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AN ANALYSIS OF IODINE DEFICIENCY DISORDER AND ERADICATION STRATEGIES IN THE HIGH ATLAS MOUNTAINS OF MOROCCO

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ABSTRACT

The population of the Ounein Valley in the High Atlas Mountains in Morocco is at high risk of iodine deficiency. We investigate local children's iodine deficiency and goiter patterns and their food consumption habits through regression analysis using data from a household survey. Median urinary iodine content and goiter analysis both reflect moderate iodine deficiency in the population. Total fish consumption has a statistically significant, positive effect on urinary iodine content. Fish consumption, like that of salt, is closely related to market access. Respondents are generally unaware of the dietary etiology of goiter. An effective strategy to reduce the high incidence of iodine deficiency disorder among children in the valley must attend to four crucial issues: fish consumption, salt iodization, nutrition education, and market access.

Key Words: iodine deficiency, micronutrient deficiency, Morocco, nutrition education, salt iodization

Running Head: Iodine Deficiency in Morocco

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INTRODUCTION

Iodine deficiency disorder (IDD) is the single most important cause of preventable brain damage throughout the world, and is also associated with increased risk of miscarriage and stillbirth (WHO, 1993). The most common manifestations of IDD, goiter and cretinism, affect over 200 million and 6 million people, respectively (UN, 1993). Iodine deficiency in general can be easily treated by iodine supplementation or by salt iodization. Nevertheless, IDD remains a major problem in some developing countries where geographic, economic, and political issues block progress towards its eradication (Hetzel et al., 1990; Koutras et al., 1993).

Most industrialized countries control iodine deficiency through nationally legislated salt iodization programs because salt is readily available, universally consumed and relatively inexpensive to iodize (Hetzel and Dunn, 1989; Mannar, 1993). Several countries have implemented iodine fortification programs using alternative food substances such as bread or candy (Stanbury and Matovinovic, 1983), and recent projects suggest it may be possible to successfully iodize water sources in rural areas (Yazipo et al., 1995).

Other than food fortification, IDD eradication efforts focus on either iodine supplementation or dietary modification through nutrition education. Supplementation through iodized oil injection or, more commonly, ingestion of iodized oil capsules works where iodized salt is not universally available or when the lag time of a salt iodization program and the urgency of the situation require an immediate interruption of the iodine deficient state (Stanbury, 1985). However, supplementation is the most expensive intervention against IDD. Modification of dietary patterns can permanently resolve dietary iodine deficiency, but it requires a behavioral change that can be difficult in some communities given monetary, cultural, or social restrictions. Hence, the appeal of fortifying foods already consumed.

IDD results from limited dietary intake of iodine. The most important natural dietary source of iodine is sea fish. Though iodine is found naturally in the soil, glaciation processes that have occured historically in mountainous regions combined with heavy rains and erosion have eliminated much of the iodine present in these soils (Subramanian, 1973). Iodine can be found in animal products, such as chicken, milk, and milk products (Muros et al., 1992; Dodd and Dighe, 1993) as well as certain vegetables, but the iodine content of these foods is not always stable. So sea fish is really the primary dietary source of iodine in the absence of fortification programs.

Iodine deficiency has only recently received attention as a major problem in Morocco. In 1993, a national program to counter IDD was begun by the Minister of Public Health in Morocco. A national survey of IDD prevalence completed in 1994 showed a national goiter prevalence rate of 22%. The range of regional prevalence varied from 0-77% with the highest incidence found in the interior, mountainous regions, like the one studied in this paper, where consumption of sea fish is lowest.

This paper focuses on the valley of Ounein, an isolated region in the High Atlas Mountains in Morocco where geography—distance from the sea and soil erosion in a mountainous region—fosters iodine deficiency in the form of goiter and limits access of the population to treatment and to education or information concerning the causes and prevention of IDD. A multidisciplinary rural development project in the region began focusing on iodine deficiency after preliminary studies reported that the dietary deficiency of iodine reaches 91.4% in some villages, touching more than 50% of households (Benjelloun, 1987) and more than 80% of women in the valley (Lakhsassi and Lemtouni, 1987). This paper presents the findings of a survey conducted in 1995, just before the Moroccan government committed to universal salt iodization and IDD eradication. We examine the correlates of iodine deficiency in the Ounein region and of dietary patterns with the intention of informing the design of an effective IDD eradication program.

REGIONAL CHARACTERISTICS

Ounein is a remote region of approximately 200 km^2 at an altitude of 900 to 2,816 meters in the High Atlas Mountains. The nearly 8,000 people of Ounein are dispersed across more than 60 villages. Natural springs provide drinking and irrigation water. Agropastoral activities dominate the region, with cropping of cereal staples (barley, wheat, and corn) and vegetables (mainly carrots, tomatoes, and potatoes) predominant below 1300 meters, and animal husbandry, primarily of small ruminants, the chief activity above 1500 meters.

Ounein's market operates on Wednesdays and Sundays in the village of Adouz, on the valley floor, with Sunday the more active day. The market offers the only source of commercial goods for most households and acts as an important information conduit between villages. Supporting infrastructive is minimal; the area lacks electricity or telephone service.

The educational system in Ounein relies on both traditional Koranic and modern public schooling. Koranic schools are found in every village and are taught by the local religious leader, the *fquih*. The *fquih* instructs children from age five on matters reading, writing, mathematics, and religion. Three central primary schools and several satellites comprise the valley's public education system. No secondary schooling is available in Ounein.

The health care system in the valley is similarly divided between modern and traditional structures. One dispensary, with a single nurse, exists in Adouz. The *fquih* also provides health care in the form of Koranic amulets, recitations, and various herbal treatments. The people of Ounein visit the *fquih* more often than the nurse due to cost and distance.

The population is high risk of endemic IDD, living in an isolated, inland mountainous region and consuming foods grown in iodine-poor soils. Sea food consumption is low because of inadequate transportation infrastructure and insufficient demand by the poor population of Ounein. Fresh or cooked seafood is only available in the winter, when colder weather permits nonrefrigerated transport from the coastal city of Agadir, several hours away. Canned sardines are sold in the market year-round.

DATA AND DESCRIPTIVE STATISTICS

Data were collected throughout the spring of 1995 from a random sample of 110 households in 19 different villages following cluster sampling techniques. Male heads of households (HOH) or their wives were interviewed as part of a survey examining household salt, fish, and animal product consumption patterns, factors affecting market purchases, and social and cultural factors surrounding IDD and perceptions of IDD. To provide an accurate measure of IDD in the population, 24-hour urine samples were collected from children ages 6-14 to establish urinary iodine content. A medical doctor later examined these children for goiter using the palpation method recommended by the WHO, UNICEF, and ICCIDD (Dunn and VanDer Haar, 1990). An anonymous referee rightly notes that these older methods are less accurate than current methods for determining thyroid size by ultrasonography. Palpation may underestimate the fraction of the population having thyroid size within the normal limits. Unfortunately, ultrasonography requires access to electricity, which is not available in Ounein.

Food consumption data were gathered using household purchasing frequencies. Salt consumption was calculated by subtracting the amount of salt given to livestock from the amount purchased. Animal product consumption was recorded through respondents' recall of average consumption patterns. Salt and sea fish consumption data are reported in grams per person per day. One problem inherent in this survey method, however, is the length of recall for food consumption. Food intake volumes were not recorded, and respondents reported yearly estimates of food consumption.

Selected respondent characteristics are reported in Table I. Household decision-making and market participation are strongly associated with cultural gender roles. While women in the households play a key role in the management of salt storage and the decision-making process regarding household provisioning, none of them go to market. Almost all of the male HOHs go to the market each week, but only one-quarter of them claimed responsibility for market purchases. Women determine which supplies are needed in 80.6% of households, while decisions are made jointly in 6.1% of the households. Eighty-eight percent of wives manage salt usage and storage, while only 4.5% of HOHs take charge of salt once it is in the household.

Education likewise reflects traditional gender roles. While 70% of HOHs had formal education, 95% of the wives of HOHs had never gone to school. Of those HOHs who had attended some schooling, 62% reported stopping at the Koranic level of education while 38% had gone on to receive some public schooling. The sex division in education is replicated among the children as well.

Urinary samples of 197 school-aged children in the study households were evaluated for iodine content; the results are shown in Table II. Of the 197 children sampled, 42.6% were found to be severely iodine-deficient, 51.3% moderately deficient, 3% mildly deficient, and another 3% normal. A slightly higher number (45.9%) of girls were found to be in the severe category than boys (39.4%), though a higher number of boys had moderate urinary iodine levels (54.5%) than girls (48%). Six boys (6.1%) showed mild iodine deficiency and none were in the normal level. No girls had a mild level of iodine deficiency; however, six girls (6.1%) had normal levels of urinary iodine. The median urinary iodine level of the sample was 2.1μg iodine per deciliter (I/dl), indicating a low moderate deficiency within the population.

188 children were subsequently examined for goiter palpation (Table III). The goiter prevalence in this population was determined to be 94%, similar to the 97% IDD rate identified by urinary iodine content. Of the subjects affected by goiter, 18.6% had a 1a grade goiter, 33% were in the 1b grade, 39.4% were at grade 2, and 3.2% had a grade 3 goiter. As with the urinary iodine measure, the gender difference in goiter is negligible. There was a very strong correlation between the goiter palpation and urinary iodine content measures. Given this correspondence, we use the continuous variable, urinary iodine content, rather than the categorical variable, goiter palpation grade, in regression analysis.

Average fish consumption per household increases considerably with child urinary iodine content (Table IV). Severely and moderately deficient children come from households consuming only 12-14 kilograms of fish per year. The households of children with mild iodine deficiency consume about twice as much fish, while the households of the few (six) children with no urinary iodine deficiency consumed almost six times as much fish as households with severely or moderately iodine-deficient children. Despite the remote, inland location, most households consume some fish. A large number of households rightly treat fresh and cooked fish with suspicion since it travels several hours to get to market . Canned fish, the only sort available year-round, is the most widely consumed, by 92% of households. 73% of households consuming canned fish limit fish consumption during summer, primarily because 82% of them feel it makes them too warm in the summer heat.

Goiter is a universally recognized problem in Ounein, but none of the households surveyed identified a link between goiter and diet. Many (40.0%) admit not knowing the origin of goiter. The most common belief (expressed by 38.2% of respondents) is that goiter is an hereditary problem. This seems to derive from the observation of a concentration of moderate and severe goiters in families and villages. While there appear to be genetic factors that predispose particular individuals to develop goiters when deprived of iodine (Koutras et al., 1993), we suspect most of what our respondents have observed is due to pockets of more severe poverty and to microvariability in soil and water conditions that influence the iodine content of locally produced foodstuffs and that create pockets of people with poor access to marketed sea fish.

Finally, an anonymous referee calls attention to the lack of evidence of IDD-induced mental retardation or cretinism in Ounein. The lack of cretinism or mental retardation, in spite of widespread moderate and severe IDD, as reflected by either goiter prevalence and severity or urinary iodine content, is attributable to the very high rate of child mortality in the area. Our IDD data come from school-aged children, but the under-five mortality rate was 262 per thousand live births in 1991 (Dahman et al. 1991). Because of dire poverty, high rates of protein-energy malnutrition, poor sanitary conditions, and health care, children suffering the most severe micronutrient deficiencies rarely survive to school age in this particular setting.

REGRESSION ANALYSIS

The survey data permit more careful statistical analysis of the correlates of children's IDD. Stating our statistical findings up front, urinary iodine deficiency among children in Ounein has a strong, positive correlation with dietary intake of sea fish. A household's proximity to market and the occupation of the male head of household, which together influence ease of market access, are in turn positively related to fish consumption, with proximity to market apparently more important.

IDD is caused primarily by insufficient dietary intake of iodine. Given that Moroccan salt was not iodized at the time of the survey, we initially estimated the relationship between a child's urinary iodine content (measured in µg/dl) and household-level consumption of fish and dairy products (measured in grams consumed per day), normalized by household size, as measured in adult male equivalent (AME) units.[1] We also included village dummy variables to proxy for local water and soil conditions that may result in the natural iodization of fruits, grains, or vegetables grown for home consumption.[2] While there is no evidence of biological sex bias in IDD among children, there could be gender discrimination in the intrahousehold distribution of food and, thus, in dietary iodine intake, so we included a dummy variable for the child's sex (boy = 1). For instance, if boys receive disproportionately large shares of food—especially of protein-rich foods like fish or dairy products that may also contain much of the household's dietary iodine—the sex variable should capture the IDD consequences of unequal intrahousehold distributions. One would expect it to be nonnegative, i.e., intrahousehold inequities, if there are any, probably advantage boys in this area. Finally, since

[1]We used the following equivalence scales based on energy requirements (FAO/WHO 1974):

adult male age > 19 = 1	boy age 10-12 = .87
adult female age > 19 = .73	boy age 13-15 = .96
child age < 1 = .27	boy age 16-19 = 1.02
child age 1-3 = .45	girl age 10-12 = .78
child age 4-6 = .61	girl age 13-15 = .83
child age 7-9 = .73	girl age 16-19 = .77 .

[2] One village had no children in the sample households, so only 18 villages are included.

dietary intake requirements increase with a child's age but our consumption data are household-level means, we also include age (measured in years) as a regressor. Since a given per capita availability of fish or other iodine-rich foods satisfies a lower proportion of an older child's micronutrient requirements, one would expect the estimated coefficient on the age variable to be nonpositive.

While dietary intake appears a leading cause of IDD, there is some evidence of genetic factors that predispose individuals toward the development of IDD when iodine intake is insufficient. Since genetic patterns are unobservable, genetic predisposition to IDD should show up in the regression residuals, insofar as the village dummy variables do not already capture clan-level genetic relationships. Given that biological siblings share genetic traits, the regression residuals may thus be correlated across observations. One can test for such serial correlation using Llung-Box-Pierce Q-statistics (Judge et al., 1985). In the presence of correlated residuals, the ordinary least-squares estimator is inefficient, so we opt instead for a generalized least-squares estimator of the form[3]

$$\mathbf{y} = X\mathbf{b} + \mathbf{e}, \text{ with } E[\mathbf{e}] = 0 \text{ and } E[\mathbf{ee}'] = \Sigma \text{ ,} \tag{1}$$

where **y** is the dependent variable (urinary iodine content), X is the matrix of regressors, **b** is the vector of coefficient estimates, **e** is the vector of residuals, and Σ is the (unknown) covariance matrix. One can consistently estimate Σ from the **e**'s derived from the ordinary least-squares regression of **y** on X, imposing some structure on the n(n+1)/2 elements of Σ, and

[3]Boldface, lowercase characters denote vectors, uppercase characters denote matrices.

thereby get consistent and efficient **b** estimates (Judge et al., 1985). To capture potential genetic correlations among siblings, we restrict the σ_{ij} elements of Σ as follows:

$\sigma_{ii} = \sigma > 0$ $\forall i$ (homoscedastic errors with positive variance)

$\sigma_{ij} \geq 0$ $\forall i,j$ in same nuclear family (nonnegative intrafamily correlation)

$\sigma_{ij} = 0$ $\forall i,j$ in different nuclear families (zero interfamily correlation).

This restriction permits nonzero correlation among that portion of siblings' urinary iodine content that cannot be explained by the structural regressors. Given this structure to the estimate of Σ, the coefficient estimates are computed by $\mathbf{b} = (X'\Sigma^{-1}X)^{-1} X'\Sigma^{-1}\mathbf{y}$.

This regression technique yields the estimation results reported in Table V. The residuals from the ordinary least-squares variant of (1) were indeed serially correlated, as evidenced by a Q-statistic with a p value of 0.011 against the null hypothesis of no serial correlation. In cross-sectional data, this serial correlation suggests relationships between observed individuals and is thus consistent with the expectation of unobservable genetic factors in IDD patterns. The GLS residuals satisfy diagnostic tests for serial correlation and heteroscedasticity; i.e. Σ seems to accommodate whatever unobservable, genetically-determined (or other household-specific) correlations exist among these children's urinary iodine content, providing an efficient estimator for the structural relationships of interest.

Urinary iodine increases by a statistically significant amount with fish consumption. The elasticity of urinary iodine with respect to a change in fish consumption equals 0.257 at the sample means, indicating that a doubling of household fish consumption is associated with more than a 25% increase in its children's urinary iodine. The coefficients on dairy consumption and sex were not statistically significant nor of the expected sign. Intrahousehold food distribution does not seem serious with respect to dietary iodine intake. The coefficient on the age variable had the expected sign but was not statistically significant. Several of the village-specific variables are statistically significant, likely capturing genetic relationships among extended family coresident in the same village or local soil and water conditions that affect dietary iodine intake through fruits, grains, and vegetables produced for home consumption. If these village dummy variables indicate locally iodized soils and plants, that may also explain the counterintuitive negative coefficient estimate on dairy consumption, since the iodine content of the milk from a family's livestock depends fundamentally on the nutrient content of local fodder.

What then are the correlates of fish consumption within the region? Basic microeconomic theory posits consumption increases with household expenditures and decreases with price. Unfortunately, we haven't reliable data on prices or household expenditures. However, market access likely also matters since all fish consumed in this region are imported from the coast and purchased in town. We measure market access by two variables: distance from market, and HOH occupation. The further a household lives from market, the less likely are they to purchase fish regularly. Thus, we group households into one of three categories: those living within 5 kilometers of the market, those living at 5-10 kilometers distance, and those living more than 10 kilometers away. Dummy variables for the latter two categories capture the effects of living beyond a 5 kilometer radius from the market. Second, some men have occupations which cause them to be in the market town regularly. The marginal cost of market access is thus quite low for them, irrespective of where they live.[4] We thus constructed a dummy variable for all households for which the HOH had an occupation requiring his presence in the market town at least every market day.

If educated adults are more likely to be aware of and to understand the inverse relationship between fish consumption and iodine deficiency, then one would expect fish consumption to increase with the education level of the household head. One must be careful, however, to distinguish between the education level of the female head, who prepares the food and may request particular food purchases of the male, and the education of the male, who undertakes all market purchases. Thus, we include two education variables as regressors: the years of formal education for both the male and female heads of each household.

Given these considerations, we estimated by ordinary least squares the relationship between household fish consumption per AME (in grams per day) as a function of distance from market, the occupation of the male household head, and the years of schooling of the female and male household heads. The results are reported in Table VI. Fish consumption indeed appears related to market access, as the coefficient estimates on the distance-from-market variables are both negative and statistically significant and the coefficient estimate associated with the household head's occupation is positive, if statistically insignificant at conventional significance levels. This finding is consistent with other, informal findings that insufficient fish consumption is closely related to remoteness from market (Benjelloun, 1994).

[4]Perhaps surprisingly, the correlation coefficient between living within 5 kilometers of the market and having a market town-based occupation was only 0.132 in sample. Hence, the importance of accounting for occupation separately.

The coefficient estimates on the male and female education level variables are of low magnitude, of mixed sign, and not statistically significant at any meaningful level. One factor is that less than five percent of the women are educated, so the statistical insignificance of the women's education parameter estimate could be due to insufficient variability in that regressor. More fundamentally, the regression results with respect to education are consistent with the respondents' widespread lack of awareness of the dietary etiology of IDD, irrespective of educational attainment.

While it is clear that sea fish consumption offers a natural source of dietary iodine, policymakers focus more on the possibility of IDD eradication through salt iodization because salt iodization is cheap and easy while increasing iodine intake through sea fish consumption requires changing food consumption behaviors and may face greater marketing infrastructure obstacles. More than one-third of the children in our sample came from households consuming less than one gram of sea fish per day per AME. Eight percent consumed no fish. And all the fish must be imported from the coast.

The impact of salt iodization on reducing the prevalence of IDD depends, however, on salt consumption patterns. It takes relatively little iodized salt to satisfy micronutrient requirements. But what if some households consume little or no salt? Although all households in the sample consume salt, 5 percent of children consumed less than ten grams of salt daily, and 14 percent consumed less than 14 grams daily. Moreover, there are several different varieties of salt (white, red, block), not all of which will necessarily be iodized under planned policy changes. Is salt iodization likely to reach all children at risk, particularly during a transition period during which noniodized salt remains available in markets?

To answer this question, we estimated (noniodized) salt consumption patterns, regressing household salt consumption per AME (in grams per day) on distance from market, HOH occupation, and the years of schooling of the female and male household heads, again by ordinary least squares (Table VII). As with fish, it appears that market access matters considerably to salt consumption, as represented both by proximity of the household's residence to market and by HOH occupation. The estimated coefficients on the distance and occupation dummy variables are of the expected sign and statistically significant. Salt consumption is also positively correlated with the male head of household's education.

DISCUSSION AND POLICY IMPLICATIONS

Iodine deficiency among children in the Ounein region of Morocco is widespread, relatively severe, and strongly and positively correlated with dietary intake of fish. A household's access to market positively affects fish consumption. All surveyed households purchase and consume salt, with salt consumption likewise strongly affected by household market access. Households were uniformly unaware of the dietary basis of IDD. It thus appears that an effective strategy to reduce the incidence of IDD in the valley must attend to four issues: salt iodization, sea fish consumption, nutrition education, and market access.

Salt Iodization: The planned introduction of iodized salt should have a great impact on IDD rates nationally. But given that almost half the salt in Morocco comes from small-scale producers, universal salt iodization may be difficult to achieve, much less quickly. Remote areas like Ounein are especially dependent on the small-scale, artisinally produced salt most likely to escape iodization. The presence of iodine in the new salt and the link between dietary iodine intake and goiter must be stressed for salt iodization to be broadly effective. As long as noniodized salt remains available villagers must actively demand iodized salt. Since the cost of iodization is minimal, iodized salt should probably not cost much more than traditional, noniodized varieties. Preferences, not price, will likely most influence the rate of acceptance of iodized salt in remote regions of Morocco.

Sea Fish Consumption: Increased fish consumption translates into higher urinary iodine content. Unfortunately, the valley of Ounein is isolated from the sea, and fish intake is limited in quantity, seasonal, and largely restricted to canned fish for health reasons. Over 90% of households reported they would consume more canned fish if they knew it could aid in the prevention of goiter or promote good health more generally. Nutrition education messages linking canned fish consumption with the eradication of goiter and the promotion of good health thus show promise. The seasonal consumption pattern of canned fish should be addressed through the idea that fish can also be consumed with “cool” foods such as salad; most households in the sample do not do this at present.

Education: Perhaps the most striking feature of IDD in Ounein is that none of the population understands its etiology. So long as noniodized salt remains on the market or significant subpopulations do not purchase and consume enough iodized salt or canned fish to prevent IDD, there must be education programs to combat iodine deficiency by promoting consumption of iodized salt and canned fish. The relation between iodine, goiter (the only recognized form of IDD in the valley), and consumption of iodized salt or sea fish must be presented in a straight forward manner. Given that almost none of the wives of HOHs are literate but are mutually acknowledged decision-makers regarding food purchases and salt storage in the majority of households, education efforts should focus on oral rather than written communication. Men must also be included in educational efforts since they make the market purchases. Cultural mores in the area dictate that the nutritional education of men and women cannot be integrated, so coordinated, parallel programs must be designed.

A logical choice as an iodine deficiency educator in the valley is the *fquih*. The local population has little faith in the dispensary and most do not have money to visit a hospital. Thus, most of the population seeking treatment for goiter turn to the *fquih*. Informal discussions with *fquih*s in villages found them willing to serve as IDD educators. But presently they are no better informed than the general population as to the etiology of goiter or IDD more generally. The *fquih* leadership would also enhance the informal nutritional education of women who visit the *fquih* on matters of health or religion. The dispensary nurse, the only local source of medical supplies and knowledge, is also indispensable to IDD education. Although the villagers rarely seek treatment for goiter at the dispensary, they recognize the dispensary as the valley's only source of modern medicine. Moreover, the *fquih* lack technical training in nutrition and may need assistance from the nurse (Benjelloun, 1994).

<u>Market Access</u>: Because locally produced foods contain little or no iodine, improved market access is crucial to combating IDD in Ounein. Subsistence production almost inevitably

leads to IDD in environments like Ounein. Nutrition educators must especially target more distant villages and HOH who do not work in the market town to encourage greater purchase and consumption of iodized salt and canned fish.

CONCLUSIONS

Survey data suggest that if the alarmingly high prevalence of IDD is to be reduced substantially, the introduction of iodized salt in the Ounein Valley of Morocco must be accompanied by nutrition education to promote consumption of iodized salt and of sea fish, targeted especially to households living more than 5 kilometers from the market and whose male head does not work in the market town. Nutrition education efforts must target both women and men in accordance with their gender-specific roles in household provisioning, food preparation and storage, and local religious leaders could be enlisted as effective nutrition educators.

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Table I: Selected characteristics of heads of households and their wives

Characteristics (Number)	Heads of Households (110)	Wives (108)
Percentage with no education	30.0% (33)	95.4% (103)
Percentage with Koranic schooling	43.6% (48)	0.9% (1)
Percentage with public schooling	26.4% (29)	3.7% (4)
Percentage who go to *souk* (market)	97.3% (107)	0 (0)
Percentage making decision regarding household purchases	25.5% (28)	80.6% (87)
Percentage managing salt storage	4.5% (5)	88.0% (95)

Table II: Levels of urinary iodine deficiency in children by sex

Level of Deficiency	Boys	Girls	Total
Severe	39.4%	45.9%	42.6%
	(39)	(45)	(84)
Moderate	54.5%	48.0%	51.3%
	(54)	(47)	(101)
Mild	6.1%	0.0%	3.0%
	(6)	(0)	(6)
Normal	0.0%	6.1%	3.0%
	(0)	(6)	(6)
Total:	100.0%	100.0%	100.0%
(N)	(99)	(98)	(197)

Note: Severe deficiency = <2.0 μg/dl urinary iodine.
Moderate deficiency = $\geq$2.0 and <3.5 μg/dl urinary iodine.
Mild deficiency = $\geq$3.5 and <5 μg/dl urinary iodine.
Normal = $\geq$5 μg/dl urinary iodine.
Due to rounding, totals do not always sum to 100.0.

Table III: Goiter prevalence in the sample population of children by sex

Grade of Goiter	Boys	Girls	Total
Grade 0	4.4%	7.2%	5.9%
	(4)	(7)	(11)
Grade 1a	24.2%	13.4%	18.6%
	(22)	(13)	(35)
Grade 1b	33.0%	33.0%	33.0%
	(30)	(32)	(62)
Grade 2	38.5%	40.2%	39.4%
	(35)	(39)	(74)
Grade 3	0.0%	6.2%	3.2%
	(0)	(6)	(6)
Total	100.0%	100.0%	100.0%
(N)	(91)	(97)	(188)

Note: Grade 0 = no goiter.
Grade 1a = goiter not visible but larger than ends of thumbs.
Grade 1b = goiter visible when neck is tilted back.
Grade 2 = goiter visible with neck in normal position.
Grade 3 = goiter visible from about 10 meters.
Due to rounding, totals do not always sum to 100.0.

Table IV: Household fish consumption patterns by children's urinary iodine deficiency level (kilograms per year)

Level of Iodine Deficiency	Fresh Fish	Cooked Fish	Canned Fish	Total
Severe	3.93	3.18	6.89	13.99
Moderate	3.49	2.38	6.03	11.91
Mild	8.08	2.89	16.58	27.55
Normal	22.15	22.40	26.53	71.08

Note: Due to rounding, the three columns do not always sum to the total column.

Table V: Correlates of children's urinary iodine content: regression results

Variable	Coefficient Estimate	Standard Error
Intercept*	3.241	1.020
Fish*	0.091	0.021
Dairy	-0.002	0.012
Age	-0.134	0.231
Sex	-0.015	1.681
Village Dummy Variables		
Ait Zekri	0.109	0.187
Tignziw*	0.387	0.128
Tinsmlal	0.213	0.227
Takordmi	-0.098	0.101
Tamsoult n'Ougard	0.674	0.988
Doutkad	-0.544	0.321
Agard†	-0.433	0.206
Imirguen*	0.766	0.308
Ait Tadrart	-0.332	0.431
Aghilas	-0.227	0.967
Afla n'Oufra*	0.087	0.034
Tamdghoust	-0.004	0.027
Ait Tachrift	0.018	0.022
Ait Masoud	0.208	0.345
Tawarda	0.355	0.283
Talat Nd Raman	-0.227	0.121
Tinmslal	-0.433	0.497

*Statistically significantly different from zero at the 1% level (p value $\leq$ 0.01).
† Statistically significantly different from zero at the 5% level (p value $\leq$ 0.05).

Table VI: Correlates of household fish consumption/AME: regression results

Variable	Coefficient Estimate	Standard Error
Intercept*	9.803	2.535
5-10 km distant*	-6.555	2.542
> 10 km distant*	-4.182	1.802
Occupation	4.443	2.872
Female education	0.085	1.360
Male education	-0.124	0.217

*Statistically significant at the 1% level (p value $\leq$ 0.01).

Table VII: Correlates of household salt consumption/AME: regression results

Variable	Coefficient Estimate	Standard Error
Intercept*	34.491	6.735
5-10 km distant†	-3.722	1.655
> 10 km distant†	-6.333	2.779
Occupation	2.918	1.572
Female education	-2.444	1.645
Male education†	1.800	0.877

*Statistically significant at the 5% level (p value $\leq$ 0.05).
†Statistically significant at the 1% level (p value $\leq$ 0.01).