Anemia in the Turks and Caicos Islands: Exploring the Dietary Link

Terese E. Maitland, PhD, MPH

Objective: To conduct the first national dietary survey and examine inter-island differences in and relationships between iron consumption and reports of anemia.

Design and Methods: A total of 144 households, randomly selected from electoral lists for Grand Turk (*n*=48), Providenciales (*n*=46), and Middle Caicos (*n*=50), participated in the survey. Food consumption (via food frequency questionnaire), self-reported health history, and sociodemographic data were collected from female household-heads during home interviews. Data on frequency of consumption and tabulated iron score for each ''normal'' food portion size were used to calculate each household's iron-intake-score. Chi-squared analyses were used to compare inter-island intake score categories.

Results: Households were assigned to low (<100), medium (100–160), or high (>160) iron-intake-score categories. The proportion of households with low scores was lower on Grand Turk (<5%) and Providenciales (0%) compared to Middle Caicos (20%), the least developed island.

Conclusion: Suboptimal iron intakes, especially on Middle Caicos, support the prevailing view that anemia in vulnerable groups could be of dietary origin. Findings highlight the need for additional research to determine how various factors (eg, diet, supplement use, physiology, and environment) impact iron status. In the short term, we must identify and treat cases and provide culturally appropriate nutrition education to increase dietary iron intake and promote safe use of multivitamin/mineral supplements. National dependence on imported foods makes this the most viable public health intervention option until the etiology of anemia is fully determined. (*Ethn Dis*. 2007;17:313–319)

Key Words: Anemia, Caribbean, Diet, Health, Iron, Turks and Caicos Islands

From the Stempel School of Public Health, Florida International University, Miami, Florida.

Address correspondence and reprint requests to Terese E. Maitland, PhD, MPH; Research Assistant Professor; Stempel School of Public Health (HLS 238); Florida International University; 11200 S.W. 8th Street; Miami, FL 33199; 305-348-3185; 305-348-1996 (fax); maitlant@fiu.edu

Introduction

Iron deficiency anemia (IDA) is a long-standing public health concern in the Turks and Caicos Islands (TCI), a Caribbean self-governing overseas territory of the United Kingdom with a predominantly (>90%) Black population.[1–3] Iron deficiency anemia (IDA)[1] is the only reported public health nutrient deficiency threat[2] to vulnerable groups, namely women and children. Concerns, however, exist over diet's role as a modifiable risk factor for chronic diseases such as heart disease and diabetes. One of every four deaths (27.3%) between 1990 and 1995 was due to diseases of the circulatory system, mainly strokes and heart attacks.[2] Diet-related health concerns are extremely significant in the TCI, with: 1) a growing economy (4.9% in 2000)[4]; and 2) no food insecurity or undernutrition concerns.[2]

Reports show that the anemia threat in TCI persisted >20 years after medical practitioners first published, in 1974, the high prevalence of anemia (hemoglobin [Hb] <10 g/dL) in school-aged children and attributed it to iron deficiency.[1,2] Using World Health Organization (WHO) standards,[5] during the 1980s other investigators reported the prevalence of anemia (Hb <12 g/dL) in school-aged children at 69%, 35%, and 97% on Grand Turk (GDT), Providenciales (Provo) and Middle Caicos (MC), respectively.[3] When Hb <10 g/dL was the cutoff, the corresponding values were 9%, 4%, and 49%.[3] More recent data report prevalence rates among pregnant women from Provo and GDT in 1996 as 17% and 24%, respectively.[2] The present study is the first and only national dietary survey conducted to date in TCI to assess food habits and dietary iron consumption.

The present study is the first and only national dietary survey conducted to date in TCI [Turks and Caicos Islands] to assess food habits and dietary iron consumption.

Iron deficiency, the most prevalent nutritional deficiency worldwide, is believed to affect 4–5 billion people.[6] Reportedly, 30% of the world's population is anemic, and impaired iron status accounts for >50% of the anemia.[6–8] In developing countries, as much as 50% of pregnant women and preschool-aged children have IDA.[9]

The decision as to which reference standard to use in defining anemia is not unanimous, and the application of a uniform standard may be questioned as data show that hemoglobin distribution varies across racial and ethnic groups.[10–12] Even so, WHO's standards are the most commonly used.[5] Data from the National Health and Nutrition Examination Survey (NHANES) II showed that Black Americans had hemoglobin concentrations that were, on average, lower than those of White Americans, even after adjusting for iron intake.[12]

A diet's iron content is one nutrition-related factor that affects bioavailability and nutritional adequacy.[13] Other factors include the type of iron (heme vs nonheme),[7] composition of meals (presence of absorption enhancers and inhibitors),[14] and other undefined physiologic factors.[15] In many developing countries, inadequate iron absorption from the largely vegetarian diets (nonheme iron) is the primary cause of anemia.[16]

Iron deficiency is categorized by various stages, and although prevalent, it is preventable. If left untreated, it results in IDA,[13] the most clearly recognizable sign of iron deficiency. However, other adverse outcomes can occur before hemoglobin concentrations warrant a diagnosis of IDA.[5] Iron deficiency is associated with decreased immune function, diminished work capacity, increased risk of low birth weight and preterm delivery in adults, and diminished cognitive development and learning capacity in children.[8,17–19]

Consuming sufficient iron is difficult, especially during periods of high requirements, eg, early childhood, adolescence, and pregnancy, which makes children, adolescents, and women vulnerable to IDA.[20,21] Relatively few reports exist of other micronutrient deficiencies in large sectors of Caribbean populations[22]; IDA in pregnant women remains a serious public health problem in the Caribbean and worldwide.[2,21,23] In some Caribbean countries, prevalence rates for the 1980s ranged from 27% to 75% in pregnant women, 19% to 55% in lactating women, and 15% to 80% in young children; severe anemia (Hb $<$8 g/dL) was found in 6% of pregnant women and 11% of preschool-aged children.[22,23] More recent data report the following prevalence rates among Caribbean antenatal clinic populations: the Bahamas (1992–1995, 29%); Jamaica (1984–1991, 30%) and Grenada (1996, 30%).[2]

Whereas marked economic and demographic growth has occurred in TCI[2] over the past 20 years, key factors that affect food availability have not changed. These include: 1) the historic dependence on imported foods, mainly from the United States, which persists because of semi-arid conditions, lack of arable land ($\approx$2.3%), and negligible agricultural production, with the exception of fishing since fish and other seafood, especially conch (*Strombus gigas*) remain the most important local food consumed[2–4]; 2) the need to offset importation costs and profit margins with substantial mark-ups on imported foods; these mark-ups are even greater for the more remote, sparsely populated islands like MC.[3]

Described herein is the first national dietary survey of a representative sample of households, randomly selected from three islands of the TCI: GDT, Provo, and MC (largest, least developed, and most sparsely populated island). The goal of the study was threefold: 1) to collect baseline dietary intake data to assess dietary habits of this previously unstudied population; 2) to examine inter-island differences in dietary iron intake; and 3) to explore the relationship between dietary iron consumption and the reported high prevalence of anemia.

METHODS

The Ministry of Health of the TCI, The Caribbean Food and Nutrition Institute, and the University of the West Indies approved the conduct of the study. Enumeration data from voters lists for the target islands (GDT, Provo, and MC) were used to randomly select 150 households (50 from each island) to participate in the study.

Over a six-month period (September 1983–February 1984), a trained nutritionist and TCI native interviewed selected female heads of household. Each woman provided informed consent and responded to questions from a precoded, pretested questionnaire that collected household dietary data (via a 52-item food frequency questionnaire [FFQ]), as well as sociodemographic and health history data for each household member.

Before being used as a survey instrument, the 52-item, semiquantitative FFQ, developed by the principal investigator and validated against three 24-hour recalls from 10 households, consisted of a list of foods frequently consumed in TCI.[3] Portion sizes were specified by using natural units (eg, slice of bread, 8 oz [227 mL] glass of milk) or other commonly used portion sizes. The frequency of consumption of each listed food, assessed by one of five possible categories, ranged from "never" to "$\geq$6 times/week." Food models, measuring utensils, and appropriate probing techniques enhanced participants' ability to provide details about cooking methods, recipes, and portion sizes.[24,25]

The iron content of each serving of food was calculated as follows: 1) the amount of iron (milligrams) in each serving of plant-based foods (nonheme iron) was halved to adjust for heme iron (largely from meat products), which is at least twice as easily absorbed as nonheme iron[26]; and 2) the adjusted iron content (AIC) score of 0–10 was used to assign an AIC score to each serving of food. A frequency (F) score of 0–4 was used to designate the frequency of consumption. The product of the AIC and F scores for each food consumed provided the iron score for that food. This FFQ also allowed for the addition of foods not included in the original food-frequency list.[24,25]

Data Analysis

Validation Study

Ten households were randomly selected for the validation study. Regression analysis[27] was used to assess the linear relationship between the iron score from the FFQ and the adjusted iron intake (in milligrams) as defined earlier from three different 24-hour recalls and also for their average. Regression lines for this relationship had different slopes. The squared correlation coefficient (R^2) of the three separate lines ranged from .749–.900 and for the line based on the average was .927.

The National Survey

Descriptive and other summary statistics (eg, frequencies, percentages, means plus or minus standard deviations [SD]) were calculated for sociodemographic variables and iron scores.

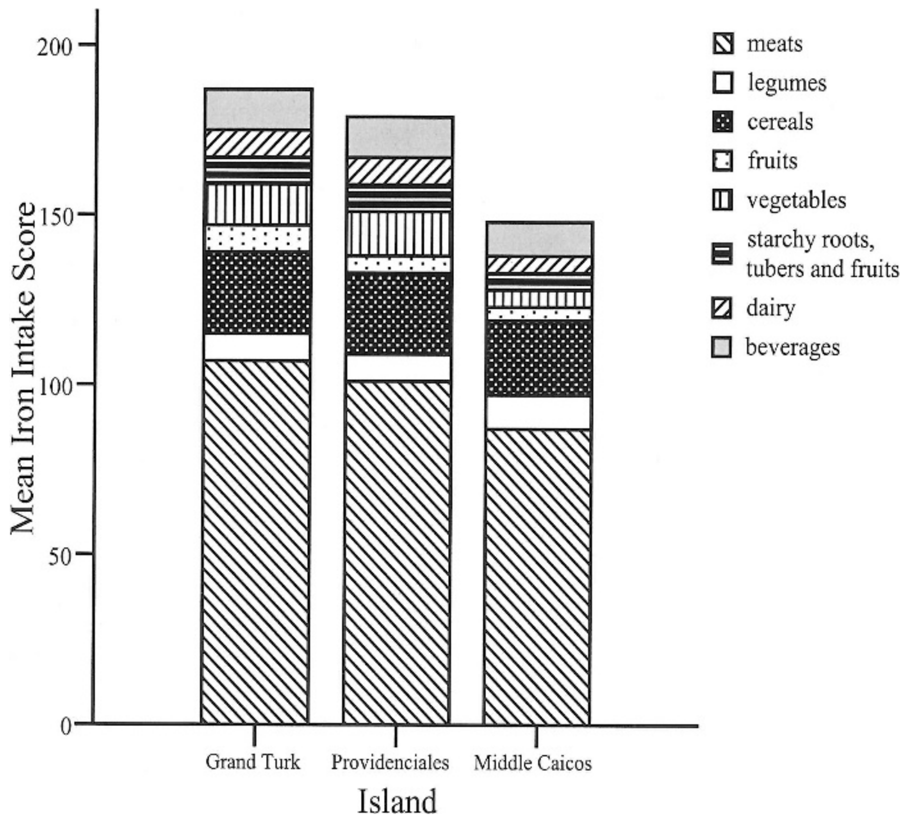

Fig 1. Contributions of food groups to mean iron intake scores of each island

The equation from the validation study was used to calculate predicted adjusted iron intakes for each household. Data were initially analyzed with the Statistical Packages for Social Sciences (SPSS) mainframe[27] and subsequently with SPSS version 11.[28] Results were considered statistically significant if the corresponding *P* value was <.05.

Chi-square (χ^2) analysis was used to compare proportions and to assess associations between categorical variables.

RESULTS

Sociodemographic Characteristics

Most (n=144) of the 150 selected households participated in the study (response rate = 96%); the remaining six households (GDT=2, and Provo=4) could not be interviewed after ≥3 attempts. At the interview, most female heads of households (132 or 92%) were TCI natives and married (n=101 or 70%). An identical number of households (n=101) listed a man as the "absolute" head of the household. Half (22 [51%]) of the 43 female "absolute" heads were either widowed or separated.

Census data for 1980 report that 59% of the population was ≥15 years old.[29] In this survey, approximately half (53%) of the 859 household occupants were ≥15 years old. The mean plus or minus SD household size ranged from 5.32±2.16 on MC to 6.14±2.43 on GDT and 6.14±2.99 on Provo.

Most households were nuclear families (72 [50%]). Families were categorized as: 1) "other" (12 [8%]) if they included non-family members (eg, boarders attending high school on GDT); or 2) "extended" if they were composed of blood relatives (eg, mother, children, and her parents).

Whereas most households (139 [96%]) had at least one employed member, the type of employment of heads of households differed markedly by island; 15 (31%) and 20 (45%) heads on GDT and Provo, respectively, were categorized as skilled or professional compared to none on MC. Most heads of households on MC (37 [74%]) were classified as semiskilled, compared to 18 (38%) and 9 (20%) on GDT and Provo, respectively.

In TCI, the combination of semiarid conditions, limited rainfall, and infertile, sandy soils translates into a lack of fresh water aquifers. Potable water, historically obtained by storing rainwater runoff from roofs in concrete cisterns called "catchment tanks," is supplemented with water obtained by reverse osmosis.[3,4] Half (73 [51%]) of participating households obtained drinking water from private tanks located on their premises as opposed to purchasing water from public, government-owned tanks.

Dietary Iron Scores

The study population's average unadjusted recommended daily allowance (RDA) for iron was 10.12 mg.[26] Households were divided among iron score categories as follows: low (>100), medium (100–160), and high (>160). The corresponding adjusted iron intakes based on the equation from the validation study were <7.7 mg, 7.7–12.8 mg, and >12.8 mg, respectively.

Mean iron scores for each island were similar for GDT (186.7±34.7) and Provo (178.7±45.3) but lower for MC (147.3±46.7) with corresponding adjusted iron intakes of 15.09±2.12 mg, 14.41±2.81 mg, and 11.76±3.06, respectively. A similar trend was seen for mean unadjusted iron intake values of 21.05 mg, 20.20 mg and 16.11 mg, respectively, after adjustment for nonheme iron's lower bioavailability was removed.

Figure 1 shows each food group's contributions to each island's iron scores. Overall, meat/legumes and cereals accounted for 63% and 12%,

Table 1. Frequency distribution of households by food category, iron intake score, and island

Food Category	Iron Intake Score	Grand Turk (n=48) N	Grand Turk (n=48) %	Middle Caicos (n=50) N	Middle Caicos (n=50) %	Providenciales (n=46) N	Providenciales (n=46) %	P value
Meat and Legumes								.044*
	<80	5	10.4	15	30.0	5	10.9	
	80–110	17	35.4	18	36.0	20	43.5	
	>110	26	54.2	17	34.0	21	45.7	
Cereals								.035†
	<20	6	12.5	19	38.0	10	21.7	
	20–25	25	52.1	21	42.0	19	41.3	
	>25	17	35.4	10	20.0	17	37.0	
Vegetables								<.001‡
	<5	8	16.7	36	72.0	9	19.6	
	5–10	15	31.3	13	26.0	11	23.9	
	>10	25	51.1	1	2.0	26	56.5	
Dairy								<.001‡
	<5	5	10.4	23	46.0	4	8.7	
	5–9	32	66.7	26	52.0	25	54.3	
	>9	11	22.9	1	2.0	17	37.0	
Beverages								.076
	<10	11	22.9	25	50.0	18	39.1	
	10–14	30	62.5	22	44.0	22	47.8	
	>14	7	14.6	3	3.0	6	13.1	
Starchy fruits, roots, and tubers								.035†
	<5	8	16.7	6	12.0	3	6.5	
	5–10	26	54.2	40	80.0	33	71.7	
	>10	14	29.2	4	8.0	10	21.7	
Fruits								<.001‡
	<5	12	25.0	40	80.0	10	21.7	
	≥5	36	75.0	10	20.0	36	78.3	

Significant pairwise comparisons:
* Middle Caicos vs Grand Turk (P=.032);
† Middle Caicos vs Grand Turk (P<.011);
‡ Middle Caicos vs Grand Turk (P<.001); vs. Providenciales (P<.001).

respectively, of total iron scores. When adjustment for nonheme iron was removed, the corresponding percentages were 43% and 19%. Table 1 compares the frequency distribution of households by food category, iron intake score categories, and island. The proportions of households in food group score categories on GDT and Provo did not differ significantly for any food group. However, on MC, proportions were significantly lower than those for GDT and Provo in six and three, respectively, of the seven categories. Figure 2 shows the distribution of the study households among score categories. Significantly more households on MC were in the low-intake category (as defined earlier) compared to GDT and Provo.

DISCUSSION

Various factors influence food choices.[30] Historically, people eat what their ancestors ate and what their environment offers, and TCI's citizenry is no exception.[3] Cultural food patterns are transmitted by example when caregivers inform children how to select desirable foods and the rules that govern conduct while eating.[31] Sociocultural inputs are complex, and once entrenched, dietary patterns are extremely difficult to change. Therefore, the TCI native population's dietary patterns are not likely to have changed appreciably, especially since dependence on imported foods and concern over the prevalence of anemia persist.[1–3]

Dietary iron absorption depends on many factors, including bioavailability, meal composition, iron stores, and the intestinal mucosa.[22,32,33] Bioavailability measures dietary iron adequacy more accurately than the total iron content of the diet.[14] Also, bioavailability of heme relative to nonheme iron is markedly influenced by enhancers and inhibitors and can exceed 10-fold.[15,16] The Caribbean's iron-RDA is predicated on the finding that absorption ranges from 1%–2% in some vegetables and 20%–30% in meats.[26] The estimated amount of heme iron in Western-type diets ranged from between 5%–10%[34] to 10%–15%.[15] Heme iron (40% of iron in animal products) is less affected by enhancers and inhibitors than nonheme iron.

While adhering to the stringent, albeit crude, criterion of halving nonheme iron to adjust for its lower bioavailability, island-specific mean iron intakes ranged from 11.76–15.09 mg/day. Also, 11%, 13%, and 37% of households on GDT, Provo, and MC, respectively, did not meet the unadjusted study population RDA of 10.12 mg /person/day. Percentages would have to be adjusted downward if the allowance for nonheme iron were removed, resulting in more households meeting the RDA. However, the trend

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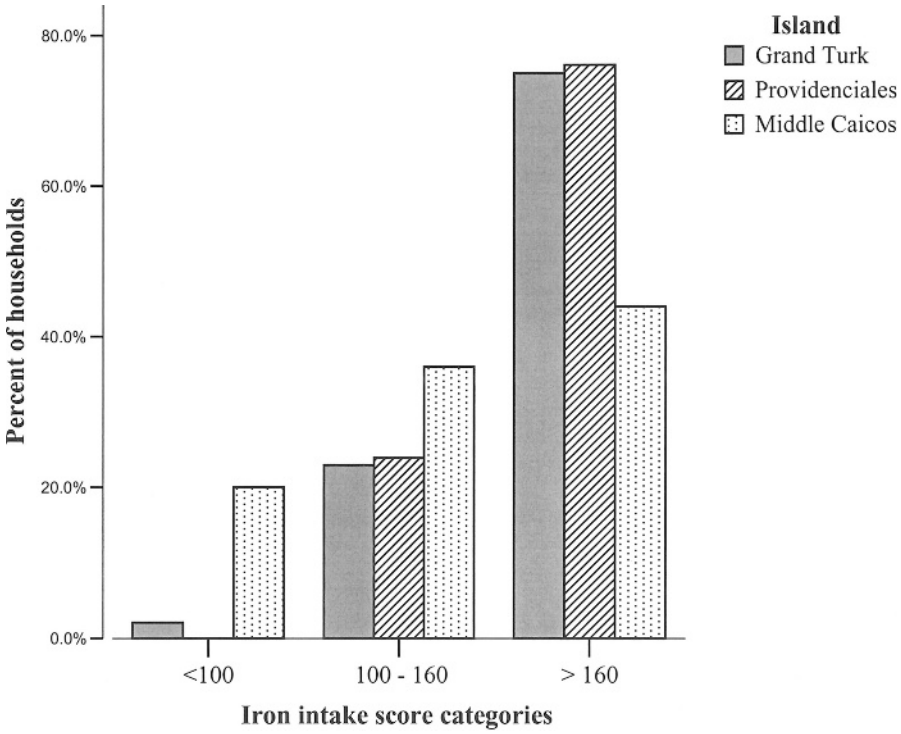

Fig 2. Distribution of households by iron intake score category and island

whereby more households on MC than on GDT and Provo did not meet the RDA would persist. The present data provide invaluable insight and possibly explain why MC reportedly had the highest prevalence of anemia among school-aged children.[1,3] However, inadequate dietary iron intakes do not completely explain the nationwide prevalence of anemia.

A study of the bioavailability of nonheme iron from different meals found only 16% of the variation in absorption was explained by dietary factors. Adding serum ferritin concentration to dietary factors improved the explained variability to 50%. They concluded that dietary factors made a relatively small contribution, while unknown physiologic factors accounted for most variation in iron absorption.[16] Also, understanding the complex interplay of factors that determine iron absorption is pivotal to determining the causes of IDA.

Anemia in TCI could be multifactorial. Possible explanations include: 1) the relative crudeness of the method used to determine iron scores; 2) underestimation of the impact of enhancers and inhibitors; 3) food procurement and preparation methods; 4) physiologic responses to nutrient imbalances such as zinc; 5) skewed intrahousehold distribution of iron-rich foods; and 6) ethnicity/race.

Limitations of the method used to determine dietary iron scores have been explained elsewhere. Even so, MC, the least developed island with lowest socioeconomic status, had significantly more low-scoring households, the least varied diet, and reportedly significantly more anemia.[1,3]

Of the TCI's population, 59% were ≥15 years old and 51% were registered voters (citizens ≥18 years old).[29] Hence by extrapolation, most eligible persons were registered on the voter's lists used for sample selection. However, an unknown number, believed to be relatively small, of undocumented Haitian immigrants were precluded. This could have introduced a selection bias that minimally impacted dietary estimation if diets of undocumented immigrants differed from those of natives. Recall bias also could have impacted dietary estimation, as female heads of households might not have been able to recall everything consumed by household members, especially foods consumed in their absence.

New information regarding the iron content of conch (1.41 mg/100 g)[35] further emphasizes inter-island iron score differences with 6% reduction for GDT and Provo, but 10% reduction for MC.[3]

Bioavailability of heme iron also differs depending on the variable degradation of the heme and food preparation methods. Traditional preparation involves washing meat with lime juice or vinegar (acetic acid) and discarding the bloody, iron-rich water before cooking.[3] Most meat originated in the United States and had likely been partially thawed and refrozen and had lost iron-rich fluids before reaching the consumer.[3] Therefore, in TCI, food composition tables' estimates[24–25] of iron from meats could be gross overestimations.

The typical western diet contains 6 mg iron/1,000 kcal.[36] However, this amount could increase appreciably by extrinsic iron solubilized from cooking utensils, especially if the pH of the food is lowered,[36,37] eg, by vinegar/lime juice marinade.[3]

Absorption enhancers include ascorbic acid; an unidentified factor found in meat, poultry, fish, and other seafood (MFP factor);[38] vitamin A; and beta-carotene.[39] Inhibitors include phytic acid, polyphenols, phosphorus, calcium, tannates, and the food additive ethylene diamine tetraacetic acid (EDTA). Iron-binding polyphenols occur naturally in cereals, vegetables, coffee, and tea.[16,40–42] Cereals accounted for 12% of iron scores.

A strong dose relationship was reported between calcium (>50 g) in a meal and the reduction in heme and nonheme iron absorption.[43–45] The bedrock of TCI is made of coral (limestone). Hence, calcium carbonate is ubiquitous, likely adhering to foods and present in water. Maintenance of water storage "catchment" tanks involves painting them, inside and outside, with "white wash" (calcium carbonate).[3] Unknown amounts of extrinsic calcium added to the diet could decrease bioavailability of both types of iron. Additionally, many antacids are calcium-based. However, antacid use was not investigated.

Historically, corrugated galvanized steel (coated with zinc for corrosion resistance) provides roofing for dwellings and water storage tanks. Rainwater, directed from roofs to tanks by gutters for domestic use, is potentially rich in zinc. Additionally, frequently consumed seafood and other meats are good sources of zinc.[35]

In humans, high zinc intakes reduce iron absorption.[46] Rats on high-zinc diets exhibited reduced iron absorption and were less able to incorporate iron into or release it from ferritin. They compensated by shortening the red blood cell's lifespan, resulting in faster turnover of iron.[47]

Animal[48,49] and human studies show that dietary zinc, iron and calcium carbonate influence copper retention in liver and other tissues. High-zinc intakes depress copper and iron absorption and retention.[50–54] Copper and zinc antagonism occurs when copper is limiting and during copper toxicosis. Large intakes of zinc could reduce copper absorption and manifest as anemia, partly because iron is transported in the ferric state and requires a copper protein, ferroxidase caeruloplasmin, to oxidize ferrous storage iron for transport.[55]

Effectiveness of absorption-enhancing capability of vitamin C[39] was possibly underutilized due to limited consumption of fruits and vegetables. Being imported and perishable, they were expensive and of questionable freshness and vitamin C content at the time of consumption. They accounted for 10% of iron scores on GDT and Provo but only 6% on MC. Beverages contributed 6% to iron scores. Vitamin C-rich beverages are enhancers, while others (eg, coffee and tea) are inhibiters.

Intra-household food distribution was not investigated. Men have lower iron requirements than adolescents and women[26] but consume most of the food, especially meat. Hence, even though a household's iron score seemed adequate, skewed intra-household distribution could have resulted in vulnerable groups consuming less iron-rich foods, thereby contributing to anemia.

Various studies show that Blacks have unexplained lower hemoglobin levels than Whites.[10–12] This could also contribute to anemia in TCI with a $\geq$90% Black population.

Simple iron deficiency could be the primary cause of anemia as some households, especially on MC, had suboptimal iron scores. Single nutrient (iron) supplementation would make more iron available for absorption and reduce possible antagonism between zinc and iron but could aggravate existing zinc-copper imbalances.

CONCLUSION

This study's findings regarding TCI's dietary consumption patterns are pivotal to the development of a national public health intervention strategy to address health concerns that have diet as a risk factor, such as anemia. Findings should initiate discussion on factors that could be responsible for anemia. Additional studies are, therefore, imperative to reexamine dietary patterns and fully explore these options so that comprehensive, culturally appropriate interventions could be implemented. In the short-term, citizens must have access to screening to identify and treat anemia and culturally appropriate nutrition education that emphasizes dietary adequacy and balance and safe use of multivitamin/mineral supplements (at levels less than nutrient RDAs unless prescribed by health professionals). Because of TCI's dependence on imported foods, supplementation, rather than fortification of a common food, is the most viable public health intervention option until the etiology of anemia is fully determined.

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AUTHOR CONTRIBUTIONS

Design concept of study: Maitland
Acquisition of data: Maitland
Data analysis and interpretation: Maitland
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