Inadequate and Excessive Urinary Iodine Concentration in School Age Girls and Women in Makueni, Eastern Kenya

Zipporah N. Bukania*, Judith Kimiywe†, Timothy Johns*, Moses Mwangi†, Lydia U.Kaduka‡, and Frits van der Haar#

1Centre for Public Health Research, Kenya Medical Research Institute, Nairobi, Kenya
2Department of Foods and Dietetics, Kenyatta University, Nairobi, Kenya
3School of Dietetics and Human Nutrition, McGill University, Ste. Anne de Bellevue, QC, Canada
4Rollins School of Public Health, Emory University, Atlanta, GA, USA

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*Corresponding author: Zipporah N. Bukania, Centre for Public Health Research, Kenya Medical Research Institute, P.O. Box 20752-00200, Nairobi, Kenya, Tel: +254-202-725-017; E-mail: zbu@kemri.org.

Abstract

Introduction: Both inadequate and excessive iodine intake may lead to thyroid dysfunction or disease including cretinism, endemic goiter, intellectual impairments, increased miscarriages and infant mortality when inadequate and autoimmune disease and iodine induced hyperthyroidism when in excess.

Objective: To assess the urinary iodine concentration (UIC) of school age girls (SAG) aged 8–12 years and women of reproductive age (WRA) 15–49 years in a rural population of lower Eastern Kenya.

Methods: A descriptive household cross-sectional survey was undertaken among 176 healthy female children and 175 non-pregnant, non-lactating women who consented to participate in the study. Casual urine samples were collected and analyzed using the Sandell Kolthoff reaction method.

Results: Median spot UIC levels were high in both girls (414 µg/L, IQR 229 to 644) and in women (515 µg/L, IQR 257 to 814), indicative of excessive iodine intake in both population groups. Thirty percent (13.0%) of SAG and 7.4% of WRA had UIC values below 100 µg/L, while 41.7% and 52.5% SAG and WRA respectively had UIC in excess of 500 µg/L. Statistically significant difference was found between level of education and UIC in both SAC (P < 0.05) and women (P < 0.05) and the UIC in SAC, but not WRA, was correlated to age (P < 0.001).

Conclusion: Presence of high urinary iodine concentration is observed in this population.

Keywords: Urinary Iodine Concentration; School age girls; Women of reproductive age; Low urinary iodine; Excessive urinary iodine

Introduction

Iodine is an essential nutrient [1,2] for the synthesis of thyroid hormones critical for brain development [1,3], normal growth, and metabolism throughout life [4]. Adequate levels of iodine during pregnancy are essential for fetal neurodevelopment, and mild iodine deficiency is linked to developmental impairment.

The most severe neurologic injury resulting from a thyroid deficiency is in endemic cretinism [5,6], According to the Iodine Global Network (IGN) the number of iodine deficient countries more than halved in past decade. In 2015 only 26 countries remain deficient, the number of iodine deficient countries has markedly improved iodine status over the past two decades [12-14]. Kenya is one of the countries with a successful iodized salt programme achieving a household coverage of more than 90% [13].

Worldwide, salt iodization programs in nearly 150 countries have markedly improved iodine status over the past two decades [12-14]. Kenya is one of the countries with a successful iodized salt programme achieving a household coverage of more than 90% [13].

Median Urinary iodine concentration (UIC) has been widely applied as an indicator of the iodine status of a given population [15]. The current consensus is that median UIC is a reliable biomarker of recent iodine intake in populations [2]. With normal renal function, the amount of iodine excreted in urine directly reflects the recent consumption of iodine and, therefore, the UIC is an index for measuring iodine status [6]. The aim of this study was to assess the iodine status of school age girls (SAG) aged 8–12 years and women of reproductive age (WRA) aged 15–49 years in Makueni County of Eastern Kenya.

Methods

Study Setting and Design

A descriptive community household-based cross-sectional study was undertaken between October and November 2013 in Kathonzweni Sub-county, Makueni County. Makueni is located in the southern part of Eastern Kenya, and covers an area of 880.7 Km². Makueni County has a population of 884,527 (Male – 49%, Female – 51 %) with population density of 110.4 people per Km². The population in this area is rural in nature and inhabitants practice subsistence agriculture despite the harsh ecological settings classified as semi-arid midlands characterized with minimal rainfall (150–650 mm per annum), persistent drought and endemic food scarcity [16]. Through Kenya’s Agricultural and Livestock Research Organization and McGill University, Canada’s joint food security project that was funded by the Canadian International Food Security Research Funds provided an opportune moment through shared costs to undertake this particular study to understand the iodine intake of the population in this food insecure region.

Study Population, Sample Size and Sampling

Healthy school age girls aged 8–12 years and non-pregnant, non-lactating, women of reproductive age (15–49 years) residing in the same households who volunteered and consented to participate were included in the study as pairs. We chose to include girls only in order to understand the iodine patterns in females from an early age.
The sample size was estimated based on 90% power estimating a minimum sample size of 144 ideal WRA and SAG that would participate in a randomized controlled trial to assess the effect of iodine on blood pressure based on a pilot study [17] whose outcome guided the calculation of this sample size. Allowing for 20% attrition and refusal, the sample size was adjusted upwards to 175 girls and 175 women recruited from 175 households.

**Sampling procedure:** We made reference to the National Sample Survey and Evaluation Programme of 2008–2009 (NASSEP IV) whose sampling frames are designed to provide estimates at the country level. First, identification of boundaries of small non-overlapping units (Enumeration Areas (EAs)) for each of the sublocations was undertaken. The EAs were then used as sampling units from where the number of the entire households was obtained. In order to estimate the population in the households in the selected EAs, a quick household count exercise listing all selected households and the residents in each household by names, age and sex was undertaken. The household counts were then used to construct the project-specific sampling frame to represent the target population of women and school age girls of the county. Using the generated sample frame, households with eligible populations of a woman of reproductive age (15–49 years) and a child girl of 8–12 years were randomly selected by making a list of all eligible populations from the household lists, then each assigned sequential numbers and a random number generator used to select study participants.

**Data collection methods and procedures:** Data on level of education, age were collected using pretested structured questionnaires between October 2013 and December 2013. Data on 24-hour food pattern were collected to assess any associations between foods eaten the previous day and UIC. The nutritional status of the study population was assessed using anthropometric measurements of weight measured using calibrated digital scales, while respondents wore minimal clothing, without shoes and results recorded to the nearest 0.1 kgs while height was measured using UNICEF height boards recorded to the nearest 0.1 cm.

**Urinary iodine measures:** 10 ml spot casual urine samples were collected from the study participants in open plastic cups, and transferred into labeled clean tightly sealed 15 ml polypropylene (PP) plastic tubes free from iodine or any possible contaminants (plastic cap without glued inserts). Caution was taken to avoid spillage and contamination from any other possible sources of iodine for example after handling table salt. The samples were transported in portable cool boxes, transferred into portable -20°C freezers at the study field laboratory before being transferred for storage at the Centre for Public Health Research –Kenya Medical Research Institute (KEMRI Laboratories) and stored for 8 months before being exported on dry ice to the Tanzania Food and Nutrition Centre (TFNC) for analysis in November 2014. The TFNC laboratory undertook. The household counts were then used to construct the project-specific sampling frame to represent the target population of women and school age girls of the county. Using the generated sample frame, households with eligible populations of a woman of reproductive age (15–49 years) and a child girl of 8–12 years were randomly selected by making a list of all eligible populations from the household lists, then each assigned sequential numbers and a random number generator used to select study participants.

**Statistical Analysis**

Data were entered into Microsoft Access and analyzed using the Statistical Package for Social Sciences version 20.0. Normality of the data was tested using ShapiroWilks, Kolmogorov Smirnov test and visual inspection of histograms. Age, weight, BMI in women, BMI-for-age in children and UIC levels were summarized into means and standard deviations and medians and interquartile ranges. All categorical data (BMI and UIC classifications) were summarized as frequencies and percentages. Chi square test was used to assess differences for categorical data. Results showing thresholds on median UIC were interpreted according to WHO guidelines [6] indicated as 50–99 µg/l (insufficient) 100–199 µg/l (adequate intake), 200–299 µg/l (above adequate), ≥ 300 µg/l (excessive). Sex- and age-specific BMI-for-age Z-scores (BAZ) were calculated using the WHO AnthroPlus program (V. 1.0.4) for children while BMI for women were categorized in reference to the WHO standards [6,20]. Statistical significance was set at 5%.

**Results**

**Demographics**

Of the 176 school age girls (SAG) between the ages of 8 and 12 years and 175 women of reproductive age (15–49 years) recruited to participate, the distribution shows more 11 year old girls (44.9%) and 10.0 (1.4) years and 35.3 (7.5) years respectively. Most women had attained primary level (67.9%) and 20.9% secondary school level education as indicated in table 1. The majority 96.6% (170) of the children were daughters of the woman of reproductive age.

**Nutritional status**

Table 2 provides the nutritional status findings in children and procedures, risks and benefits of the study were explained to all the respondents in a simple and well understood language before being recruited. All adult women consented on informed consent, guardians to the children agreed to their daughters to participated through written enrollment document while the children consented using an assent document. All participants who were not able to write used thumb print to consent after detailed explanation on the study by the researcher.

**Table 1: Demographic characteristics in the SAG and WRA.**

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<th>Characteristics</th>
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women. The mean (SD) BMI for Age (BAZ) score for the children was -0.1 (0.8) kg/m² and classified as normal for this group. When classified according to World Health Organization, only 6.9% of the girls were thin (< -2SD). Only 6.4% were underweight while 38.7% were found to be overweight and obese. Both children and women did not report any major known chronic conditions such as diabetes, heart disease, asthma. The respondents were generally in good health based on inflammatory markers C-reactive protein and α-1 acid-glycoprotein (data not shown).

**Urinary Iodine Concentration (UIC)**

The median spot UIC levels were high in both women (515 µg/L, IQR 257-814), and children (414µg/L, IQR 229-644), indicative of excessive iodine intake in both population groups.

Using WHO criteria for classification of UIC levels for measure of iodine, close to two thirds of the SAG (63.7%) and the WRA (65.7%) had excessive iodine concentrations (>300µg/L) while a very small proportion had low UIC levels as indicated in figure 1. Age-wise distribution of urinary iodine showed that the proportion of women with elevated UIC (>300µg/L) was higher (72.8%) in older women (31–49years) but this was not statistically significant. A higher (77.3%) proportion of the older women (31–49years) but this was not statistically significant of women with elevated UIC (> 300µg/L) was higher (72.8%) in older women (31–49years) but this was not statistically significant.

To understand the source of foods, since it has a relation with iodine consumed as shown in table 3, findings show, both those who do not eat lunch at home (81.1%) and those who do not purchase (78.9) had excessive UIC levels.

The UIC distribution in women (Table 4) shows most women with excess UIC levels, irrespective of whether they consumed food at home or not or took medication. A total of 31 respondents out of 35 who took medication had excessive UIC levels. The survey did not collect the type of medications to determine if they had an effect on the raised UIC levels.

**Discussion**

The World Health Organization has recommended UIC as a preferred marker of dietary iodine intake [6]. In addition school-aged girls (SAG) have traditionally been used as a proxy for iodine status in the general population [1,6] explicitly identify the steps taken through various studies to finally conclude that school children are the best population to assess iodine status of a population albeit the possibility of over estimating iodine deficiency. It is however noted that WHO adopted this approach and school age children continue to be point of reference in population assessment of iodine status.

This baseline survey illustrated UIC findings suggestive of co-existence of insufficient and Excess UIC within the same population. Despite this finding, it’s important to note that day to day variations in UIC should be put into consideration in interpretation. According to Zimmerman and Anderson [1] the day to day variations in UIC range between 30–40%. UIC above 300 µg/L was observed in more than half of both SAG and WRAs. It is therefore important to note that both iodine deficiency and iodine excess are associated with an increased risk of thyroid disorders [11].

Geographical locations and season have been identified to influence UIC [21]. Makueni is a seasons region bordering the coast; most likely potentiating that water from wells and boreholes in the region are likely sources of iodine in water. A study undertaken in Somalia was suggestive that groundwater and surface iodine content is a potential determinant of dietary iodine [22].

Significant difference was found in age categories and UIC in girls but not in the women. These findings concur with results of a study in Switzerland which found that UIC varied significantly depending on the specific age group.
between age categories. The Swiss study found that median UIC decreased with age from adolescents to adults, lowest in seniors [23].

Level of education among WRA has been shown to have impact on nutrition status of populations [24]. Findings showed a significant difference between UIC and level of education in women. A study undertaken in Quetta city of Balochistan found that lack of education among pregnant women was associated with increased risk of iodine deficiency [25]. Another study in Sierra Leone found significant progressive increase in the geometric mean UIC with educational level [10].

The study population is predominantly food insecure as a result of unfavorable climatic conditions with minimal rainfall, hence the possibility that UIC levels are high due to low water intake. Potential sources of excess iodine consumption could be attributed to presence of iodine in water, or other sources including high consumption of salt which is the main source of iodine for the Kenyan population.

Limitations

Since this was a baseline study for a randomized controlled trial as indicated in the methodology, there was a need to confine the study population to allow ease of follow up through the study period. The study findings are therefore confined to one Sub County within Makueni County and cannot be generalized for the entire of Makueni or the Kenyan population.

Secondly, the urine samples were collected randomly without consideration of time of collection due to logistical challenges to collect all samples from the population at specified times, preferably in the morning [21]. UI concentrations are known to be at lowest concentration in the mornings and peak after 11.00 hrs. However, random spot UI concentration measurements are valid in population samples. Variations in hydration among individuals and day to day variations in iodine intake even out when large populations are assessed for UIC (1). Importantly a casual single UI measurement is not representative of an individual’s iodine nutritional status, and that the time of the testing is important [26]. This study did not assess the iodine levels in water and salt used by the population, nor did it assess water intake.

Conclusion

Presence of high urinary iodine concentration is observed in this population. Further research would help understand the UI patterns over time in this population.

References


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