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# Factors Associated with Household Iodised Salt Use and Iodine Deficiency Among Nepalese School Children Aged 6-9 Years

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**Abstract:** Iodine deficiency is one of the world's leading causes of delay in cognitive growth of children, and remains a public health problem, particularly in low-income countries including Nepal. This current study used cross-sectional data to examine factors associated with iodine deficiency and household iodised salt among Nepalese children. The source of data was the 2016 Nepal National Micronutrient Status Survey (NNMSS). Household iodised salt and urinary iodine were examined (by using and multivariate statistical models that adjust for clustering and sampling weights) against a set of non-biological and eating habits factors of 1153 Nepalese children aged 6-9 years. The mean household salt iodine concentrations (in ppm) in the Eastern, Central, Western, Mid-Western and Far-Western were 1.15 ± 1.6, 9.6 ± 2.6, 43.5 ± 12.9, 69.1 ± 3.7 and 85.6 ± 3.9 respectively. The corresponding median iron status of the children (and interquartile range IQR) in µg/l were 299 (177.6-569.2), 387.8 (197-604.8), 357.7 (203.8-566.7), 239.2 (140.3-493.1) and 238.5 (114.1-397.5) respectively. The likelihood of iodine deficiency was significantly higher among children from the Mountain ecological zone compared with those from the Terai zone [adjusted odds ratio (AOR): 0.02; 95% confidence interval (CI): (1.03, 1.49)]. Children who consumed dark green leafy vegetables were significantly less predisposed to iodine deficiency compared with those who did not [AOR: 0.87; 95% CI: (0.77, 0.99)]. The likelihood of household iodised salt use was significantly lower among children from the Far-Western region compared with those from the Eastern region [AOR: 0.81; 95% CI: (0.68, 0.97)]. The use of iodised salt was significantly more likely among children from rich households compared with those from poor households [AOR: 1.19; 95% CI: (1.06, 1.33)]. The likelihood of iodised salt use was significantly higher among households where children consumed meat compared with those in which children did not consume meat [AOR: 1.07; 95% CI: (1.01, 1.15)]. Among the development regions, it is only the Mid-Western region where household iodine concentration among the children was less than 75%. Appropriate interventions should be put in place to improve this situation. Interventions to improve household iodised salt use should target should also target children from poor households and those from households where children did not consume meat.

**Keywords:** Iodine, Deficiency, Household Iodised Salt, Children, Nepal

## 1. Introduction

Iodine is an essential element for human and health of unborn children. In addition to supporting thyroid function in infants, children and adults, it is critical for neurological function as well as the development of the foetus and brain of infants [1]. Deficiency of iodine has been found to be one of the world's leading causes of cognitive delay in children [1]. Although it is the world's most prevalent, and can cause brain damage, especially among people living in iodine-deficient areas of Africa and Asia, it is preventable [2]. In spite of the concerted efforts of organisations such as the World Health Organisation (WHO) and the International Council for the Control of Iron Deficiency Disorders (ICCIDD) in minimising the prevalence, iodine deficiency disorders (IDD) still persist, particularly among women of child-bearing age [3]. Among adults, iodine deficiency has been linked to breast cancer, thyroid disease, fatigue, depression and tenderness of the breast. Further, among pregnant women, deficiency in iodine has been linked to miscarriages and stillbirths [4].

The most prominent global strategy for controlling iodine deficiency is universal salt iodisation (USI); which means that all salts consumed by humans and animals are iodised [5]. Substantial progress has been made since the institution of USI in 1993 to curb IDD [2]. The intervention chose salt because of its wide availability, regularity of consumption and low cost [2]. This strategic intervention has been implemented in majority of countries where deficiency of iodine is a public health problem. The United Nations International Children's Emergency Fund (UNICEF) estimates that globally, about 66% of all households now have easy access to iodised salt [2], and according to the 2016 Nepal Demographic and Health Survey report, 95% of Nepalese households use iodised salt [6].

There have been a number of past studies on iodine status in Nepal [7-10]. One such study assessed iodine status among Nepalese primary school children [10]. However, this study was limited in scope, as it covered only children from the Dhankuta and Dharan districts in eastern Nepal. In this current study, we sought to determine and examine factors associated with deficiency of iodine among Nepalese children aged 6-9 years. Children of this age group were considered for our study due to their physiological vulnerability, and accessibility from schools [11-13]. Furthermore, since the excretion of urinary iodine is the main indicator of the current iodine nutrition status of an individual, and therefore used as a measure of the success of iodine supplementation along with household iodised salt, our study also examined factors associated with household iodised salt use. Results of this current study would inform the government of Nepal, public health professionals and other stakeholders to institute appropriate interventions to improve the iodine status of young Nepalese children.

Key Messages

The majority of the children lived in rural areas (89%).

Household salt iodine was least among children from the Mid-Western region.

Children from the Mountain ecological zone were significantly more likely to be iodine deficient compared to those from the Terai region.

Children who were fed dark green leafy vegetables were significantly less predisposed to iodine deficiency compared with those who were not.

Iodised salt use was significantly more likely among children from rich households compared with those from poor households.

## 2. Methods

### 2.1. Study Design and Participants

The source of data for this current study was the cross-sectional and nationally representative 2016 Nepal National Micronutrient Survey (NMS). The NMS carried out a stratification process to provide representative estimates for the five development regions in Nepal, namely, Eastern, Central, West, Midwest and Far West. A similar stratification was conducted in the three ecological zones of the entire the country, namely, Terai (plains), Hills, and Mountains to obtain representative estimates. The survey collected nationally representative samples from children aged between 6 and 9 years. Additionally, data representative of the 5 development regions and 3 ecological zones were collected on this category of children.

#### 2.1.1. Data Collection and Specimen Analysis

A specialised child's (aged 6-9 years) questionnaire was used to collect information on socio-demographic characteristics, dietary diversity scale, two week recall of contraction of fever, cough and diarrhoea and documenting the collection of biological data.

Iodine status among the children was assessed by measuring and testing urinary iodine using the Ammonium persulfate method, which is the WHO-recommended method, and which involves a simple spectrophotometric detection of the Sandell-Kolthoff colour reaction. A 250 µL sample of urine was required for this analysis; and iodine deficiency was considered severe when the iodine level was less than 20 µg/L.

#### 2.1.2. Descriptive Study Variables

For this current study, the outcome variables were iodine deficiency and household iodised salt use. Individual-, household- and community-level factors constituted the potential covariates of the current study. Other potential covariates included environmental factors (type of toilet facility used in households, quality of drinking water, health status). Other covariates were level of household security of households, as well as the diet habits of the children.

The individual-level factors included carers' age and gender, child's age, gender, and number of years in school. Household level factors were household wealth index and ethnicity (caste). The household wealth index (an indicator of wealth) was represented as a score of household assets through the principal components analysis method (PCA) [14]. Scores were assigned to each de jure household member after the index was calculated, ranking each member of the sample by their score. In our study, the wealth index was categorized into five quintiles, namely, poor, middle, rich and rich. The bottom 40% of the households was referred to as poor, the next 40% as the middle-class, and the top 20% as rich. Our analysis included all socio-demographic variables contained in the dataset of the Nepal National Micronutrient Status Survey. Geographical region, state and ecological zone constituted community-level factors.

### 2.2. Statistical Analysis

In this current study, STATA/MP version 14 (Stata Corp, College Station, TX, USA) was used to carry out all statistical analyses. We used the ‘Svy’ commands to allow for adjustments for the cluster-sampling design and weight. We first conducted frequency tabulations to describe the data used in the study. A contingency table was then created to examine the impact of all potential covariates of iodine deficiency, and household salt use. We utilised the Taylor series linearization method during the estimation of confidence intervals (CIs) around prevalence estimates. Further, we calculated the multivariable logistic regression that adjusted for clustering and sampling weights to determine the unadjusted odds ratios of iodine deficiency. As part of the multivariable logistic regression analysis, we performed a six-stage model to determine the adjusted odds ratios of iodine deficiency.

In the stage model, we entered the individual-level factors into the first model, and conducted a manually executed elimination procedure to assess factors associated with iodine deficiency at a 0.05 significance level. In the second model, we added the significant factors in the first stage to the household-level factors. This was then followed by the elimination procedure. We used a similar approach for the community-level, anthropometric, health status and diet habits factors in the third, fourth, fifth and sixth stages, respectively.

We tested for, and reported any co-linearity in the final model. We calculated the odds ratios with 95% confidence intervals to determine the adjusted odds ratios (possible confounding) variables.

### 2.3. Ethical Consideration

There were concerns about creating fear and high refusal rates among illiterate participants. Consequently, oral informed consent procedures were carried out with participants. The interviewers or supervisors read the informed consent to each participant. Parents of children were asked to provide permission and consent for their children’s participation, and each child was asked to provide assent before interviewing or biological data collection. We sought permission from the Nepal Ministry of Health and Population (which approved the NNMSS) for use of available dataset.

## 3. Results

### 3.1. Characteristics of the Sample

This study utilised data from 1153 Nepalese children with ages ranging between 6 and 9 years (Table 1). The majority of the carers for these children (41%) were aged between 31 and 40 years, and most of them (67%) were females. Male and female children were almost equally represented (49.5 and 50.5 years respectively). The majority of the children (28%) were aged 8 years, whilst the minority (23%) were aged 9 years. Most of the children (46%) were not attending school at the time of the survey, and only 11% of them had between 4 and 6 years of schooling. Less than a third (31%) of the children could not read, and most of them (44%) came from poor households. More than three-quarters of the children (89%) came from poor households, and the majority of them (31%) were from the Janajati ethnic group. The Central region and the Terai ecological zone were home to the majority of the participating children (38 and 53% respectively). More than two-thirds of the children’s households (67%) used flush or pour flush toilets, and a large majority of the households (84%) did not use treated water. Most of the children did not have fever, cough of diarrhoea in the two weeks prior to the survey (84, 84 and 94% respectively). In the last six months before the survey, about two-thirds of them (64%) had intestinal worms. Approximately one out of every 10 of the children came from households with severe food insecurity. The majority of the children consumed starchy foods, legumes and nuts and other fruits (81%, 74%, and 67% respectively). On the other hand, most of the children did not consume foods made from nuts or seeds, dairy products, eggs, offal, red meat, white meat, other vitamin A-rich foods, vitamin A-rich fruits, dark green leafy vegetables, and other vegetables (95%, 56%, 89%, 95%, 77%, 95%, 60%, 94%, 87% and 64% respectively).

***Table 1.*** *Distribution of characteristics of Nepalese children aged 6-9 years (n=1153).*

| Characteristics | N (%) |
|---|---|
| Individual-level factors | |
| Carer's age (years) | |
| <= 30 | 375 (32.5) |
| 31-40 | 468 (40.6) |
| 40+ | 310 (26.9) |
| Carer's gender | |
| Male | 382 (33.1) |
| Female | 771 (66.9) |
| Child's gender | |
| Male | 563 (49.5) |
| Female | 575 (50.5) |
| Child's age (years) | |
| 6 | 268 (23.6) |
| 7 | 286 (25.2) |
| 8 | 323 (28.4) |
| 9 | 261 (22.9) |
| Years of schooling | |
| No schooling | 287 (45.8) |
| 1-3 | 274 (43.5) |
| 4-6 | 67 (10.7) |
| Literacy level | |
| Could not read | 354 (31.3) |
| Could read part of a sentence | 777 (68.7) |
| Household-level factors | |
| Household Wealth Index | |
| Poor | 496 (43.5) |
| Middle | 448 (39.4) |
| Rich | 194 (17.1) |
| Ethnicity (Caste) | |
| Brahmin/Chettri | 322 (28.2) |
| Dalit | 208 (18.3) |
| Janajati | 349 (30.7) |
| Others | 258 (22.7) |
| Community-level factors | |
| Location | |
| Urban | 132 (11.4) |
| Rural | 1022 (88.6) |
| State | |
| Province 1 | 169 (14.7) |
| Province 2 | 281 (24.4) |

| Characteristics | N (%) |
|---|---|
| Province 3 | 208 (18.0) |
| Province 4 | 88.3 (7.6) |
| Province 5 | 215 (18.7) |
| Province 6 | 71 (6.1) |
| Province 7 | 120 (10.4) |
| Geographical region | |
| Eastern | 225 (19.5) |
| Central | 433 (37.6) |
| Western | 203 (17.6) |
| Mid-western | 172 (14.9) |
| Far-western | 120 (10.4) |
| Ecological zone | |
| Mountain | 84 (7.2) |
| Hill | 461 (40.0) |
| Terai | 609 (52.8) |
| Environmental factors | |
| Type of toilet facility | |
| Flush or pour flush toilet | 771 (66.9) |
| Pit latrine | 382 (33.1) |
| Used treated water | |
| No | 966 (83.8) |
| Yes | 187 (16.2) |
| Health status | |
| Had fever | |
| Yes | 187 (16.5) |
| No | 951 (83.5) |
| Had cough | |
| Yes | 186 (16.4) |
| No | 952 (83.6) |
| Had diarrhoea | |
| Yes | 72 (6.3) |
| No | 1066 (93.7) |
| Had intestinal worms (last 6 months) | |
| Yes | 741 (64.3) |
| No | 412 (35.7) |
| Household food insecurity (access) | |
| Household food security | |
| Food secure | 524 (45.4) |
| Mildly insecure | 133 (11.5) |
| Moderately insecure | 387 (33.6) |
| Severely insecure | 110 (9.5) |
| Dietary habits (a day before the survey) | |
| Consumed roots or tubers/starchy foods | |
| Yes | 918 (80.7) |
| No | 220 (19.3) |
| Consumed legumes and nuts | |
| Yes | 836 (73.5) |
| No | 302 (26.5) |
| Consumed nuts and seeds or any food from nuts or seeds | |
| Yes | 62 (5.5) |
| No | 1074 (94.5) |
| Consumed dairy products | |
| Yes | 503 (44.2) |
| No | 635 (55.8) |
| Consumed eggs | |
| Yes | 131 (11.5) |
| No | 1007 (88.5) |
| Consumed Liver, kidney, heart or other organ meat or blood | |
| Yes | 62 (5.4) |
| No | 1076 (94.6) |
| Consumed other meats (chicken, goat, buffalo, pigs, ducks) | |
| Yes | 267 (23.5) |
| No | 871 (76.5) |
| Consumed fish (fresh or dried fish, shellfish, prawn, crab etc) | |
| Yes | 61 (5.4) |
| No | 1077 (94.6) |

| Characteristics | N (%) |
|---|---|
| Consumed other vitamin A-rich fruits | |
| Yes | 463 (40.7) |
| No | 675 (59.3) |
| Consumed vitamin A-rich fruits | |
| Yes | 69 (6.1) |
| No | 1069 (93.9) |
| Consumed other fruits | |
| Yes | 766 (67.3) |
| No | 372 (32.7) |
| Consumed dark green leafy vegetables | |
| Yes | 149 (13.1) |
| No | 989 (86.9) |
| Consumed other vegetables | |
| Yes | 406 (35.6) |
| No | 732 (64.4) |
| Mean food groups (sd) | 4.1 (1.7) |

### *3.2. Prevalence of Concentration of Household Salt Iodine Among Children Aged 6-9 Years*

Households of children from the Mid-Western region were ranked the highest in terms of non-use of iodised salt (<5 ppm) [Prevalence (P): 19.25; 95% confidence interval (CI): (9.60, 34.88)] (Table 2). The least prevalence of non-use of iodised salt was in households in the Western region [P: 1.66; 95% CI: (0.28, 9.38)]. Households of children from the Mid-Western region had the highest use of under-iodised salt (5-14.9 ppm) [P: 13.53; 95% CI: (7.94, 22.12)]. Households of children from the Eastern region had the least use of under-iodised salt [P: 4.39; 95% CI: (1.68, 10.94)]. Households of children with the highest use of salt with acceptable concentration of iodine (15-64.9 ppm) were in the Central region [P: 87.69; 95% CI: (73.42, 94.84)]. The least use of salt with acceptable concentration of iodine was households of children from the Mid-Western region [P: 61.71; 95% CI: (43.87, 76.86)]. Households of children in the Eastern region recorded the highest use of salt with concentrations higher than the required value (≥ 65-79.9 ppm) [P: 7.92; 95% CI: (2.96, 19.12)], whilst households of children from the Far-Western region recorded the lowest [P: 3.37; 95% CI: (0.83, 12.69)].

### *3.3. Prevalence of Iodine Status of Children Aged 6-9 Years*

Children with the highest prevalence of severe iodine deficiency (< 20 µg/l) came from the Far-Western region [P: 2.01; 95% CI: (9.2, 4.30)], whilst those with the lowest prevalence were from the Western region [P: 0.51; 95% CI: (0.07, 3.89)] (Table 3). Children with the highest prevalence of sufficient iodine (100-199.9 µg/l) were from the Mid-Western region [P: 27.63; 95% CI: (22.94, 3288)], and those with the lowest prevalence of sufficient iodine came from the Central region [P: 13.34; 95% CI: (9.51, 18.38)]. Further, the Western region was house to children with the highest prevalence of excessive iodine (>300 µg/l) [P: 58.55; 95% CI: (51.86, 64.94)], whilst the Far-Western region was house to children with the lowest prevalence of excessive iodine [P: 38.34; 95% CI: (27.61, 50.33)].

***Table 2.*** *Household salt iodine concentration among children aged 6-9 years by geographical region.*

| **Salt iodine concentration (ppm)** | **Geographical region** | | | | |
|---|---|---|---|---|---|
| | **Eastern** | **Central** | **Western** | **Mid-western** | **Far-western** |
| Non-iodised (< 5 ppm) | 7.81 [2.70, 20.53] | 2.81 [0.72, 10.41] | 1.66 [0.28, 9.38] | 19.25 [9.60, 34.88] | 6.16 [2.88, 12.70] |
| Under-iodised (5–14.9 ppm) | 4.39 [1.68, 10.94] | 5.93 [1.51, 20.59] | 11.95 [5.72, 23.29] | 13.53 [7.94, 22.12] | 12.44 [7.28, 20.45] |
| Acceptable (15–64.9 ppm) | 79.98 [64.60, 89.74] | 87.69 [73.42, 94.84] | 76.56 [69.02, 82.72] | 61.71 [43.87, 76.86] | 78.03 [67.50, 85.86] |
| More than required (≥ 65–79.9 ppm) | 7.82 [2.96, 19.12] | 3.56 [1.11, 10.80] | 7.18 [3.48, 14.24] | 4.65 [1.35, 14.81] | 3.37 [0.83, 12.69] |
| Excessive (≥ 80 ppm) | - | - | 2.64 [0.60, 10.86] | 0.86 [0.11, 6.33] | - |
| Mean (sd, ppm) | 1.15 (1.6) | 9.6 (2.6) | 43.5 (12.9) | 69.1 (3.7) | 85.6 (3.9) |

### *3.4. Factors Associated with Household Iodised Salt Use and Urinary Iodine Deficiency*

Table 4 presents iodine deficiency and household iodised salt use and their associated non-biological factors among children aged 6-9 years. Children from any other caste other than the Dalit or Janajati were significantly more predisposed to iodine deficiency compared with those from the Brahmin/Chettri caste [AOR: 1.11; 95% CI: (0.90, 1.36)]. The odds of iodine deficiency were significantly higher among children from the Mountain ecological zone compared with those from the Terai zone [AOR: 1.24; 95% CI: (1.03, 1.49)]. Compared with children from the poor households, those from the middle class households were significantly more likely to be iodine deficient [AOR: 1.27; 95% CI: (1.08, 1.50)]. Children who were cared for by females were significantly more likely to be iodine deficient compared to those care for by males [AOR: 1.14; 95% CI: (1.02, 1.27)]. The likelihood of being iodine deficient was significantly lower among children who consumed dark green leafy vegetables compared with those who did not [AOR: 0.87; 95% CI: (0.77, 0.99)].

***Table 3.*** *Iodine status of children aged 6-9 years by Geographical region.*

| **Iodine status (μg/l)** | **Geographical region** | |
|---|---|---|
| | **Eastern** | **Central** |
| Severe iodine deficient (< 20) | 0.52 [0.12.30] | 0.78 [0.12.68] |
| Moderate iodine deficient (20–49.9) | 4.07 [1.58 0.09] | 1.82 [0.62.23] |
| Mild iodine deficient (50–99.9) | 9.27 [5.65 4.84] | 10.08 [7.18 3.98] |
| Iodine sufficient (100–199.9) | 16.35 [11.53 2.68] | 13.34 [9.51 8.38] |
| Above requirement (200–299.9) | 19.68 [14.61 5.97] | 16.6 [10.65 4.95] |
| Excessive (≥ 300) | 50.11 [41.63 8.58] | 57.39 [46.89 7.26] |
| Median (IQR), UIC (μg/l) | 299 (IQR 177.6–569.2) | 387.9 (IQR 197–604.8) |

***Table 3.*** *Continued.*

| **Iodine status (μg/l)** | **Geographical region** | | |
|---|---|---|---|
| | **Western** | **Mid-western** | **Far-western** |
| Severe iodine deficient (< 20) | 0.51 [0.07.89] | 0.69 [0.18.59] | 2.01 [0.92.30] |
| Moderate iodine deficient (20–49.9) | 2.49 [0.80.47] | 3.58 [1.47.47] | 5.52 [3.46.69] |
| Mild iodine deficient (50–99.9) | 7.57 [4.17 3.35] | 7.29 [4.40 1.85] | 11.93 [8.77 6.03] |
| Iodine sufficient (100–199.9) | 13.78 [10.19 8.37] | 27.63 [22.94 2.88] | 22.72 [15.40 2.19] |
| Above requirement (200–299.9) | 17.1 [11.97 3.84] | 17.64 [13.45 2.80] | 19.49 [15.42 4.33] |
| Excessive (≥ 300) | 58.55 [51.86 4.94] | 43.17 [34.47 2.30] | 38.34 [27.61 0.33] |
| Median (IQR), UIC (μg/l) | 357.7 (IQR 203.8– 566.7) | 239.2 (IQR 140.3–493.1) | 238.5 (IQR 114.1–397.5) |

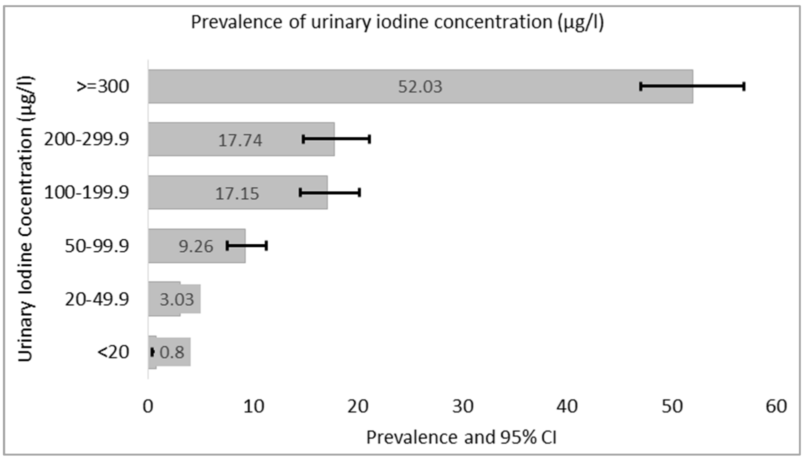
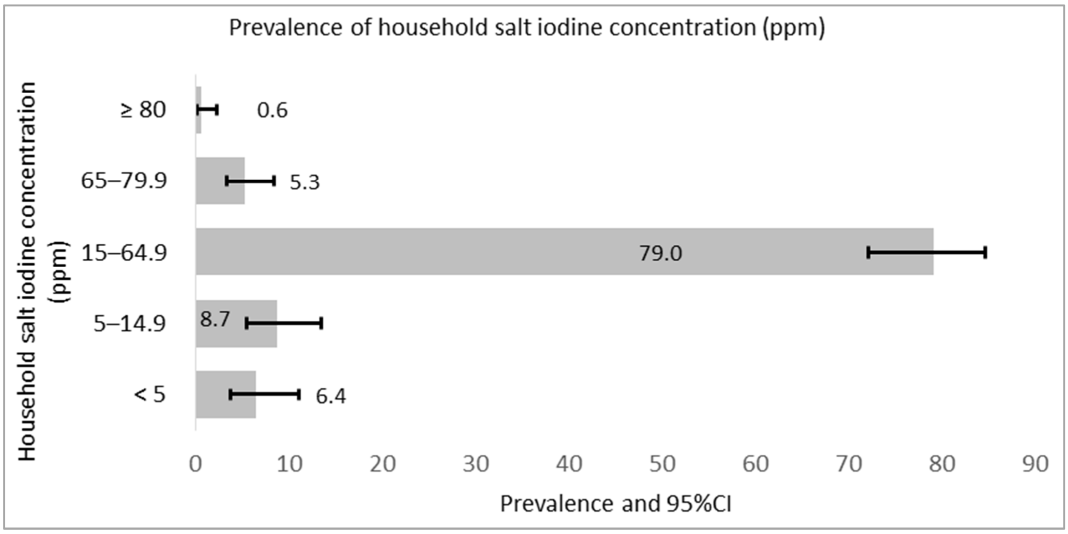



***Figure 1.*** *Prevalence and 95% confidence intervals of urinary iodine concentration (UIC) (μg/l) of children aged 6-9 years.*

***Table 4.*** *Factors associated with urinary iodine deficiency and household iodised salt use among Nepalese children aged 6-9 years.*

| Characteristic | Unadjusted OR (95% CI) | p-value | Adjusted OR (95% CI) | p-value |
|---|---|---|---|---|
| Urinary iodine | | | | |
| Ethnicity (Caste) | | | | |
| Brahmin/Chettri | 1.00 | | 1.00 | |
| Dalit | 1.27 (1.08, 1.49) | 0.004 | 1.28 (1.12, 1.46) | 0.001 |
| Janajati | 1.25 (1.08, 1.45) | 0.003 | 1.29 (1.13, 1.47) | <0.001 |
| Others | 1.24 (0.99, 1.54) | 0.058 | 1.11 (0.90, 1.36) | 0.331 |
| Ecological zone | | | | |
| Terai | 1.00 | | 1.00 | |
| Hill | 1.25 (1.03, 1.50) | 0.022 | 1.16 (0.97, 1.41) | 0.130 |
| Mountain | 1.46 (1.25, 1.70) | <0.001 | 1.24 (1.03, 1.49) | 0.026 |
| Household Wealth Index | | | | |
| Poor | 1.00 | | 1.00 | |
| Middle | 1.31 (1.14, 1.50) | <0.001 | 1.27 (1.08, 1.50) | 0.004 |
| Rich | 1.24 (0.99, 1.53) | 0.055 | 1.24 (1.04, 1.54) | 0.037 |
| Carer /household head gender | | | | |
| Male | 1.00 | | 1.00 | |
| Female | 1.13 (1.02, 1.27) | 0.025 | 1.14 (1.02, 1.27) | 0.017 |
| Child consumed dark green leafy vegetables | | | | |
| No | 1.00 | | 1.00 | |
| Yes | 0.86 (0.75, 0.98) | 0.030 | 0.87 (0.77, 0.99) | 0.037 |
| Household Iodine salt use | | | | |
| Ethnicity (Caste) | | | | |
| Brahmin/Chettri | 1.00 | | 1.00 | |
| Dalit | 0.96 (0.81, 1.13) | 0.602 | 0.95 (0.82, 1.11) | 0.535 |
| Janajati | 1.07 (0.94, 1.22) | 0.291 | 1.04 (0.93, 1.16) | 0.468 |
| Others | 0.75 (0.59, 0.95) | 0.019 | 0.68 (0.54, 0.84) | 0.001 |
| Geographical region | | | | |
| Eastern | 1.00 | | 1.00 | |
| Central | 1.00 (0.79, 1.26) | 0.979 | 1.06 (0.89, 1.26) | 0.511 |
| Western | 1.02 (0.75, 1.39) | 0.885 | 1.02 (0.82, 1.26) | 0.859 |
| Mid-western | 0.77 (0.56, 1.05) | 0.092 | 0.80 (0.62, 1.04) | 0.092 |
| Far-western | 0.83 (0.68, 1.01) | 0.06 | 0.81 (0.68, 0.97) | 0.019 |
| Household Wealth Index | | | | |
| Poor | 1.00 | | 1.00 | |
| Middle | 1.04 (0.91, 1.19) | 0.549 | 1.11 (0.99, 1.23) | 0.065 |
| Rich | 1.22 (1.07, 1.39) | 0.004 | 1.19 (1.06, 1.33) | 0.004 |
| Gender of carer/household head | | | | |
| Male | 1.00 | | 1.00 | |
| Female | 1.23 (1.08, 1.42) | 0.002 | 1.23 (1.10, 1.38) | 0.001 |
| Child consumed other meats (Chicken, goat, buffalo, pigs, ducks) | | | | |
| No | 1.00 | | 1.00 | |
| Yes | 1.17 (1.06, 1.29) | 0.003 | 1.07 (1.01, 1.15) | 0.047 |




Note: ppm = mg of iodine per kg of salt.

***Figure 2.*** *Prevalence and 95% confidence intervals of Household salt iodine concentration of children aged 6-9 years.*

The likelihood of households not using iodised salt was significantly lower among children from castes other than the Dalit and Janajati compared with those from the Brahmin/Chettri caste [AOR: 0.68; 95% CI: (0.54, 0.84)]. Children of households from the Far-Western region were significantly more likely to use iodised salt, compared with those of households from the Eastern region [AOR: 0.81; 95% CI: (0.68, 0.97)]. The likelihood of use of iodised salt was significantly higher among children of rich households compared with those of poor households [AOR: 1.19; 95% CI: (1.06, 1.33)]. Children who had female carers were significantly more likely to have iodised salt in their food compared with those who had male carers [AOR: 1.23; 95% CI: (1.10, 1.38)]. Finally, the likelihood of having iodised salt in their food was significantly higher among children who consumed meat compared with those who did not [AOR: 1.07; 95% CI: (1.01, 1.15)].

# 4. Discussion

In this current study, we sought to assess the non-biological factors associated with iodine deficiency and iodised salt use among children aged 6-9 years. Caste, residence in ecological zone, household wealth index, gender of caregiver and consumption of food type were associated with iodine deficiency among the children. Non-biological factors associated with iodised household salt use included caste, administrative region, household wealth index, gender of caregiver and consumption of food type.

Our study revealed that children from castes other than the Dalit and Janajati were positively associated with iodine deficiency. Further, children from the Terai ecological zone were positively associated with iodine deficiency. Our finding is consistent with a finding from a study in Ethiopia, which found mean rates of iodine deficiency disorders to be higher in highlands above 2000 metres than at lower elevations [15]. A World Bank report also reveals that a simple iodine deficiency is prevalent in the eastern part of Senegal [16], which, incidentally is the highest parts of the country [17]. The government of Nepal and other stakeholders should pay more attention to children in the Mountain ecological zone when considering interventions to improve the occurrence of iodine deficiency among children in the country. These findings are not surprising, as iodine deficiency disorder has been found to occur in the world's mountainous and flood plain areas, where iodine has been washed away from soils [18].

We found that children from castes other than the Dalit and Janajati and those from the Eastern region were associated with non-use of household iodised salt. This finding is consistent with findings from a previous research in Indonesia [19] in which the use of iodised salt was lowest in some provinces such as Lombock, Banten, and south Sulawesi. Some of these areas in Nepal may be of low socio-economic status, and may find iodised salt more expensive than non-iodised salt. A recent newspaper article indicated that iodine deficiency has become a major health concern in Dhungachalna, a remote village in Achham district, where most households consume non-iodised salt they come cheaper than a packet of iodised salt. The article went further to note that the "villagers risk their own and their children's health to save a few rupees (Rs)". It revealed that a packet of iodised salt costs up to Rs 40 in this remote part of the district while non-iodised salt is available at Rs 20 per packet [20]. The differences in the use of iodised salt in different areas of a country highlight the fact that there is no uniform distribution of the commodity in Nepal. It is suggested that in situations or areas where iodised cannot be accessed, government and non-governmental organisations (NGOs) should consider making iodine supplements available to deprived areas and/or households. Prices of iodised salt should be made affordable to all populations in Nepal.

The likelihood of iodine deficiency was significantly higher among children who did not consume dark green leafy vegetables compared with those who did. Also, children who did not consume meat were found to be positively associated with non-use of household iodised salt. The association of consumption of vegetables and iodine deficiency is lacking in the extant literature. However, a past study indicated that the iodine content of foods from plants varied according to the species [21]. According to this study, most nutrient components of plants such as fruits and vegetables had low iodine content except herbs, leafy and nightshade vegetables.

A major strength of our study is its use of data from the NNMSS, which is nationally representative, and therefore results of the study can be generalised to the whole Nepal. The study is limited, however, in a number of ways. Some of the limitations are: 1) causation between independent and dependent variables could not be established due to the cross-sectional design of the study 2) Although the data used were nationally representative our study captured less than 300 participants.

# 5. Conclusion

In this study, factors that influence iodine deficiency among Nepalese children were identified, as well as factors associated with household iodised salt use among those children. Despite celebrating February as IDD month, the government of Nepal and other stakeholders should step up efforts to strengthen the production of iodised salt, monitor and ensure that iodised salt is readily affordable, especially in deprived areas such as the Mountain ecological zone. There should also be increased awareness of the need to consume iodised salt in households. As this study showed that children from Dalit and Janajati castes and those from the Eastern region were associated with non-use of household iodised salt, a best approach would be social mobilization to convince them to use daily iodized salt in the regular family meal to reach high-risk populations like Dalit and Janjati and those who live in remote areas in Nepal.

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