Original Article

Determination of discretionary salt intake in an iodine deficient area of East Java-Indonesia using three different methods

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As salt is a potential vehicle for delivering iodine to a population, study on salt intake is important. Many methods have been used to measure iodised-salt intake, but the methods were suspected to be inaccurate. A new method, called a lithium-marker technique, has been considered as suitable and safe; hence it has been proposed as a gold standard for measuring the actual salt intake of an individual. We conducted a study to determine discretionary salt intake using the lithium marker technique. The study shows that the total salt intake for children (N =15) and mothers (N =15) were 5.4±2.1 g/d and 5.8±1.7 g/d respectively in which 48.5±17.1% and 50.5±17.3% were discretionary salt. The discretionary salt intake measured using lithium marker (2.53 ± 1.2 g/d for children and 2.99 ± 1.5 g/d for mother) were significantly lower than using 24-hour salt recall (7.01±2.44 g/cap/d) and salt weighing (6.00±1.8 g/cap/d) (P<0.001). In conclusion, the discretionary salt intake by 24-hour salt recall and salt weighing were over estimated as compared to the lithium-labelled salt measurement. It is recommended that the level of iodine fortification in salt be increased up to 80-100 ppm of KIO_3 to provide iodine intake of 150µg/d.

Key Words: lithium marker technique, 24-hour salt recall, salt weighing, discretionary salt intake.

Introduction

The government of Indonesia has initiated an iodination program on salt with the level of fortification of > 30 ppm potassium Iodate (KIO_3).[1] The fortification is based on surveys which show that the discretionary salt intake in Indonesia is 10 g/d.[2] In spite of that, iodine deficiency is still prevalent in Indonesia[3], this is probably a result of low iodine daily intake, which is mainly from iodised salt.

Two methods, namely 24-hour salt recall and salt weighing, have been used to measure discretionary salt intake in different countries. The methods suggest that the discretionary salt intake ranges from 5-15 g/d for children and adults.[4] Unfortunately, the methods lack in precision and accuracy. Current studies suggest that the lithium-marker technique can be used as a gold standard for measuring discretionary salt intake. The method is more precise and biologically safe. The lithium-marker technique has been employed to measure discretionary and total salt intake of European[5-7], African and Latin American countries.[8] There have been no salt consumption studies using the gold standard method in Asia. The current study was conducted in Indonesia to compare three methods of discretionary salt measurements, i.e. lithium-labelled, 24-hour recall, and salt weighing. More precise data of discretionary salt intake amongst Indonesians would be obtained, so that the fortification level of iodine in salt could be reformulated to combat iodine deficiency.

Subjects and methods

Fifteen schoolboys aged seven to ten years (from the same school) and their respective mothers participated voluntarily. This study was carried out in an endemic, mountainous rural area in the district of Malang, East Java Indonesia. Malang is 1300m above sea level and has an average temperature of 22°C. The prevalence of TGR (Total Goitre Rate) in East Java is 15.31%.[9] The TGR among school-children measured by palpation is 46% or 100% using USG technique.[10] Ethical approval was obtained from the Faculty of Medicine, University of Indonesia by considering the guidelines of the Council for International Organisation of Medical Sciences.[11] Participating mothers signed written informed consents.

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Accepted 10th October 2005

Preparation and administration of lithium-labelled salt

Lithium-labelled salt was prepared by the Centre of Nutrition Research and Development Bogor Indonesia, following a method outlined by Sanchez-Castillo *et al*.[12] Lithium content in the salt was then validated using AAS method by the National Institute of Atomic Energy (BATAN) Indonesia. The average lithium content was 1.5607 mg Li/g salt, with coefficient of variance (CV) of 2,35% and 88% lithium recovery. The participating families were provided with 500g lithium-labelled salt for seven consecutive-days cooking and any other ways of salt consumption. All other salt in the household was taken. On the sixth and seventh day, the left over labelled salt in the household was weighed.

Urine collection and Analysis

The 24-hour urine of mothers and their respective sons was collected in the morning using a urine bag in the beginning of the study for baseline purposes. This was also carried out on the sixth and seventh day. Before study commencement the participating mothers and sons were gathered to highlight the importance of total urine inclusion over 24 hours. Teachers and local health workers were also summoned in the group meeting. The teachers were asked to direct the subjects to collect their urine at school, whilst the health workers visited the subjects everyday to ensure that urine collection was properly performed. The subjects were provided with chamber pots for use at home and plastic bags for use outside the home. All subjects were advised to bring at least 5 plastic bags of 100 cc each when they went out. The subjects provided a verbal verification for the completeness of 24 hour urine collection.

Approximately 100 cc urine samples were transferred to small-labelled plastic bottles from which 15cc was stored on ice and sent to BATAN on the same day for lithium content analysis. The analysis was performed using AAS AA 775 wave length 670.8 nm.[13] The content of urinary sodium and chloride was determined on the same day of urine collection using the remaining urine samples following AAS wave length 589 nm and Argentometry techniques respectively, outlined by Greenberg *et al*.[14] This was carried out at Brawijaya University, Malang, Indonesia.

Measurement of salt intake by lithium-labelled method

Total salt intake was calculated from the urinary excretion of sodium and chloride. The lithium excretion was obtained from the mean of the lithium on the sixth and seventh day, and corrected from the lithium excretion on the first day. Discretionary salt intake was estimated by dividing the excretion of the lithium for each subject by the proportion of lithium content in salt (1.5607 mg Li/g salt), expressed as a percentage of total salt intake. Finally, the means for groups of mothers and children were calculated.

24-hour salt recall

Mothers were interviewed to obtain information on salt use for food preparation for the whole family. Salt in foods and beverages consumed outside the home was not regarded as discretionary. In order to get precise amounts, mothers were asked to describe the ways of adding salt to foods using a standardised spoon. One heaped standard spoon equalled 5g salt.[15] The total salt intake in the family during 24 hours was calculated by multiplying the number of spoon with 5g. The discretionary salt intake/cap/d was then determined from the total salt use divided by total family members.

Salt weighing method

On day 0, every household received 500 g iodine-labelled salt to use on the consecutive seven days of the study. The left over salt in the household was weighed to the nearest 0.1 g on the day sixth and seventh to estimate the average total salt consumption. In order to maintain the common household's use of salt, the mothers were reminded to use the labelled-salt during food preparation. The number of people who eat the food prepared by respective mothers were noted, and the amount of labelled-salt intake per capita per day in the household was calculated from the total salt consumed for all family members divided by the number of household members.

Anthropometric measurement

The weights of schoolboys and their mothers were measured using an electric weighing scale SECA 870 to nearest 0.1 kg. Samples used light clothing and no shoes. Body stature was measured to the nearest 0.1 cm with microtoise.[15]

Statistical methods

Data was reported as (Mean ± SD). The significant differences among groups were determined by one-way ANOVA. A Pearson correlation coefficient was used to show the correlation of salt intake between different methods. $P<0.05$ was considered as statistically significant. The agreement between methods of salt intake was tested based on the Bland and Altman method.[16] Statistical analysis were performed using a Statistical Package for Social Sciences version 9.0 software for Windows.[17]

Results

The boys were 8.7 ± 0.6 years old, 117.3 ± 5.0 cm tall and weighed 20.0 ± 1.9 kg. The children weight-for-age z-score was -1.93±0.53, height-for-age z-score -2.19±0.76, and weight-for-height z-score -0.17±0.52. Of those 15 boys, 53% were underweight, 73% were stunted and 13% were severe stunted. Their respective mothers were 33.2 ± 4.0 years old, 148.6 ± 4.7 cm tall, weighed 49.6 ± 6.1 kg and had body mass index 22.5 ± 2.9 kg/m^2. Only one mother had body mass index <18.5 kg/m^2. Due to economic restriction, the families rarely spent money for food out of home. According to the result of 24-hour salt recalls, salt was added to almost all of foods (in form of brick salt) prepared by the mothers in the households, except for cooking rice. Almost all (80%) mothers added salt before or during cooking. Urinary volume, frequency, ion excretion and salt intake are shown on Table 1. Total salt intake of mothers based on urinary sodium and chloride excretion was 5.8 ± 1.7 g/d, while for children was 5.4 ± 2.1 g/d. Total salt intake ranged from 2.71- 9.42

Table 1. Daily ion excretion, urinary frequency, total and discretionary salt intakes measured by lithium-marker technique in mothers and their children in Malang†

Excretion and intake	*Day 0*		Day 6th and 7th‡	
	Mothers (N = 15)	Children (N =15)	Mothers (N = 15)	Children (N =15)
Urine excretion (L/d)	0.81±0.23	0.61±0.27	0.65±0.19*	0.62±0.19
Urinated frequency/d	5.9 ±1.6	5.4 ±1.5	5.1 ±0.9	5.2 ±1.2
Ion excretion (mmol/d)				
Sodium	118.3±58.2	76.2±32.3**	100.8±36.7	85.8±39.1
Chloride	125.2±52.5	86.5±33.8**	100.8±27.3	96.8±36.1
Lithium	0.00±0.00	0.00±0.00	0.67±0.33	0.56±0.28
Estimated salt intake				
Total (g/d)	7.1±3.1	4.8±1.9 -	5.8±1.7	5.4±2.1
Discretionary (g/d)	-	-	2.99±1.5	2.53±1.2
Discretionary (%)	-	-	50.5 ±17.3	48.5±17.1

† = mean±SD; ‡ =average of 2 consecutive days measurement (day 6th and 7th); * = significantly different from day 0, P=0.01
** = significantly different from mother, P =0.02

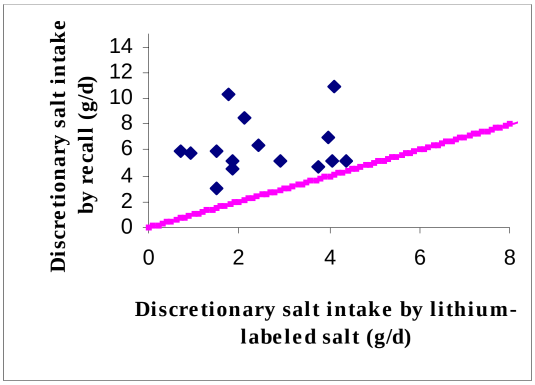
g/d and 2.47–12.55g/d for mothers and children respectively. Discretionary salt contributed to 50 ± 17% and 48 ± 17% of the total salt ingested by the mothers and children respectively. The proportion of discretionary salt intake among children was 85% that of mothers. Total and discretionary salt intake of mothers were not significantly different (P = 0.36) from that of their children. However, children had significant higher intake of salt per kg body weight than that of mothers (0.27 vs. 0.12 g/kg body weight, P<0.001). A significant difference was found for sodium excretion and chloride excretion (P = 0.02) on 0-day between mothers and children. Meanwhile, there were no significant differences between sodium and chloride excretion for mothers and children during the experiment days.

The range of discretionary salt intake measured by 24-hour salt recall and by salt weighing methods was 3.2-11.9 g/d and 2.6-9.5 g/d respectively. While by lithium-labelled salt was at a range of 0.71-4.38 g/d. Estimation of discretionary salt intake measured by 24-hour salt recall and salt weighing methods were twice higher than those by lithium-labelled salt measurements. The estimation of discretionary salt intake measured by three different methods was shown on Table 2. There are no significant correlation between 24-hour salt recall and salt weighing, and between 24-hour recall and lithium-labelled salt method among mothers (*r = 0.32, P = 0.25* and *r = 0.10 P = 0.72*) respectively. These are also the case for children (*r = 0.60, P = 0.14* and *r = 0.23, P = 0.29*) respectively. The difference between 24-hour recall and salt weighing method, compared to lithium-labelled salt, were plotted on Figures 2 and 3. These figures showed that all points are above the line of the equality (y ≠ x). This indicates that discretionary salt intake measured by 24-hour salt recall and salt weighing are likely to be over estimate compared to the estimation of discretionary salt intake measured by lithium-labelled

Table 2. Discretionary salt intake using three different methods†

	Disretionary Intake per capita/day (g/d)‡
Lithium-labeled salt	
Mother	2.53 ± 1.24 [a]
Children	2.99 ± 1.50 [a]
24-hour salt recall	7.01 ± 2.44 [b]
Salt weighing	6.00 ± 1.88 [b]

† = mean±SD; ‡ =Different superscripts denote LSD test significant difference (P<0.05)



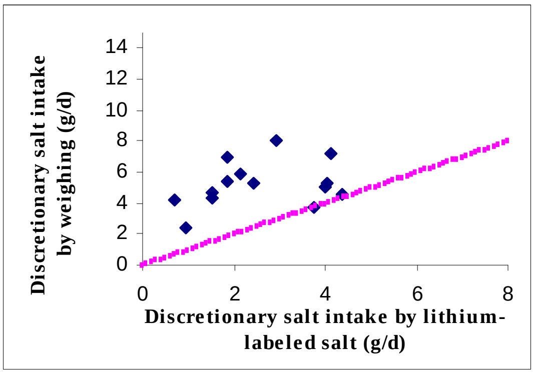
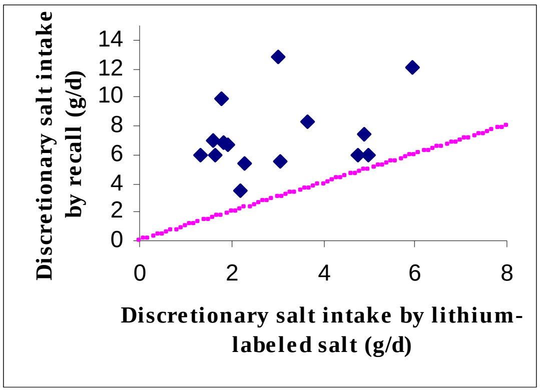


Figure 1. Discretionary salt intake of children measured by 24-hour salt recall and weighing compared to lithium-labeled salt (g/d), with line of equality.



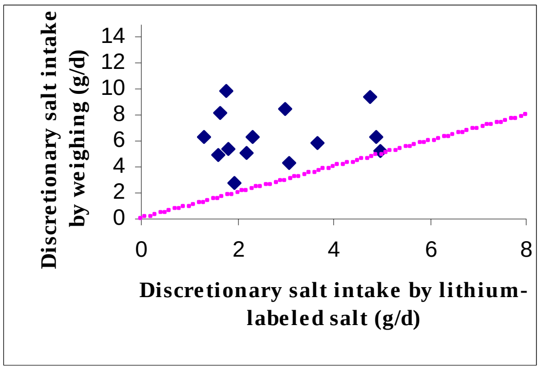


Figure 2. Discretionary salt intake of mothers measured by 24-hour salt recall and weighing compared to lithium-labeled salt (g/d), with line of equality.

salt, and the measurements are significantly higher ($P < 0.001$).

Discussion

Total and discretionary salt intake measured by lithium-labelled salt

The amount of salt intake from household and outside household for schoolchildren and mothers, i.e. 5.4±2.1g/d and 5.8±1.7 g/d respectively, were close to 6 g/d of salt intake recommended by WHO.[4] These intakes should provide balance of sodium chloride of 2-3 g/d in the body. The value of salt intake was considerably lower compared to the existing data of Indonesian of 10 g/d.[2] However, the finding shows similar results with studies conducted in Guatemala and Benin.[8] The latter study shows salt intake among mother was 5.2 g/d, and among Beninese children 5.7 g/d. (Table 3). This might be due to similarities between Guatemala, Benin and Indonesia in terms of tropical climate and temperature.

There were no significant differences between daily ion excretion, total and discretionary salt intake among mothers and children at baseline and experimental days (P>0.05). Engle and Nieves[18] reported that adults consume more sodium than children, and adults appear to eat more salty diet than children do. However, this study did not show a similar trend. Discretionary salt intake measured by lithium-labelled salt only contributed 48% and 50% to the total salt intake, another 50% was from outside source. The coefficient of variance for discretionary salt intake measured by lithium-labelled salt of mothers was 30.7% (range:13.6–52.2%) and children 28.8% (range:2.20–61%) respectively. Since the CV was not more than 50%, the discretionary salt intake in this study did not vary among people.[6] The means of CVs were in fact lower than the value obtained form Guatemalan children (47.2%) and mothers (39.8%).[8]

Discretionary salt intake measured using three different methods

Measurements using 24-hour salt recall indicated a significant higher result ($P<0.001$) than that of weighing method (Table 2). Both methods revealed higher values as compared to the lithium-labelled salt technique (Fig.2 & 3). This finding is similar to the earlier study in Guatemala, which demonstrated that discretionary salt intake assessed by 24-hour salt recall was twice higher than that of measured by lithium-labelled salt.[8] The overestimation in the 24-hour salt recall and salt weighing methods are likely due to the fact that there is an equal discretionary salt intake distribution of adult and children regardless of age and preferences. Although the discretionary salt intake measured by salt weighing was overestimated and significantly higher (P <0.001) than that of salt measured by lithium-labelled salt, salt weighing method is considered to be more accurate compared to 24-hour salt recall method.

This is probably because the weighing gives accurate estimation than recall method, which depends very much upon memory.[15,19] This present study also shows that there are no significant difference between discretionary salt measured by 24-hour salt recall and salt weighing (P>0.05). The 24-hour salt recall and salt weighing methods do not consider the left over in pan or on the plate.[18] Mothers usually add a small amount of salt to a wide variety of side dishes (eg meat, fish, vegetable and condiment). Total salt consumption in the household depends on the type of side dish or condiment that the mothers cook.[20] The more the vegetables and side dishes were prepared, the more the salt was likely added.

Table 3. Daily total and discretionary salt intakes in mothers and their children using lithium-labeled salt use in Guatemala, Benin and Indonesia†

	Guatemala‡		Benin‡		Indonesia§	
Estimated salt Intake per capita	Mother (N=9)	Children (N =9)	Mothers (N =13)	Children (N =13)	Mother (N =15)	Children (N =15)
Total (g/d)	5.2±1.7	1.8±0.6	9.0±2.9	5.7±2.8	5.8±1.7	5.4±2.1
Discretionary (g/d)	3.9±2.0	1.3±0.6	4.7±1.9	2.9±1.9	2.99±1.5	2.53±1.2
Discretionary (%)	77±24	72±12	52±14	50±13	50.5±17.3	48.5±17.1

†1 = Mean ± SD; ‡ = Melse Boonstra *et al*, 1998; § = Present study

Implication to the program

The finding of this study, which shows that the discretionary salt intake is only about 50% from the total salt intake, indicates that people living in this iodine deficient area might not be able to satisfy their daily iodine requirements. The requirements for children and mothers are 120μg/d and 150μg/d respectively. The main source of iodine is from iodised salt. As per government legislation, iodine level in salt is 40 ppm of KIO_3.[1] At the current level of fortification and salt intake found in this study, the iodine intake from salt is approximately 65 μg/d for children and 87μg/d for mothers; which is 50% short of the requirements. Therefore it is advisable to increase the level of the fortification to 80-100 ppm of KIO_3 in the production stage. This increase is to compensate iodine losses during distribution and storage before reaching the consumers, which may take up to 50%. The suggested level of fortification is determined as such in order to achieve the requirement of 150μg iodine per capita per day. As this study shows that the discretionary salt intake contributes only 50% of the total salt sources (another 50% come from the other sources) it is recommended that all salt sources to be iodised. These include salt used in food industries as an ingredient. It is also highly important to endorse monitoring system on salt iodisation in order to achieve the goal of iodine deficiency eradication program in Indonesia through universal salt iodisation.

Conclusion

The discretionary salt intake using three different methods, as well as total salt intake using lithium-labelled salt, in district of Malang, East Java, Indonesia have been estimated. The study shows that the total amount of salt intake (NaCl) among schoolchildren and their respective mothers were 5.4 ± 2.1g/d and 5.8 ± 1.7g/d respectively, 48% and 50% were from discretionary source. Discretionary salt intake of schoolchildren was 2.5 ± 1.2 g/d, and of mothers 2.9±5.9g/d as measured by lithium-marker technique. The discretionary salt intake measured by 24-hour salt recall was 7.0 ± 2.4g/cap/d while by salt weighing was 5.9±1.8g/cap/d. In conclusion, the discretionary salt intake by 24-hour salt recall and salt weighing were over estimated as compared to the lithium-labelled salt measurement. It is recommended that the level of iodine fortification in salt be increased up to 80-100 ppm of KIO_3. All salt sources required to be iodised and well-monitored.

Acknowledgements

We acknowledge Alida Melse-Boonstra for her useful information on lithium-marker method; Dra. Suwirma M.Si (the National Institute for Atomic Energy -Jakarta Indonesia), for analysis of lithium concentration in urine and in the labelled-salt; DR. Komari (Nutrition Research and Development Centre-Bogor, Indonesia), for the preparation of the lithium-labelled salt. Special thanks are due to Dr. Beny Sugianto, MPS, for all of his very valuable suggestions to the implementation of this study and Dr. Bambang Budi and his staff from Pujon Community Health Centre for their assistance during data collection.

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Original Article

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用三种不同方法检测印尼瓜哇岛东部碘缺乏地区的任意盐摄入量

由于盐是传递碘给人的一种潜在媒介物， 所以研究盐的摄入量是重要的。已经有很多方法用来测量碘盐的摄入，但这些方法还是被怀疑不准确的。一种被称为锂标志技术的新方法，已经被认为合适的和安全的；因此，这种技术已经提议作为测量个体真实盐摄入量的最佳标准。我们引导了一个用锂标志技术检测任意盐摄入的研究。本研究显示孩子(*N* =15)和母亲(*N* =15)总的盐摄入量分别是 5.4±2.1 g/d 和 5.8±1.7 g/d，其中 48.5±17.1%和 50.5±17.3%是任意盐。任意盐的摄入量使用锂标志技术(孩子：2.53 ± 1.2 g/d，母亲：2.99 ± 1.5 g/d)比使用 24 小时盐回忆(7.01±2.44 g/cap/d)和盐称重(6.00±1.8 g/cap/d)显著性偏低。结论，和锂标志盐测量作比较，24 小时盐回忆和盐称重对任意盐摄入量是高估计的。我们推荐盐中的碘强化水平应增加到 KIO_3 在 80-100 ppm 以提供碘的摄入量在 150μg/d。

关键词：锂标志技术、24 小时盐回忆、盐称重、任意盐摄入。