Child malnutrition and mortality among families not utilizing adequately iodized salt in Indonesia[1–3]

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ABSTRACT

Background: Salt iodization is the main strategy for reducing iodine deficiency disorders worldwide. Characteristics of families not using iodized salt need to be known to expand coverage.

Objective: The objective was to determine whether families who do not use iodized salt have a higher prevalence of child malnutrition and mortality and to identify factors associated with not using iodized salt.

Design: Use of adequately iodized salt (≥30 ppm), measured by rapid test kits, was assessed between January 1999 and September 2003 in 145 522 and 445 546 families in urban slums and rural areas, respectively, in Indonesia.

Results: Adequately iodized salt was used by 66.6% and 67.2% of families from urban slums and rural areas, respectively. Among families who used adequately iodized salt, mortality in neonates, infants, and children aged <5 y was 3.3% compared with 4.2%, 5.5% compared with 7.1%, and 6.9% compared with 9.1%, respectively ($P < 0.0001$ for all), in urban slums; among families who did not use adequately iodized salt, the respective values were 4.2% compared with 6.3%, 7.1% compared with 11.2%, and 8.5% compared with 13.3% ($P < 0.0001$ for all) in rural areas. Families not using adequately iodized salt were more likely to have children who were stunted, underweight, and wasted. In multivariate analyses that controlled for potential confounders, low maternal education was the strongest factor associated with not using adequately iodized salt.

Conclusion: In Indonesia, nonuse of adequately iodized salt is associated with a higher prevalence of child malnutrition and mortality in neonates, infants, and children aged <5 y. Stronger efforts are needed to expand salt iodization in Indonesia. *Am J Clin Nutr* 2008;87:438–44.

KEY WORDS Children, iodized salt, mortality, Indonesia

INTRODUCTION

Iodine deficiency disorders consist of a wide spectrum of disorders, including mental retardation, reduced intellectual capacity, impaired physical development, increased perinatal and infant mortality, hypothyroidism, cretinism, and goiter. Worldwide, an estimated 36.5% of children are affected by iodine deficiency (1). Universal salt iodization is the main public health strategy for improving iodine status, and access to iodized salt by households increased from 5–10% in 1990 to 68% in 1999 (2) and was accompanied by a large decrease in the occurrence of brain damage and mental retardation due to iodine deficiency (1, 3). Despite this progress, an estimated 2 billion people worldwide have insufficient iodine intakes (1).

In Indonesia, national coverage of households with iodated salt (>5 ppm) was reported to be 78.2% in 1995 and 81.5% in 1999 (4). The prevalence of goiter has decreased among Indonesian schoolchildren from 29% in 1982 to 11% in 2003 (5), and a national survey in 2003 showed that the median urinary iodine concentration was 229 μg/L (6), well above the minimum for median urinary iodine of 100 μg/L recommended by the International Council for the Control of Iodine Deficiency Disorders (7).

Our previous studies showed that programs aimed at improving child health and survival, such as vitamin A capsule distribution and childhood immunization, do not meet recommended coverage levels, and that the remaining sector of the population that is not covered by these programs has a disproportionately high prevalence of morbidity and mortality (8, 9). We hypothesized that families that do not use adequately iodized salt have a higher proportion of children who are malnourished and a higher mortality rate in neonates, infants, and children aged <5 y. We also sought to characterize families that did not use adequately iodized salt, which in this article is defined as ≥30 ppm, as compared with international criteria of >15 ppm (7). To address these hypotheses, we examined the relation between household use of adequately iodized salt and mortality in neonates, infants, and children aged <5 y using the Nutrition Surveillance System (NSS)—a large population-based nutritional surveillance database of urban and rural families in Indonesia.

SUBJECTS AND METHODS

The study subjects consisted of households that participated in a major nutritional surveillance system (NSS) in Indonesia, which was established by the Ministry of Health, Government of Indonesia, and Helen Keller International in 1995 (10). The NSS was based on UNICEF's conceptual framework on the causes of malnutrition (11) with the underlying principle to monitor public health problems and guide policy decisions (12). The NSS was

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based on stratified multistage cluster sampling of households in subdistricts of administrative divisions of the country and in slum areas of large cities (10). The NSS in Indonesia involved the collection of data from ≈40 000 randomly selected households every quarter. The NSS involved 5 major urban poor populations from slum areas in the cities of Jakarta, Surabaya, Makassar, Semarang, and Padang and the rural population from the provinces of West Sumatra, Lampung, Banten, West Java, Central Java, East Java, the island of Lombok (West Nusatenggara), and South Sulawesi.

New households were selected every round. Data were collected by 2-person field teams. A structured coded questionnaire was used to record data on children aged 0–59 mo, including anthropometric measurements, date of birth, and sex. The mother of the child or other adult member of the household was asked to provide the following information: household's composition, parental education, birth weight of children, any history of neonatal death before 1 mo of age, any history of infant death before 12 mo of age, any history of child death before 5 y of age, weekly household expenditures, and other socioeconomic, environmental sanitation, and health indicators. They were also asked whether they thought that iodized salt was used in the household. The interviewee was asked to provide a sample of salt that was used in the household to the interviewer, and the interviewer tested the sample for the presence of iodine using a UNICEF rapid test kit (PT Kimia Farma, Jakarta, Indonesia). The training of the fieldworkers included standardization in the use of the rapid test kit. The kit was used to distinguish between salt with ≥30 ppm (adequate) or <300 ppm (inadequate) iodine. The kit provided for possible outcomes of no color to a light purple color that is lighter than the reference color (<30 ppm) or a purple color the same as or darker than the reference color (≥30 ppm); thus, the interviewer recorded either ≥30 ppm or <30 ppm for each household in which salt was tested. In this article, the term *adequately iodized salt* is used to refer to salt that tested positive for ≥30 ppm I. Birth dates of the children were estimated by using a calendar of local and national events and converted to the Gregorian calendar.

In the interview, the mother was asked whether any of her children had died and the age of any children who had died at the time of death. In both the urban and rural NSS, data on mortality in neonates, infants, and children aged <5 y were collected from December 2000 onward. The participation rate of families in the surveillance system was >97% in both urban slum and rural areas, and the main reason for nonresponse was that the family had moved out of the area or was absent at the time the interviews were conducted. Nonresponse because of refusal to participate in the surveillance system was very low (<1%).

In each household, data were gathered regarding the expenditures in the previous week. Expenditure and price variables were collected in Indonesian rupiah. For this analysis, expenditures are presented in US dollars to control for the fluctuation of the rupiah. Monthly exchange rates from 2000 to 2003 were established using historic data publicly available through the Bank of Canada (13). Average exchange rates by data collection round were calculated on the basis of the months in which data were collected for each round. Expenditure and price variables in US dollars per round were created and calculated by using the exchange rates by round.

The study protocol complied with the principles enunciated in the Helsinki Declaration (14). The field teams were instructed to explain the purpose of the NSS and the data collection to each child's mother or caretaker, and, if present, to the father and/or head of household; data collection proceeded only after written informed consent was obtained. Participation was voluntary, and all subjects were free to withdraw at any stage of the interview. The NSS was approved by the Ministry of Health, Government of Indonesia, and the plan for secondary data analysis was approved by the Institutional Review Board of the Johns Hopkins University School of Medicine.

The youngest child in the household was used as the index of child stunting, underweight, or wasting for that particular household (ie, households were not counted more than once). Only one child was counted for each household, because childhood malnutrition is often correlated within the same household, and inclusion of multiple children from the same household would violate the assumption of independence of the outcome variable. The World Health Organization Child Growth Standards were used as the reference growth curves (15). In the analyses of mortality in neonates, infants, and children aged <5 y, respectively, the outcome was death of any neonate, infant, or child aged <5 y in the family versus no death of any neonate, infant, or child aged <5 y in the family. Maternal and paternal ages were divided into quartiles. Maternal and paternal education were categorized as 0, 1–6 (primary), 7–9 (junior high), or ≥10 y (high school or greater). The proportion of mothers and fathers who had achieved >12 y of education (high school graduate) was small and was thus included in the category ≥10 y. Weighting was used to adjust for urban and rural population size, by city and province, respectively, and all results reported in the tables are weighted. Chi-square tests were used to compare categorical variables between groups. Univariate and multivariate logistic regression models were used to examine factors associated with not using adequately iodized salt. Variables were included in the model if they were significantly related to the use of iodized salt in the univariate analyses and could be considered a causal factor. $P < 0.05$ was considered significant. Data analyses were conducted by using SAS SURVEY (SAS version 9.13; SAS Institute, Cary, NC) (16). SAS SURVEY procedures are designed for sample survey data. PROC SURVEYFREQ, PROC SURVEYMEANS, AND PROC SURVEYLOGISTIC were used for all the analyses, and these procedures take into the stratified multistage cluster sampling design by putting the stratum and cluster variables into the corresponding statements, respectively, when applying the survey procedures.

RESULTS

The use of iodized salt was assessed in 145 522 families in urban slums and in 445 546 families in rural areas in Indonesia between January 1999 and September 2003. The proportion of families from urban slums and rural areas who used adequately iodized salt (≥30 ppm), as shown by the rapid test kits, was 66.6% and 67.2%, respectively.

We compared the results of the rapid test kits with the responses of the interviewee about whether the family was using iodized salt or not. The concordance between the responses of the interviewees and the actual testing of the salt for an iodine content > or <30 ppm is shown for families from both urban slums and rural areas in **Table 1**. In both urban slums and rural areas, the proportion of families using adequately iodized salt was high

TABLE 1
Response of interviewees regarding use of iodized salt versus testing for adequately iodized salt (≥30 ppm) with a rapid test kit

Iodized salt by testing	Urban slums "Use iodized salt" (n = 109 959)	Urban slums "Don't use iodized salt" (n = 15 767)	Urban slums "Don't know" (n = 16 628)	Rural areas "Use iodized salt" (n = 335 666)	Rural areas "Don't use iodized salt" (n = 73 827)	Rural areas "Don't know" (n = 46 865)
		%			%	
≥30 ppm	81.1	24.5	49.1	83.2	11.3	52.6
<30 ppm	18.9	75.5	50.9	16.8	88.7	47.4

among those who reported using iodized salt and low among those who reported not using iodized salt.

The demographic characteristics and child anthropometric measures were compared between families in urban slums and in rural areas who did and did not use adequately iodized salt (**Table 2**). In both urban slums and rural areas, adequately iodized salt was more likely to be used in families with higher maternal and paternal education levels; in which children were more likely to be stunted, underweight, or wasted; in which there were ≤4 individuals eating from the same kitchen; in which mortality in any neonate, infant, or child aged <5 y was more common; and in which there was a lower weekly per capita household expenditure. Large differences in the use of adequately iodized salt were observed between the different urban slums and between the different provinces.

Among families who did and did not use adequately iodized salt, respectively, the proportion of children with stunting, underweight, or wasting was 30.5% compared with 32.6%, 24.6% compared with 26.5%, and 10.8% compared with 11.4% ($P <$ 0.0001 for all) in urban slums and 32.0% compared with 37.2%, 18.7% compared with 23.1%, and 5.9% compared with 6.7% (P < 0.0001 for all) in rural areas. Among families who did and did not use adequately iodized salt, respectively, any history of mortality in neonates, infants, and children aged <5 y was 3.3% compared with 4.2%, 5.5% compared with 7.1%, and 6.9% compared with 9.1% ($P < 0.0001$ for all) in urban slums and 4.2% compared with 6.3%, 7.1% compared with 11.2%, and 8.5% compared with 13.3% ($P < 0.0001$ for all) in rural areas.

Multivariate logistic regression models were used to examine factors associated with families not using adequately iodized salt in both urban slums and rural areas of Indonesia (**Table 3**). In families from urban slums and from rural areas, lower maternal age, lower maternal education, and lower paternal education were significantly associated with not using adequately iodized salt. In both urban slums and rural areas, families in the lowest quintiles of per capita weekly expenditure were less likely to use adequately iodized salt.

Alternative multivariate logistic regression models were also explored to examine factors associated with whether the respondent thought that the family was using iodized salt or not. In multivariate models that adjusted for the same factors in Table 3 above, for families in both urban slums and rural areas, lower maternal education, lower paternal education, and low weekly per capita household expenditure were associated with the respondent's report that they were not using iodized salt (**Table 4**).

DISCUSSION

The present study showed that about two-thirds of families in Indonesia are using adequately iodized salt and that the one-third of families not using adequately iodized salt had a significantly higher prevalence of malnutrition, neonatal mortality, infant mortality, and mortality in children aged <5 y. To our knowledge, this is the first report from a developing country to show that malnutrition and neonatal, infant, and child mortality are higher among families who do not use adequately iodized salt; these findings do not necessarily imply that the use of iodized salt reduces mortality, because there are many other differences in social and demographic factors between families using or not using iodized salt that could account for the differences in mortality. Moreover, causal associations between the use of adequately iodized salt and child malnutrition and mortality cannot be inferred in a cross-sectional study. However, these findings suggest that adequately iodized salt fails to reach families who could potentially benefit the most. Improvement of iodine status has been shown to reduce infant and child mortality (17, 18), increase child growth (19), and increase the intelligence quotient of young children by 10–15 points (20). The large sample size used in the present study gave high power to detect small differences that were statistically significant. Thus, the magnitude of the differences between groups should be considered when interpreting the public health significance of the results.

Although most data on iodized salt in national population surveys depend on rapid kits alone to assess adequately iodized salt, rapid test kits in general have shown a high level of inaccuracy in the quantitative measurement of iodine concentration (21). A limitation of the present study was that adequately iodized salt was assessed as ≥ and <30 ppm as per the color reaction of the rapid test kit. Complete absence of a color reaction was graded as <30 ppm, and the proportion of households using salt with no detectable level of iodine is not known. However, it should be noted that the concordance between the family member's report of using iodized salt and the actual testing for adequately iodized salt was high. Another limitation of the study was that the sensitivity and specificity of the kit was not tested against the titration method. Misclassification of households using the rapid test kit would likely attenuate the association that was found between the use of adequately iodized salt and child malnutrition and mortality.

In Indonesia, salt iodation began under Dutch rule in 1927 but ceased in 1945 (4). Efforts to improve iodine status were renewed in 1976, but these efforts were hampered by lack of national data on the problem and lack of authority and coordination within the government (4). A nationwide program to control iodine deficiency disorders began in the mid-1990s with the use of iodized salt, and, although methods have varied between surveys, data show that the prevalence of goiter decreased from 37.2% in 1980–1982 to 9.8% in 1996–1998 (4). Currently, Indonesia has ≈25 000–30 000 small salt farmers that produce three-quarters

TABLE 2
Univariate comparisons of demographic characteristics of families using adequately iodized salt in urban slums and rural areas of Indonesia

	Families using adequately iodized salt			
	Urban slums (n = 94 823)		Rural areas (n = 296 170)	
Characteristics	No. of subjects[1]	P[2]	No. of subjects[1]	P[2]
Maternal age				
≤24 y	25 482 (65.0)	<0.0001	95 154 (64.3)	<0.0001
25–28 y	24 547 (67.3)		76 492 (67.9)	
29–32 y	21 491 (68.3)		67 335 (69.8)	
≥33 y	23 303 (66.1)		67 635 (68.3)	
Maternal education				
0 y	3729 (57.2)	<0.0001	10 020 (40.9)	<0.0001
1–3 y	5532 (56.4)		17 225 (51.8)	
4–6 y	36 185 (64.0)		142 803 (64.6)	
7–9 y	22 658 (68.0)		66 540 (73.9)	
≥10 y	26 398 (73.8)		68 431 (82.0)	
Paternal education				
0	1528 (57.1)	<0.0001	6339 (39.4)	<0.0001
1–3	3023 (56.5)		12 440 (51.6)	
4–6	27 836 (64.1)		126 957 (64.4)	
7–9	22 790 (64.1)		58 891 (72.2)	
≥10	37 438 (70.5)		91 243 (78.3)	
Child sex				
Male	49 103 (66.7)	0.39	156 768 (67.2)	0.96
Female	45 712 (66.4)		150 149 (67.2)	
Child age				
0–5 mo	12 738 (65.0)	0.0003	44 035 (66.1)	<0.0001
6–11 mo	15 766 (66.4)		55 506 (66.1)	
12–23 mo	26 035 (66.7)		86 809 (66.6)	
24–35 mo	19 313 (66.7)		58 806 (67.8)	
36–47 mo	13 194 (67.2)		38 996 (69.3)	
48–59 mo	7595 (68.0)		22 377 (70.1)	
Height-for-age z score				
<−2	28 844 (65.1)	<0.0001	98 196 (63.7)	<0.0001
≥−2	65 644 (67.2)		208 103 (69.0)	
Weight-for-age z score				
<−2	23 177 (64.8)	<0.0001	57 312 (62.3)	<0.0001
≥−2	71 114 (67.1)		248 682 (68.4)	
Weight-for-height z score				
<−2	10 242 (65.5)	<0.0001	18 127 (64.4)	<0.0001
≥−2	84 021 (66.7)		287 734 (67.4)	
Number of individuals eating from same kitchen				
2–4	53 025 (67.3)	<0.0001	125 173 (69.1)	<0.0001
>4	41 544 (65.5)		150 148 (68.0)	
Location (urban slum)				
Padang	943 (93.4)	<0.0001	—	—
Jakarta	44 444 (52.7)		—	
Semarang	14 043 (87.9)		—	
Surabaya	31 286 (90.9)		—	
Makassar	4106 (60.0)		—	
Location (rural province)				
West Sumatra	—	—	11 392 (94.3)	<0.0001
Lampung	—		18 054 (77.4)	
Banten	—		6664 (47.8)	
West Java	—		76 809 (60.4)	
Central Java	—		83 883 (80.6)	
East Java	—		95 353 (21.6)	
Lombok	—		2622 (18.7)	
South Sulawesi	—		12 148 (81.4)	
Weekly per capita household expenditure, quintile[3]				
1	17 636 (69.2)	<0.0001	49 695 (61.0)	<0.0001
2	18 703 (68.9)		57 884 (64.4)	
3	19 137 (66.9)		64 670 (67.9)	
4	19 459 (64.9)		66 237 (69.4)	
5	19 888 (63.8)		68 438 (72.4)	
Neonatal mortality (<1 mo)				
Reported deaths	1729 (62.8)	<0.0001	8525 (58.8)	<0.0001
No reported deaths	50 073 (68.5)		192 641 (68.4)	
Infant mortality (<12 mo)				
Reported deaths	2855 (62.5)	<0.0001	14 458 (57.5)	<0.0001
No reported deaths	48 945 (68.6)		186 719 (68.9)	
Child mortality (<5 y)				
Reported deaths	3600 (62.1)	<0.0001	17 118 (57.5)	<0.0001
No reported deaths	48 187 (68.8)		184 005 (69.1)	

[1] Percentages in parentheses.
[2] Chi-square tests used to compare families using or not using adequately iodized salt.
[3] Quintile 1 represents the poorest and quintile 5 represents the wealthiest.

TABLE 3
Multivariate logistic regression models of factors associated with families not using adequately iodized salt in urban (n = 142 522) and rural (n = 445 546) Indonesia

Characteristic	Urban[1] OR (95% CI)	Urban[1] P	Rural[1] OR (95% CI)	Rural[1] P
Maternal age				
≤24 y	1.13 (1.08, 1.18)	<0.0001	1.48 (1.41, 1.56)	<0.0001
25–28 y	1.07 (1.03, 1.12)	0.0013	1.27 (1.21, 1.33)	<0.0001
29–32 y	1.03 (0.99, 1.07)	0.23	1.12 (1.08, 1.17)	<0.0001
≥33 y	1.00 (—)	—	1.00 (—)	—
Maternal education				
0 y	1.72 (1.58, 1.88)	<0.0001	3.88 (3.42, 4.41)	<0.0001
1–3 y	1.48 (1.36, 1.60)	<0.0001	2.86 (2.65, 3.08)	<0.0001
4–6 y	1.32 (1.26, 1.38)	<0.0001	1.90 (1.80, 2.00)	<0.0001
7–9 y	1.18 (1.13, 1.23)	<0.0001	1.35 (1.29, 1.42)	<0.0001
≥10 y	1.00 (—)	—	1.00 (—)	—
Paternal education				
0 y	1.35 (1.20, 1.53)	<0.0001	2.59 (2.39, 2.80)	<0.0001
1–3 y	1.21 (1.10, 1.34)	0.0001	1.97 (1.86, 2.08)	<0.0001
4–6 y	1.19 (1.14, 1.24)	<0.0001	1.51 (1.47, 1.55)	<0.0001
7–9 y	1.08 (1.04, 1.12)	0.0002	1.17 (1.15, 1.20)	<0.0001
≥10 y	1.00 (—)	—	1.00 (—)	—
Weekly per capita expenditure quintile				
1	1.14 (1.08, 1.19)	<0.0001	1.23 (1.16, 1.31)	<0.0001
2	1.03 (0.98, 1.09)	0.27	1.17 (1.11, 1.23)	<0.0001
3	1.01 (0.97, 1.05)	0.70	1.12 (1.07, 1.17)	<0.0001
4	0.99 (0.96, 1.03)	0.76	1.12 (1.09, 1.16)	<0.0001
5	1.00 (—)	—	1.00 (—)	—

[1] Multivariate analyses were conducted separately for urban and rural areas. Multivariate analyses of families in urban and rural areas were adjusted for city and province, respectively.

of the country's 1.2 million tons of salt per year, and iodation is conducted in >300 processing plants distributed in 24 provinces (22). Although national regulations by the Indonesian Ministry of Industry and Trade require salt iodation at 30–80 mg KIO_3/kg, noniodized unprocessed or "raw" salt is often used, especially in rural villages (23). Besides the high number of small salt producers, a further challenge to wider usage of adequately iodized salt is the geography of Indonesia in which >230 million people are spread over a large archipelago that consists of thousands of islands.

The present study showed that there is considerable variability among the urban slums and provinces of Indonesia in the use of adequately iodized salt. Among the provinces, the lowest use of adequately iodized salt occurred in Lombok, Banten, and South Sulawesi. Of the urban slums, Jakarta and Makassar had the lowest use of adequately iodized salt. As noted in the *Jakarta Post* of 17 June 17 2005, "A lot of salt with no iodine is still being sold in the market. It is even packaged in a similar way to the iodized salt that has a certificate from the Ministry of Health." The findings from the present study suggest that noniodized salt makes it to the kitchens and tables of many families in many areas of Indonesia. Monitoring and enforcement of iodization may be especially difficult because of the large number of producers and processing plants and the widespread availability of raw salt. The Ministry of Industry and Trade has acknowledged that only a portion of producers meets the national standard for salt iodization (24). The Food and Drugs Board conducts salt inspections in the markets, but it does not have any legal authority to prohibit the sale of noniodized salt (24). Thus, there are no legal repercussions or prosecutions for violating national regulations regarding iodized salt (24).

The findings from this study were generally consistent for families from both urban slums and rural areas of Indonesia, but the magnitude of differences in stunting, underweight, and wasting as well as mortality in neonates, infants, and children aged <5 y were greater in families using and not using iodized salt in rural areas than in families in urban slum areas. The differences may be greater in rural areas because the prevalence of both malnutrition and infant and child mortality are higher in rural areas than in urban slums of Indonesia.

These data show that a low level of formal maternal education was the factor mostly strongly associated with nonuse of adequately iodized salt. This relation was attenuated by the fact that in households in which the mother thought they were using iodized salt, nearly 20% were actually using salt that was not adequately iodized, as determined by rapid testing. When the mother's belief that she was using iodized salt was considered in alternative analyses, the relation between low level of maternal education and nonuse of iodized salt was even stronger. In other words, noniodized salt was consciously purchased for the family more often by mothers with a lower education level, which suggests that they may have purchased noniodized salt because they were unaware of the benefits of iodized salt. These findings reinforce the importance of maternal education to family health and also suggest that social marketing of iodized salt to mothers may be an important strategy for increasing the use of iodized

TABLE 4
Multivariate logistic regression models of factors associated with family member's report of not using iodized salt in urban (n = 142 522) and rural (n = 445 546) Indonesia

	Urban[1]		Rural[1]	
Characteristic	OR (95% CI)	P	OR (95% CI)	P
Maternal age				
≤24 y	1.39 (1.30, 1.49)	<0.0001	1.76 (1.65, 1.89)	<0.0001
25–28 y	1.04 (0.97, 1.11)	0.23	1.36 (1.29, 1.43)	<0.0001
29–32 y	0.98 (0.93, 1.04)	0.57	1.12 (1.07, 1.17)	<0.0001
≥33 y	1.00 (—)	—	1.00 (—)	—
Maternal education				
0 y	5.97 (5.31, 6.71)	<0.0001	9.77 (8.66, 11.0)	<0.0001
1–3 y	4.00 (3.65, 4.40)	<0.0001	6.84 (6.34, 7.37)	<0.0001
4–6 y	2.24 (2.09, 2.39)	<0.0001	3.14 (2.51, 2.88)	<0.0001
7–9 y	1.24 (1.17, 1.33)	<0.0001	1.67 (1.57, 1.77)	<0.0001
≥10 y	1.00 (—)	—	1.00 (—)	—
Paternal education				
0 y	1.83 (1.61, 2.08)	<0.0001	3.29 (3.01, 3.61)	<0.0001
1–3 y	1.68 (1.50, 1.89)	<0.0001	2.69 (2.51, 2.87)	<0.0001
4–6 y	1.44 (1.37, 1.51)	<0.0001	1.81 (1.74, 1.89)	<0.0001
7–9 y	1.19 (1.13, 1.26)	<0.0001	1.27 (1.22, 1.33)	<0.0001
≥10 y	1.00 (—)	—	1.00 (—)	—
Weekly per capita expenditure quintile				
1	1.57 (1.47, 1.67)	<0.0001	1.55 (1.43, 1.67)	<0.0001
2	1.37 (1.29, 1.45)	<0.0001	1.42 (1.33, 1.53)	<0.0001
3	1.29 (1.21, 1.38)	<0.0001	1.27 (1.20, 1.34)	<0.0001
4	1.22 (1.15, 1.30)	<0.0001	1.17 (1.12, 1.23)	<0.0001
5	1.00 (—)	—	1.00 (—)	—

[1] Multivariate analyses were conducted separately for urban and rural areas. Multivariate analyses of families in urban and rural areas were adjusted for city and province, respectively.

salt. In some areas, the local chapters of the National Women's Organization (PKK) have created markets in which only iodized salt is allowed, has established certified village salt vendors, and has involved local leaders in the promotion of iodized salt (24). In this regard, the recent strategy to increase the iodization of salt among small producers is important, and various methods have been proposed and implemented in different countries (25, 26).

Although there have been no systematic surveys of price differences between iodized and noniodized salt across Indonesia, in general, iodized salt costs 2–3 times that of noniodized salt (23). In rural areas, and to a lesser extent in urban slums, families in the lowest quintile of per capita household income were more likely to not use adequately iodized salt, which suggests that the price difference may be a factor for poorer families not using iodized salt, particularly in rural areas. The collective data suggest that both maternal education and the cost of salt play a role in the use of adequately iodized salt: some mothers may know of the benefit of iodized salt but cannot afford it, and some may not be aware of the benefits and buy salt on the basis of price alone.

It is not known whether the findings from this study regarding coverage of households with adequately iodized salt could be generalized to other developing countries, and further studies are needed to corroborate these findings. However, the same type of conditions, such as multiple sources of salt production, multiple centers for processing of salt, widespread availability of raw salt, and difficulties in monitoring and enforcement are also present in other countries in the world.

The present study identifies some areas in which further research on iodine deficiency is needed and provides insight into strategies to eliminate iodine deficiency. Iodine status should be assessed in families that are characterized by low maternal education, low income, and high infant and child mortality to verify the need for targeting the most vulnerable population groups. Further efforts are needed to strengthen the production of iodized salt, monitor and enforce the correct levels of iodine in salt, and ensure that iodized salt is readily affordable. Awareness about the need to consume iodized salt needs to be increased. Targeted distribution of oral iodized oil capsules is another approach that has been used in Indonesia to reach high-risk populations (4). Worldwide, there are still an estimated 45 million newborns who are not brain-protected against iodine deficiency (27). In 2002, at a United Nations Special Session for Children, the Network for Sustained Elimination of Iodine Deficiency (26), a global coalition of public, private, international, and civic organizations, was launched with the goal of reaching the last "thirty percent". As shown in the present article, reaching the remaining households would likely show a disproportionately greater benefit, given the higher prevalence of malnutrition and mortality among the remaining "thirty percent" of families in Indonesia not reached by adequately iodized salt.

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