Endemic Goiter Associated With High Iodine Intake

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ABSTRACT

Objectives. This study assessed the relation of iodine content of household water to thyroid size and urinary iodine excretion in an area with high iodine concentration in the water.

Methods. The iodine content of household water and indicators of iodine status (thyroid size and urinary iodine level) were assessed in selected villages in Jiangsu Province, China.

Results. Water iodine levels were positively correlated with urinary iodine levels and indicators of thyroid size at the township level.

Conclusions. Excess iodine in household water was the likely cause of endemic goiter and elevated urinary iodine levels in the study area. This finding affects public health policy on the institution of universal salt iodization for the elimination of iodine deficiency disorders. (*Am J Public Health.* 2000;90:1633–1635)

Iodine deficiency is a global public health problem for which the primary intervention is universal salt iodization.[1,2] Endemic goiter has been defined as a prevalence of 5% or greater in schoolchildren.[1] The primary causes of endemic goiter include iodine deficiency and iodine excess, the latter associated with high levels of iodine in water, food, medications, disinfectants, and contrast media.[3,4]

Iodine deficiency disorders are a significant public health problem in Jiangsu Province, China.[5,6] Iodized salt is being delivered throughout the province, except in 3 counties where the cause of goiter was not clear. These 3 counties (Feng, Pei, and Tongshan) have a population of 2.4 million and are located in a 4000-km^2 floodplain formed by the Yellow River. Household water is primarily from shallow wells with depths of 7 to 12 m and occasionally deep wells at depths of more than 60 m. Few centralized water supply systems exist, surface water is scarce, and rainfall amounts are low. The goiter prevalence in schoolchildren in the 1980s was 25%, suggesting iodine deficiency, whereas urinary iodine concentrations in adults indicated iodine excess. The primary objective of the present study was to determine the extent of iodine excess, population involved, source(s) of iodine, and how these relate to thyroid size and urinary iodine levels.

Methods

The present study was divided into 2 phases. In phase 1, the iodine concentration in drinking water was measured in all 65 townships of the 3 affected counties. Townships were divided into 5 strata, and 1 easily accessible village was selected in each stratum in which water from at least 3 shallow wells (<60 m) and all deep wells (≥60 m) was sampled. In phase 2, townships were divided into 5 groups based on median water iodine concentrations: <300, 300 to 499, 500 to 699, 700 to 899, and ≥900 μg/L. In each group, 2 to 3 townships studied during phase 1 were randomly selected, for a total of 12 townships.

In each of these 12 townships, palpation of the thyroid was performed in pupils (aged

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TABLE 1—Relationships Among Median Water Iodine Concentration, Median Urinary Iodine Concentration, Prevalence of Goiter, and Prevalence of Abnormal Thyroid Volume: Selected Townships in Feng, Pei, and Tongshan Counties, Jiangsu Province, China

	Water Iodine		Urinary Iodine		Prevalence of Goiter and Abnormal Thyroid Volume, %		
Township	n	Median, μg/L	n	Median, μg/L	n	Goiter (95% CI)	Abnormal Thyroid Volume (95% CI)
1	13	187	52	520	151	12 (7, 18)	…
2	50	204	49	619	609	15 (12, 17)	…
3	16	290	52	802	152	15 (10, 21)	5 (3, 10)
4	50	311	47	759	247	22 (17, 27)	…
5	20	315	54	871	154	21 (15, 28)	9 (5, 14)
6	16	537	53	1194	151	22 (16, 29)	…
7	18	543	49	1256	150	23 (17, 31)	10 (6, 16)
8	15	550	50	1260	157	28 (21, 35)	…
9	21	745	51	1352	153	30 (23, 38)	…
10	19	754	50	1483	242	35 (29, 41)	13 (9, 18)
11	20	952	50	1282	155	36 (28, 43)	…
12	15	1145	50	1961	150	38 (31, 46)	17 (11, 23)
Total	273		607		2471		

Note. Abnormal thyroid volume was based on ultrasonography; confidence interval [CI] based on exact mid-*P* method.

6 to 15 years) attending the township elementary school, and casual urine specimens were obtained from 50 adults by standard methods.[1,7,8] Adults who had consumed seafood within the previous week were excluded. One school was randomly selected in each of the 5 groups for thyroid volume measurement by ultrasonography. This study was approved by the Provincial Center for Public Health, and verbal consent/assent was obtained from all participants. Because of skewed distributions, medians were used for the measure of central tendency. The Spearman rank correlation was used for comparing continuous variables.

Results

During phase 1 of this study, a total of 1151 wells were sampled from the 65 townships, with 4% of the samples from deep wells. The water iodine concentrations ranged from 0.4 to 2804 μg/L (median=552 μg/L); 76% of the well water samples had a median greater than 300 μg/L.

In phase 2, in which 12 townships were investigated for indicators of iodine status, thyroid palpation was performed in a total of 2371 schoolchildren aged 6 to 15 years (prevalence of goiter ranging from 12% to 38%), and ultrasonography was performed in 1069 pupils from 5 townships (prevalence of abnormal thyroid volume ranging from 5% to 17%; see Table 1). The median urinary iodine concentration from 607 adults ranged from 520 to 1961 μg/L; 85% of the urine specimens had concentrations greater than 500 μg/L, and 53% had concentrations greater than 1000 μg/L. Townships with a higher median level of iodine in well water had a higher (1) median urinary iodine concentration (Spearman rank correlation=0.94), (2) prevalence of goiter (Spearman rank correlation=0.91), and (3) prevalence of abnormal thyroid volume (Spearman rank correlation=0.95) (all 3 correlations, $P<.001$).

Discussion

In populations with sufficient iodine intake, the prevalence of goiter in schoolchildren is usually less than 5%. From goiter and thyroid ultrasound results in our study, the areas under study could have been misclassified as having iodine deficiency because adult urinary iodine concentrations indicated normal to excessive iodine intake (normal being a median urinary iodine concentration between 100 and 200 μg/L in a population).[9] The significant positive correlation at the township level between the iodine content of the water and urinary iodine concentrations suggested that household water was the source of the excess iodine. Other investigations into the area under study did not find elevated iodine levels in the soil or locally grown grains, fruits, or vegetables.[10] The significant correlation at the township level between the median iodine content of the water and measures of thyroid size (goiter and thyroid volume by ultrasonography) also suggested that the high iodine content in the water was the primary cause of the enlarged thyroids. Other factors, such as genetics or foods containing goitrogens (such as cabbage), may have played some role.

Although the association of goiter and excess iodine intake or exposure has been reported previously, the results of this study provide evidence that iodine excess from local water sources can occur on a large scale. The dose–response was strong at the township level over a wide range of median water iodine levels with the different indicators of iodine status (urinary iodine concentration, goiter, and thyroid volumes based on ultrasonography).

In the population group with the highest median urinary iodine concentration (township 12 in Table 1), 62 adults were tested for thyroid function. Of these, 52% had elevated thyrotropin (>3.6 mU/L), and 2 had biological evidence of hypothyroidism. Although not representative of all the groups in this study, this result showing some perturbation of thyroid function is consistent with previous findings in populations exposed to excessive iodine intake.[11]

The results of this study should be interpreted cautiously. Villages within townships were not selected randomly. During phase 2 of the study, the investigators were not blinded as to the iodine content of the water at the township level. Comparisons of the iodine content of the water with indicators of iodine status of the population (urinary iodine concentration, goiter, and thyroid volume) were performed at the township level and are therefore ecologic correlations. Two adults who had consumed seafood in the week before urine collection were excluded from the study to increase internal validity of the study (relating iodine levels of the water to iodine levels in the urine). The exclusion of these individuals would have a minimal effect on potential selection bias for the overall study.

The following important policy and research issues must be addressed: (1) Should iodized salt be distributed in populations with excessive iodine intake from other sources? and (2)

Should areas with high iodine concentrations in the water find alternative sources of water?

With regard to the first issue, universal salt iodization is being pursued in most affected countries to eliminate iodine deficiency, with the goal of having median urinary iodine concentrations in the range of 100 to 200 µg/L.[9] The results of this study suggest that the use of thyroid size alone, without measuring urinary iodine concentration, is insufficient to determine whether endemic goiter in an area is caused by iodine deficiency or excess. The risks and benefits of providing iodized salt in areas with excessive iodine intake from other sources must be carefully assessed. Excessive iodine exposure may cause some perturbation of thyroid function. Additional research is needed to determine whether the small increase in iodine intake from iodized salt would substantially increase this risk. If the iodine level in salt is carefully controlled at 20 ppm, the contribution to the urinary iodine level would be about 100 µg/L/day and is unlikely to be detrimental. However, policies to ensure that only iodized salt reaches iodine-deficient areas and only noniodized salt reaches areas with iodine excess can be difficult to implement and are likely to be resisted by some salt producers, distributors, and consumers.

With regard to the second issue, areas with excessive iodine intake due to high iodine concentrations in the water should seek other sources of water. Results from this study found that the iodine concentration in water samples from deep wells was lower than that in samples from shallow wells. The precise point at which alternative sources of household water should be sought is not known with any certainty but such sources may be considered for populations with a median urinary iodine concentration in the range of 1000 to 2000 µg/L or greater. Additional research is needed to determine the point at which the excess iodine intake from water results in substantial negative health effects. □

Contributors

J. Zhao planned the study, analyzed the data, and wrote the paper. P. Wang and L. Shang participated in the study design, data collection, data entry, and analysis. K.M. Sullivan assisted in the analysis and interpretation of the data, was actively involved in the writing of the paper, and took primary responsibility in responding to the reviewers' comments and revising the paper. F. van der Haar and G. Maberly contributed to the interpretation of results, editing of the paper, and responding to the reviewers' comments.

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