameter	Unit	Test Result	SNI 3556:2024 Standard
NaCl content	%	94.54	≥ 94
Moisture content	%	4.72	≤ 7
Insoluble matter in water	%	0.39	-
Pb	ppm	< 0.002	≤ 10
Cd	ppm	< 0.07	≤ 0.5
As	ppm	< 0.003	≤ 0.1
Hg	ppm	< 0.002	≤ 0.1

The introduction of the "Urut Sewu" community-based salt brand marked a significant milestone in the program's success, underpinned by key licensing and quality certifications from trusted authorities like SNI, BPOM, and MUI. While the high cost of certification presents a barrier for small-scale producers, these regulatory achievements have laid the groundwork for broader market access and have enhanced the credibility of local products.

After three months of monitoring, it is clear that the intervention has led to sustained community engagement in iodized salt production and education. Notably, the local community's capacity for salt production has improved significantly, with KUGAR's production output increasing from 300-400 kg of salt per tunnel per operation to 1,200 tons annually. Local leaders, including women's groups, have remained actively involved, embedding the principles of the Iodized Salt Awareness Movement (ISAM) within ongoing coastal empowerment and nutrition village initiatives. This continuous participation highlights the intervention's potential to be replicated in other coastal areas, where marine resource utilization and public health objectives can align and support each other.

4 Discussion

The Iodized Salt Awareness Movement (ISAM) in Purworejo Regency effectively demonstrated that community-based participatory approaches can improve both knowledge and production capacity related to iodized salt. The increase in participants' knowledge and the adoption of iodized salt practices indicate that integrated interventions, combining education, mentoring, and local participation, can yield measurable behavioral changes. The involvement of community leaders and women's groups proved essential, reinforcing evidence from similar participatory programs in Bangladesh and India that demonstrated improved nutritional and health outcomes through women-centered initiatives [4,5].

The introduction of tunnel geomembrane technology provided a practical and affordable solution for small-scale salt producers. This simple innovation enhanced salt purity and production efficiency, allowing local cooperatives to meet the Indonesian National Standard (SNI 3556:2024). The findings align with previous studies in North Sumatra and other coastal regions, which reported that local adaptation of solar evaporation technologies increased both product quality and resilience against seasonal disruptions [6–8].

Laboratory analyses confirmed the high NaCl content (94.54%) and low moisture (4.72%) in KUGAR's salt, consistent with international food-grade standards. Laboratory testing verified the high-grade standard quality of KUGAR's salt, sodium chloride (NaCl) of 94.54% and moisture content of 4.72% which meets the premium A standard [9]. The insoluble matter content (0.39 %) was lower than that generally found in conventional salts, since according to the international food-grade salt reference standards, the insoluble dry matter cannot exceed 0.2 %. Moreover, the remarkably low heavy metal level was consistent with standards from the Codex Alimentarius [10]. These results are similar to those of Gujarat, India (NaCl: 96.2%) and Australia (95-96%) [11]. Close evaporated techniques may increase the quality of the salt in Bangladesh, and long-term sustainability may rely on the financial support and modernization of the process.

Despite the positive outcomes, a number of structural barriers persist. The high costs associated with certification, particularly those related to SNI and BPOM, pose a substantial obstacle for micro and small businesses, impeding their ability to access broader market opportunities. Similar financial constraints have been reported in the Madurese Coastal Area, Indonesia, where certification expenses hindered the sustainability of small-scale salt enterprises. Addressing these challenges requires coordinated government support through subsidized certification schemes and inclusive market access policies.

Regular participation of local actors in monitoring activities enhanced awareness and accountability, consistent with findings from various community-based nutrition interventions. Monitoring was carried out not only among the community as consumers but also toward the salt industry as producers to ensure the production of iodized salt that meets quality standards. Nutrition International, in collaboration with the Government of Indonesia, introduced a village-level monitoring system using portable mini-labs, which successfully strengthened enforcement and increased community awareness [12]. A more comprehensive

monitoring approach, encompassing both households and the food industry, is essential to ensure sustainable iodine adequacy in the population [13]. However, economic disparities continue to affect access to quality iodized salt. Lower-income households remain vulnerable to market fluctuations, sometimes reverting to non-iodized salt when prices rise or supply chains weaken, an issue also noted in urban Bangladesh [14].

Sustaining behavioral changes requires ongoing political and social support. Evidence from South Sulawesi indicates that the long-term success of IDD prevention depends on continuous community engagement, cultural reinforcement, and local institutional backing [15]. While ISAM achieved significant short-term gains, the short intervention duration and limited geographic scope restrict generalization. Future studies should consider longer follow-up periods and include diverse coastal contexts to capture broader socioeconomic dynamics.

Overall, this study contributes to the growing evidence that community empowerment, combined with accessible technology and supportive policy frameworks, can drive sustainable improvements in public health and coastal resource management. The ISAM model illustrates how participatory, multi-sectoral collaboration can strengthen the intersection of nutrition, economic development, and environmental sustainability in Indonesia's coastal regions.

However, this study was limited by its short intervention period and geographical focus on a few coastal villages, which may restrict the generalization of findings. Future studies should involve longer-term monitoring and broader regional coverage to capture sustained behavioral and production changes.

5 Conclusion and Recommendations

This study confirms the success of the Iodized Salt Awareness Movement (ISAM), implemented through the Program for Strengthening Iodized Salt Awareness Nationwide (PSIAN), in enhancing community knowledge, production capacity, and multi-sector collaboration for the production and use of iodized salt meeting national standards. Active engagement of local communities, cross-sectoral partnerships, and the use of locally available resources were key factors contributing to the program's effectiveness.

Sustaining the progress achieved requires continued mentoring, institutional capacity building, and supportive policies to make certification more accessible for small-scale producers. Strengthened coordination among health, marine, and trade sectors will help maintain quality assurance, while expanding community education and replicating this participatory model in other coastal regions can reinforce iodine deficiency prevention and promote the integration of coastal resource management with public health improvement.

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