Iodine Status in Individuals from a Rural and Urban Area in Bolivia

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Summary

Iodine is an essential component of thyroid hormone, which is indispensable for normal development, growth and metabolism. Iodine Deficiency (ID) results in decreased thyroid hormone synthesis, which can lead to mental retardation. ID is actually the most prevalent preventable cause of mental impairment. Although recent attempts have been made to eradicate ID, the threat still persists, especially in developing countries. The urinary iodine concentration of a population in Santa Cruz, Bolivia, was evaluated because certain parts of Bolivia are thought to be mildly iodine deficient, but current data are not available. It was hypothesized that an urban population would have higher iodine nutrition than a rural population, where iodine deficiency was believed to exist. In summer 2006, I collected urine and blood samples from approximately 183 rural and 110 urban patients from the Santa Cruz area in the Bolivian lowlands. Iodine concentrations in the samples were determined using the Sandell-Kolthoff Method. In the rural population, 11.5 % of samples had iodine deficient values (0-100 µg/L), 81.9 % had iodine sufficient values (100-600 µg/L), and 6.56 % had high levels of iodine that exceeded 600 µg/L. In the urban samples, 16.4 % had iodine deficient values, 77.3 % had iodine sufficient values, and 6.36 % had levels of iodine exceeding 600 µg/L. Rural and urban populations in Santa Cruz are generally iodine sufficient, although iodine deficiency continues to exist.

Introduction

Iodine is an indispensable micronutrient because it is essential for the synthesis of the thyroid hormones, T3 and T4. During development, these hormones are active in cell differentiation, and therefore in overall brain maturation (Delange, 2001). Also, thyroid hormones regulate many metabolic steps, and lack of iodine leads to decreased levels of thyroid hormones (T4, T3) (Delange, 2001). The most visible sign of iodine deficiency (ID) is an enlargement of the thyroid gland, a goiter. However, more severely, iodine deficiency in the nursing mother or maturing fetus can cause mental retardation and other neurological deficits. ID is the most widespread cause of preventable mental impairment, and the range of mental retardation and complications vary depending on the degree of iodine deficiency (Dunn, 1996). Mental retardation due to inhibition of neurointellectual development by ID can cause symptoms ranging from delayed reaction time (Delange, 2001) to a lowered Intelligence Quotient (IQ) (Santiago-Fernandez, 2004) or even severe retardation, as seen in cretinism. Other iodine deficiency disorders (IDD) include decreased fertility rates (Delange, 2001), pregnancy complications (Dunn, 2003) and increased infant and child mortality rates (Delange, 2001; Dunn, 2003). These disorders further indicate iodine's significance in biological functions. Iodine status in pregnancy is critical because of placental transfer of necessary thyroid hormones to the developing fetus and maternal effects are present until late stages of development (Delange, 2001). Therefore adequate iodine nutrition is imperative during pregnancy and nursing.

Iodine deficiency continues to be a global health issue (Dunn, 1996). 35.2% of the world's population are still affected by ID at varying levels (Pretell et al, 2004) despite efforts by UNICEF (Unite Nation Children Fund), WHO (World Health Organization), and ICCIDD (International Council for Control of Iodine Deficiency Disorder) to eradicate ID by 2000 (Delange, 2006).

In countries where governments are complacent and lack consistent monitoring of nutrition programs and salt iodization (Dunn, 2000), the degree of national iodine deficiency becomes intensified and reversed. One such example is Bolivia. By the 1980s, Bolivia had one of the most severe ID problems in the world, with a goiter prevalence of 60% (Panam, 1997) and up to 16% cretinism in some areas. In 1983, action was taken by the Bolivian government in collaboration with WHO and UNICEF to set up a national program (PRONALCOBO) to combat ID through a Universal Salt Iodization program and widespread education and communication about ID (Panam, 1997). By 1996, 90% of households had iodized salt, which lead a team of reviewers to label Bolivia as "iodine sufficient" (Panam, 1997). However, these observations overshadowed the continuous prevalence of low urinary iodine levels (100µg/L and below) that were masked by the normal/sufficient median of 250µ/L. Other recent studies observed that although median levels of urinary iodine are normal, there are significant ranges in the urinary iodine levels, and no direct relationship between these levels and goiter prevalence (Pretell et al, 2004). Since urinary iodine levels and goiter prevalence are normally correlated, the lack of correlation provides evidence for the difficulties in accurate assessment of iodine deficiency (Dunn, 1996) and the effects of lack of sustainability (Pretell et all, 2004).

Isolated communities, including mountainous villages, (IDD newsletter, 2004) are therefore assumed to still have significant iodine deficiency (Panam, 1997). Moreover, since 1996, Bolivian household consumption of iodized salt dropped to between 65-69% (IDD newsletter, 2004). There is also limited data on the iodine nutrition of the tropical region of Santa Cruz and the surrounding villages. The purpose of the study was therefore to analyze the iodine status in this specific part of Bolivia. This study aims at evaluating the iodine status of both a rural and urban population in the Santa Cruz region. The hypothesis is that iodine deficiency exists in the Santa Cruz region, most likely with higher prevalence in rural than urban populations.

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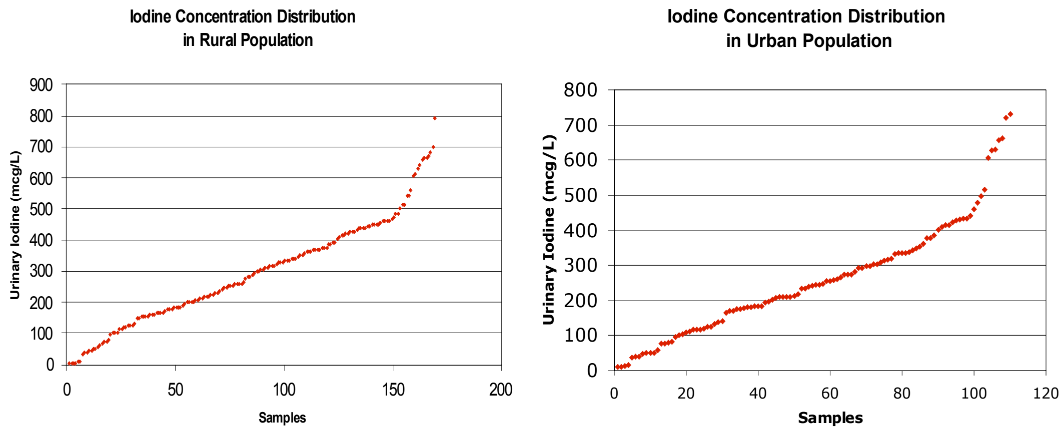

Figure 1 A-B. Iodine Distribution in Rural and Urban Bolivian Population. Majority of samples (81.9 % in rural, 77.3 % in urban) were in the iodine sufficient range (100-600 µg/L).

Materials and Methods

Field Sample Collection

Clinica de Humeberto Parra, Palacios, Bolivia

After an informational session about ID and the details of the study, participants were asked to sign up, as a form of consent. For each participant, 1 mL of urine was collected and a blood sample was taken on filter paper (dry blood sampling) from a finger by pricking with sterile lancets. 181 participants from the rural population were recruited for the study.

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107 individuals, visiting two clinical laboratories in Santa Cruz, represent the urban population.

Urinary Iodine Assessment

The urine was assessed by using a modified version of the Sandell-Kolthoff reaction, a protocol for measuring urinary iodine (Braverman, 1996). The Sandell-Kotlhoff reaction is based on the principle that urinary iodide acts as a catalyst for the reaction of Ceric Ammonium Sulfate (yellow) to its Cerous form (colorless) in the presence of Arsenious Acid.

A standard curve with known iodine concentrations (0- 3.94 µmol/L) was first established. For the standard curve, a stock solution of KIO_3 (7.87 mmol/L) was diluted to 78.7 µmol/L, and further to obtain the following concentrations: 3.94, 3.18, 2.36, 1.57, 0.78, and 0.10 µmol/L. ddH_2O was used at the 0 µmol/L concentration. All standards were analyzed two times.

Each sample (200 µL), whether iodine standard or urine sample, was mixed with 1 mL of 1 M Ammonium Persulfate and heated at 91-95º C on a heating block. This step, the oxidizing step, eliminates interfering ions from the assay. After cooling to room temperature, the following were added: 2 mL of Arsenious Acid, 1 mL 1.25 M Sulfuric Acid, and 1 mL dH_2O. After adequate mixing/vortexing, the samples were placed in a water bath at 32º C for 10 minutes and 500 µL of Ceric Ammonium Sulfate was added to each sample at intervals of 15 seconds between the samples. Exactly 10 minutes after addition of Ceric Ammonium Sulfate, the samples were analyzed using a spectrophotometer at 420 nm. Measuring absorbance after an exact and defined interval was important because the digestion reaction has no specific end point. The iodine concentrations in the samples were then determined based on the standard curve, which was established using linear regression analysis with the Graph Pad software. The medians of the groups were compared because they represent more accurately the variability of the iodine concentrations.

Results

Urinary Iodine Distribution in a Rural Bolivian Population

In the rural population, 183 urine samples were collected. Of these, 21 (11.5 %) of had urinary iodine concentrations below 100 µg/L, classifying them as "iodine deficient values" according to the ICCIDD. Among the 21 samples, 9 (4.92 %) had values in the "mild deficiency" range (50 µg/L to 100 µg/L of iodine), 8 (4.37 %) were of "moderate deficiency" (10 µg/L and 50 µg/L), and 4 (2.19%) samples had urinary iodine concentration less than 10 µg/L. 81.9 % of the total rural population had iodine sufficient values that range between 100 µg/L and 600 µg/L (Figure 1A). Within this range, 72 (39.3 %) samples had optimal iodine concentrations of 100-300 µg/L and 78 (42.6 %) samples had "more than adequate" iodine concentrations of 300-600 µg/L. 12 (6.56 %) samples had "high" values of over 600 µg/L urinary iodine (Figure 2A). The median for the total rural population was 290 µg/L.

Urinary Iodine Distribution in an Urban Bolivian Population

In the urban population, 110 samples were collected, out of which 18 (16.4 %) had iodine deficient values (< 100 µg/L). 10 (9.09 %) were mildly deficient (50-100 µg/L). 6 (5.45 %) of the samples were in the "moderate" deficiency category, with an urinary iodine concentration ranging from 10 to 50 µg/L. 2 (1.82 %) samples fell into the "severe deficiency" category, in which the values are less than 10 µg/L. 77.3 % of the total urban population samples were in the iodine sufficient category, ranging from urinary iodine concentrations of 100 to 600 µg/L (Figure 1B). 53 (48.2 %) samples were optimal values (100-300 µg/L), while 32 (29.0 %) were in the "more than adequate" iodine concentration category. 7 (6.36 %) samples had "high" values of above 600 µg/L (Figure 2B).The median for the total rural population was 250 µg/L.

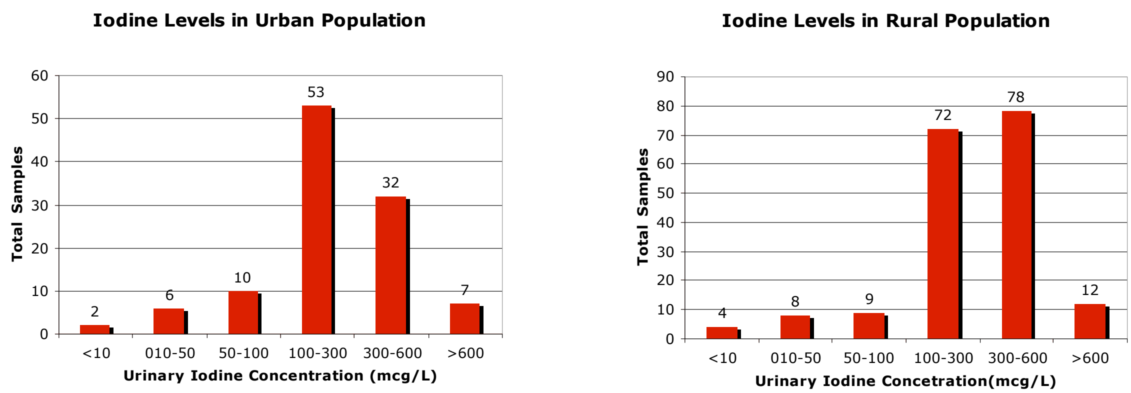

Figure 2 A-B. Iodine Levels in Rural and Urban Bolivian Populations. A: Rural: 21 samples had concentrations below 100 µg/L; 150 samples had concentrations between 100-600 µg/L; 12 samples had concentrations higher than 600 µg/L; B: Urban: 18 samples had concentrations below 100 µg/L; 85 samples had concentrations between 100-600 µg/L; 7 samples had concentrations higher than 600 µg/L.

Total Urinary Iodine Distribution in a Selected Bolivian Population.

78.5 % of the entire sampled population, including both the rural and the urban populations, had normal or sufficient values of urinary iodine (100-600 µg/L). 13.3 % of total sample population had values lower than 100µg/L and therefore "iodine deficient" urinary concentrations. 6.48 % of total sample population had "high" urinary iodine concentration exceeding 600 µg/L.

Discussion

In both rural and urban Bolivian populations, the majority of samples (81.9 % in rural, 77.3 % in urban) were consistent with a sufficient iodine concentration. However, 13.3 % of the entire sampled population had values suggesting "iodine deficiency," with 11.3% of total samples being in a critically low range. This suggests that although the status of the Santa Cruz population generally has normal/sufficient iodine nutrition, ID may continue to linger. This observation is similar to the observations of previous studies conducted in Bolivia in the 1990s. In 1996, it was found that 10.2 % of the sampled Bolivian population had critical iodine deficient values below 50 µg/L (Panam, 1996). Similarly, the overall median in the study was 250 µg/L, while the current study's median was 261 µg/L. However, the 1996 study used several laboratories and methods to analyze the samples and reached the conclusion that nationally, iodine deficiency has been eliminated in Bolivia (Panam, 1996).

In a study performed by Pretell et al. between 1998 and1999, an equipped van (ThyroMobil) traveled throughout South America assessing urinary iodine and found that the median urinary iodine concentration in Bolivia had decreased to 100 µg/L (Pretell, 2004). This study's sample population size was larger than the present study's, as was the range of communities analyzed. The study's results document the development of a critical change in urinary iodine status over a short amount of time, most likely due to lack of sustainability.

It is important to note that the values labeled as "sufficient" or "deficient" are just indicators that suggest actual iodine nutrition status. An individual or a lone urine sample cannot be deemed as "iodine deficient" without also analyzing appropriate hormones (TSH, T4). Nonetheless, urinary iodine concentrations are good indicators of overall iodine nutrition. Urinary iodine assessment is the most common method for analyzing iodine nutrition in a given population. The method is recommended by the International Council for Control of Iodine Deficiency Disorders (ICCIDD) and WHO based on its easy technical approach, low cost, and reproducibility.

It was hypothesized that if there were to be significant differences between the data of the two populations, the rural population would most likely have a higher percentage of iodine deficiency. This hypothesis was based on the fact that there is more access to adequate healthcare and education in the urban as opposed to the rural setting. The results, however, indicate the opposite to be true, where 11.5 % of the rural samples, but 16.4 % of urban samples fell in the iodine deficient category. Also, in the rural population, fewer samples (39.3 %) were of optimal than "more than adequate" values (42.6 %). This was not so in the urban population, where 48.2 % of samples fell in the optimal range and less (29 %) fell in the "more than adequate." The reasons for the differences are currently unclear but could include differences in nutritional salt intake, access to varying types of salt, or diversity in eating habits.

Moreover, sample sizes were different between the rural and urban population. There were more samples collected in the rural setting than in the urban location. This sampling difference could have lead observed difference, although there is a similar trend in the overall urinary iodine concentration distribution.

A further reason for the differences in results may be due to the fact that the types of subjects in both areas varied. At the rural clinic, members from each community visit once a month for check ups and general health problems. However, in the urban setting, only patients directed by a physician to undergo laboratory tests participated in the study.

However, the overall similar trend (majority iodine sufficient and some deficient values), indicates that perhaps the differences between communities are not as great as previously hypothesized despite the obvious socioeconomic contrasts. The village (Palacios) and the city (Santa Cruz) are at most two hours apart.

There is public transportation for most of the journey between the two. Perhaps the data between the more remote villages and the cities would be greater. It is believed that isolated populations in Bolivia are likely to have a persistence of IDD (Panam, 1996).

Trends of a decreasing iodine nutrition status in Bolivia may be due to complacency and lack of sustainability and monitoring (Dunn, 2000). Another related issue is the inequality in distribution and/or availability of iodized salt. This inequality may arise from obvious geographic and physical limitations, and socioeconomic reasons. However, two other important factors are problems within the public healthcare systems in general, and maternal education/awareness.

Many countries in Latin America have and continue to experience political and economic instability. Within an unstable system, distribution of funds for healthcare is limited. In order to improve the healthcare sector, the Bolivian government passed the Law of Popular Participation in 1994, through which decentralization of health systems would theoretically transfer the responsibility, authority, and funds to municipal authorities (Bossert, 2000). International organizations such as the World Health Organization (WHO) and Health Maintenance Organizations (HMOs) in general (Tollman, 1990), as well as international laws set by the World Trade Organizations (WTO), have attempted to push for a more sustainable health care system. However, international aid and involvement is often limited and a one-time occurrence.

In a study by Frost et al. (2005), it was found that several issues, including socioeconomic status and health knowledge, link maternal education and child survival. In these situations, there is a lack of awareness of the necessity of certain supplements and micronutrients, such as iodine. However, it has been found that among these women of lower socioeconomic status in Bolivia, social marketing has improved the use of multivitamins and supplements (Warnick, 2004). This improvement in supplementation indicates that if provided with the information and education, these women are ready to learn and improve their health and that of their family. More consistent and progressive local systems focusing on maternal awareness thus need to be established, as this is often restricted by limited education.

The mortality rate in Bolivia between 1975-1980 was 221 out of 1000 (22.15 %) children (under the age of 5) (Rosas, 1988). The main causes of death were infectious disease and parasites, respiratory infections, and perinatal difficulties (Rosas, 1988). These perinatal difficulties may, in part, be associated with IDD, which is known to increase perinatal and infant mortality (Delange, 2001). Lack of nutrition is therefore linked to increased susceptibility of infection, disease, and complications. Currently, the WHO's records indicate that mortality under 5 years of age, is now 75 out of 1000 (7.5 %) in Bolivia. Among some public health issues that are present in Bolivia are malaria, Chagas disease, tuberculosis, and diarrhea. Half of the 10.6 million child deaths that occur every year may actually be prevented, largely through proper nutrition.

Therefore, it is absolutely necessary to continue investigating and monitoring nutritional status, including iodine levels. A more in-depth and expansive study on iodine status in Bolivia is important for the near future. Assessing a variety of communities, isolated and remote, as well as the Bolivian highlands, would give a better understanding and estimate of the overall iodine nutrition in Bolivia. Analysis on the availability of iodized salt based on participant surveys, interviews with local salt companies and health care administrators would also give more detailed information on the nutritional iodine status in the country. Analysis of blood and hormones would be necessary in order to correlate urinary iodine concentrations and thyroid hormone levels in order to come to a more definite conclusion about "deficiency" and "sufficiency". More importantly, a consistent study or analysis of the Bolivian population should be conducted every several years in order to avoid the reoccurrence of ID and related complications. A future study involving these elements will be planned in collaboration with the ICCIDD representatives for South America and Bolivia and Bolivian National Director of Goiters.

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