SUMMARY AND CONCLUSION

Introduction:

The entire state of Uttarakhand in India is a known iodine endemic state for more than 6 decades. A significant progress has been made in the control of Iodine Deficiency Disorder through supply of Iodised salt. The pregnant mothers, neonates, school age children (6-12 years) and adolescent girls are the most vulnerable groups as they are especially sensitive to even marginal iodine deficiency. There was lack of data available on affects of iodine deficiency on these 4 vulnerable groups from Uttarakhand state. Hence, the study was conducted to assess the iodine status amongst pregnant mothers, neonates, school age children (6-12 years) and adolescent girls in three regions of Uttarakhand state, utilizing indicators recommended by WHO (2007). Moreover, we do not have data on the environmental influences (iodine content in water and food samples) on iodine deficiency from Uttarakhand state. Thus to fill the gap in the existing knowledge the present study was conducted with the following objectives:

Objectives of the Study:

1. Assessment of iodine nutritional status amongst pregnant mothers, neonates, school age children (6-12 years) and adolescent girls in the selected 3 districts namely Udham Singh Nagar, Nainital and Pauri Garhwal, in three regions of Uttarakhand namely: i) Terain (Plain) ii) Kumaon and iii) Garhwal
2. Assessment of Iodine content of salt consumed by the population in the selected 3 districts namely Nainital, Udham Singh Nagar and Pauri Garhwal, in three regions of Uttarakhand namely: i) Kumaon, ii) Terain (Plain) and iii) Garhwal.
3. To assess Environmental influences; iodine content in water and food samples of Uttarakhand state

Methodology:

Three districts, namely: Udham Singh Nagar, Nainital and Pauri Garhwal were selected. In each district, thirty clusters (schools/villages) were identified by utilizing the population-proportional-to-size cluster sampling methodology. Total of 1727 Pregnant Mothers (Udham Singh Nagar; 632, Nainital; 614, Pauri Garhwal: 481), 2013 Neonates (Udham Singh Nagar; 649, Nainital; 670, Pauri Garhwal: 694), 6143 School Age Children (Udham Singh Nagar; 1807, Nainital; 2269, Pauri Garhwal: 2067) and 5430 Adolescent Girls (Udham Singh Nagar; 1823, Nainital; 1811, Pauri Garhwal: 1796), were included in the study. Clinical examination of thyroid of each pregnant mother, school age children and adolescent girl was conducted. Spot urine and salt samples were collected from pregnant mother, school age children and adolescent girl. Cord blood samples were collected on filter paper for estimation of Thyroid Stimulating Hormone amongst neonates and venous blood sample was collected on filter paper for confirmation of neonatal hypothyroidism. For Environmental Influences: A total of 90 water samples (30 from each district) and 45 food samples i.e cereals and pulses (15 from each district) were collected for iodine content in water and food samples from each of the district.

Summary of the findings:

Part 1: Iodine Nutritional Status amongst Pregnant Mothers

1. Total Goiter Rate:

- According to WHO, 2007; TGR of ≥5% indicates iodine deficiency in the population studied and further signal the public health problem.
- In the present part on pregnant mothers, higher TGR was found in district Pauri Garhwal (24.9%), followed by district Nainital (20.2%) and Udham Singh Nagar (16.1%), respectively, indicating mild iodine deficiency in district Udham Singh Nagar and moderate iodine deficiency in districts Nainital and Pauri Garhwal.
- Moreover, higher prevalence of ID according to TGR was observed in Hilly terrain (Nainital and Pauri Garhwal) than plain area (Udham Singh Nagar).

- **According to different Age groups:** TGR amongst pregnant mothers was found to be more in the age group of 18-25 years than ≥26 years in all the three districts. Combining all the three districts there was a statistical significant difference in the TGR and age groups of pregnant mothers studied.
- **According to Trimester of pregnancy:** There was no statistical difference in the trimester of pregnancy and TGR. Moreover no trend was observed between TGR and different trimester of pregnancy.

2. Urinary iodine concentration level

- WHO (2007), median UIC level of <150µg/L amongst pregnant mothers indicates iodine deficiency in the population studied.
- Further WHO (2007) also states that UIC level of >150µg/L among Pregnant mothers defines a population with no iodine deficiency i.e at least 50% of the samples should be above 150µg/L.
- In the present part on pregnant mothers, median UIC level was found to be 124µg/L (Udham Singh Nagar), 117.5µg/L (Nainital) and 110µg/L (Pauri Garhwal), respectively indicating biochemical deficiency of iodine amongst pregnant mothers studied.
- It was also found that 54.3% (Udham Singh Nagar), 57.7% (Nainital) and 61.8% (Pauri Garhwal) of the subjects studied had UIC level of <150 µg/L further indicating deficiency of iodine in the subjects studied.
- Similarly it was found that TGR was higher amongst pregnant mothers of hilly terrain (Nainital and Pauri Garhwal) compared to plain area (Udham Singh Nagar). Thus indicating that amongst pregnant mothers studied higher prevalence was found in districts Pauri Garhwal and Nainital compared to district Udham Singh Nagar as depicted by TGR and UIC levels.
- **UIC level with age:** It was found that with increasing age the median UIC level also increases. Median UIC level was lesser in the pregnant mothers in the age group of 18-24 years, compared to pregnant mothers in the age group of 26 and above. Similarly TGR also reported the same trend.

Comparing it with district wise, it was found that iodine deficiency was found to be more in the hilly terrain (Nainital and Pauri Garhwal) compared to plain area (Udham Singh Nagar) of Uttarakhand state as estimated by Total goiter rate and Urinary iodine concentration levels.

- **UIC level trimester wise:** In district Udham Singh Nagar: a rise from the first trimester to the second trimester, followed by a fall in the third trimester. In districts Nainital and Pauri Garhwal: the median UIC level was decreasing with increase in trimester of pregnancy. Also combining all the three districts a decreasing trend of median UIC level with increasing trimester was found. Moreover, when comparing district wise high iodine deficiency was observed in hilly terrain (Nainital and Pauri Garhwal) compared to plain area (Udham Singh Nagar).

3. Iodized Salt Intake

- National goal of iodized salt coverage is more than 90%, but in our present study none of the districts were consuming salt with iodine content of ≥15ppm in more than 90 percent of the population.
- It was found that higher percentage of families 49.7% (Udham Singh Nagar), 42.1% (Pauri Garhwal) and 33.0% (Nainital) were consuming salt with iodine intake of less than 15ppm.
- Comparing it with the other studies conducted in Uttarakhand state, there is a decline in consumption of iodine salt in Uttarakhand state. NFHS surveys also reported that the consumption of iodized salt has declined over the past few years, from NFHS-2 to NFHS-3 survey. Our study also reported similar findings.
- **Iodized salt Intake in different age groups:** combining all the three districts studied, higher percentage of pregnant mothers in the age group of 18-25years were consuming inadequately iodized salt (<15ppm) compared to pregnant mothers of 26 years and above. Though the difference between the age groups and iodized salt consumption was statistically non significant.

4. It was also found that the median UIC level of pregnant mothers when combining all the three districts studied was lower in the age group of 18-25 years compared to pregnant mothers of 26 years and above. Likewise the consumption of adequately iodized salt (≥15ppm) was higher in the age group of 26 years and above compared to pregnant mothers of 18-25 years.

5. Iodized salt intake in different trimesters of pregnancy: It was found that the higher percentage of pregnant mothers in the 2nd trimester of pregnancy were consuming adequately iodized salt (≥15ppm) compared to other two trimesters in all the three districts. Moreover, when combining all the three districts also higher percentage of pregnant mothers in the 2nd trimester of pregnancy were consuming adequately iodized salt compared to other two districts.

6. It was found that there was no statistical significant difference in the trimesters of pregnancy and iodized salt intake level in all the three districts studied. However, when combining all the three districts, there was a statistical significant difference in the iodized salt intake in different trimesters of pregnancy.

7. Thus, when comparing with the different age groups in all the three districts, the higher prevalence of iodine deficiency according to the TGR and median UIC level was found in the age group of 18-25 years compared to 26 years and above. Combining all the three districts similar trend was observed. Higher prevalence was observed in the age group of 18-25 years compared to pregnant mothers of 26 years and above.

8. Further it was found that the pregnant mothers in the age group of 18-25 years were consuming higher percentage of inadequately iodized salt (<15ppm) as compared to pregnant mothers of 26 years and above in district Udham Singh Nagar and Nainital. Whereas, in district Pauri Garhwal higher percentage of pregnant mothers in the age group of 26 years and above were consuming inadequately iodized salt compared to pregnant mothers of 18-25 years.

9. It was found that the higher pregnant mothers consuming inadequately iodized salt (<15ppm) had low urinary iodine concentration level compared to pregnant mothers were consuming adequately iodized salt. A statistical

significant difference between the salt intake and UIC levels was observed in district Udham Singh Nagar and Nainital. However, no statistical significant difference between the salt intake and UIC levels was observed in district Pauri Garhwal. Moreover, when combining all the three districts there was a statistical significant difference between the iodized salt intake levels and UIC levels of the pregnant mothers studied indicating that iodized salt intake affects the UIC levels of the pregnant mothers.

10. According to TGR and median UIC level higher iodine deficiency was observed in hilly terrains (Pauri Garhwal; 5951 ft above sea and Nainital; 6837 ft above sea level) compared to plain areas (Udham Singh Nagar; 1129 ft above sea level) of Uttarakhand state.

11. Findings of our study indicates that the pregnant mothers in all the three districts of Uttarakhand are iodine deficient as indicated by low median UIC levels and lower consumption of adequately iodized salt. Thus, there is a need for revitalizing the National IDD control program to ensure supply of salt with adequate iodine content of 15 ppm and more to achieve elimination of IDD in Uttarakhand state. Since, most vulnerable group for ID for health consequences is the fetus and hence the assessment of ID status of the Pregnant mothers should be included in the monitoring of IDD control program.

Part 2: Iodine Nutritional Status amongst Neonates

1. Thyroid Stimulating Hormone :

- According to WHO (2007), >3% frequency of TSH concentrations above 5mIU/L indicates iodine deficiency in a population (WHO, 2007).
- In the present study, 55.3 (Udham Singh Nagar), 76.4 (Nainital) and 72.8 (Pauri Garhwal) percent of neonates were found with TSH levels of more than 5mlU/l indicating presence of iodine deficiency in all the three districts. This could be possibly due to higher percentage of pregnant mothers (results of Part 1) were consuming salt with iodine content of less than 15ppm.

- Comparing between the three districts, higher prevalence was reported from district Nainital and Pauri Garhwal which is at higher altitude compared to Udham Singh Nagar which is a plain area. Thus higher the altitude of the district higher is the prevalence of iodine deficiency amongst neonates could be observed.

2. Effect of other factors on TSH levels of the neonates

i. Effect of gestational age on TSH levels

- In **district Udham singh Nagar**, It was found that, 42.5% (<37weeks) and 12.9% (37-<42 weeks) neonates had TSH level of >5µIU/L. Whereas, in **district Nainital**: 43.0% (<37weeks), 33.1% (37-<42 weeks) and 0.3% (>42 weeks) neonates had TSH level of >5µIU/L. Similarly in **district Pauri Garhwal**, 21.5% (<37 weeks) and 51.4% (37-<42 weeks) neonates had TSH level of >5µIU/L. In districts Udham Singh Nagar and Nainital, higher percentage of neonates with TSH level of >5µIU/L was preterm. But in district Pauri Garhwal higher percentage of neonates with TSH level >5µIU/L were term.
- No statistical significant difference in the TSH levels and gestational age were found in districts Udham Singh Nagar (p=0.223) and Nainital (p=0.092). Whereas, a statistical significant difference was found in district Pauri Garhwal (p=0.001).
- Combining all the three districts surveyed, a statistical significant difference was observed between the TSH levels and gestational age (p=0.001).

ii. Effect of Gender on TSH levels

- 57.2% (males) and 53.3% (females) from district Udham Singh Nagar had TSH levels of more than 5µIU/L. Similarly from district Nainital, 76.7% (males) and 76.2% (females) and from district Pauri Garhwal, 73.1% (males) and 72.7% (females) had TSH levels of more than 5µIU/L.
- Higher percentage of males had TSH levels >5µIU/L compared to females in all the three districts studied.

- But there was no statistical significant difference between the TSH levels and gender in districts Udham Singh Nagar (p=0.548), Nainital (p=0.692) and Pauri Garhwal (p=0.913).
- Combining all the three districts, no significant difference was observed in the TSH levels and gender (p=0.906).

iii. Effect of Birth Weight on TSH levels

- 3 neonates with TSH >5µIU/L had very low birth weight (<1.5kg). One hundred and fourteen neonates with TSH >5µIU/L had low birth (<2.5kg), 1295 neonates with TSH >5µIU/L had normal birth weight.
- No significant difference was found in the TSH levels and birth weight in districts Udham Singh Nagar (p=0.152) and Pauri Garhwal (p=0.965). Whereas, a statistical significant difference was found in district Nainital (p=0.001).
- Combining all the three districts studied, a statistical significant difference was observed between the TSH levels and birth weight (p=0.001).

3. Neonatal Hypothyroidism

- Out of the 12 (Udham Singh Nagar), 20 (Nainital) and 35 (Pauri Garhwal) samples collected for repeat TSH level estimation, only 2 (Nainital) samples had TSH levels of 10mlU/L and higher and were diagnosed to be suffering from Neonatal hypothyroidism.
- The prevalence of neonatal hypothyroidism was found to be 0.3% in Nainital district. However, no single case of neonatal hypothyroidism was found from districts Udham Singh Nagar and Pauri Garhwal.

4. Findings of our study indicate that the neonates in all the three districts of Uttarakhand were iodine deficient as indicated by higher TSH levels at screening.

5. Thus, there is a need for revitalizing the National IDD control program to ensure supply of salt with adequate iodine content of 15 ppm and more to achieve elimination of IDD in Uttarakhand state.

6. Since, most vulnerable group for ID for health consequences is the fetus and hence the assessment of ID status of the pregnant mothers should also be included in the monitoring of IDD control program.
7. There is an urgent need of initiating a neonatal screening program for assessment of neonatal hypothyroidism and also for early detection of children with iodine deficiency.

Part 3: Iodine Nutritional Status amongst School age Children

1. Total Goitre Rate:

- TGR: The TGR was found to be 13.2% (Udham Singh Nagar), 15.9% (Nainital) and 16.8% (Pauri Garhwal), respectively indicating mild iodine deficiency in the subjects studied.
- This higher TGR in Pauri Garhwal (5951 ft above sea level) and Nainital district (6837 ft above sea level) compared with Udham Singh Nagar (1129 ft above sea level) is due to difference in hilly and plain terrain district.
- Combining all the three districts the prevalence of TGR was found to be 15.4% in Uttarakhand state indicating mild iodine deficiency in the population studied.
- **According to Gender:** Higher TGR was observed in males as compared to females of districts Nainital and Pauri Garhwal. Whereas, same TGR was observed in both male and female of district Udham Singh Nagar. The overall, prevalence of TGR in males were higher compared to females in three districts of Uttarakhand state. The difference in the TGR and gender is statistically insignificant in all the three districts. It was also found that hilly terrain (Nainital and Pauri Garhwal) had higher prevalence of TGR compared to plain area (Udham Singh Nagar) of Uttarakhand state.
- **According to different age groups:** Comparing with the age group it was found that as the age of the child increases the TGR also increases. There was an increasing trend of TGR with the different age groups studied. There was a statistical significant difference in the TGR with different age

groups in districts Udham Singh Nagar (p=0.016), Nainital (p=0.001) and Pauri Garhwal (p=0.001).

- Combining all the three districts, it was found that as the age of the children increases the TGR also increases. A statistical significant difference (p=0.001) was found between the TGR and age of the children. This increase in TGR in higher age group could be due to increasing demands of thyroid hormones during puberty.
- Comparing between the districts higher TGR in all the age groups was observed in hilly terrain (Nainital and Pauri Garhwal) compared to plain area (Udham Singh Nagar).

2. Urinary iodine concentration level

- According to WHO (2007), median UIC level of <100µg/L amongst school age children indicates iodine deficiency in the population studied.
- Further WHO (2007) also states that UIC level of >100µg/L among school age children defines a population with no iodine deficiency i.e at least 50% of the samples should be above 100µg/L.
- In the present study on school age children, median UIC level was found to be 150µg/L (Udham Singh Nagar), 125µg/L (Nainital) and 115µg/L (Pauri Garhwal), respectively indicating no biochemical deficiency of iodine in the subjects studied.
- It was also found that 72.7% (Udham Singh Nagar), 63.3% (Nainital) and 57.5% (Pauri Garhwal) of the subjects studied had UIC level of >100µg/L further indicating no biochemical deficiency of iodine.
- **According to gender:** it was found that higher percentage of females had UIC level of <100µg/L compared to males.
- **According to different age groups:** it was found that there was no association of age with UIC levels. No trend of UIC level with age was observed.

3. Iodized Salt Intake

- National goal of iodized salt coverage is more than 90%, but in our present study none of the districts were consuming salt with iodine content of >15ppm in more than 90 percent of the population.
- It was found that higher percentage of families 59.6% (Pauri Garhwal), 53.3% (Udham Singh Nagar) and 42.3% (Nainital) were consuming salt with iodine intake of less than 15ppm.
- **According to gender:** There was no significant difference of salt intake with gender in districts Udham Singh Nagar (p=0.166), Nainital (n=0.846) and Pauri Garhwal (p=0.884).
- **According to age groups:** There was no significant difference of salt intake with different age groups in all the three districts. Moreover, combining all the three districts there was no statistical significant difference of salt intake with different age groups.
- Comparing it with the other studies conducted in Uttarakhand state, there is a decline in consumption of adequately iodized salt in Uttarakhand state. NFHS surveys also reported that the consumption of iodized salt has declined over the past few years, from NFHS-2 to NFHS-3 survey. Our study also reported similar findings.

4. According to TGR and median UIC level higher iodine deficiency was observed in hilly terrains (Pauri Garhwal; 5951 ft above sea and Nainital; 6837 ft above sea level) compared to plain areas (Udham Singh Nagar; 1129 ft above sea level) of Uttarakhand state.

5. Thus UIC level indicates the current iodine status and TGR indicates past chronic iodine status. Thus in the present study, UIC levels were adequate and TGR was more than 5%, indicating that the three districts in Uttarakhand are in the transition phase from iodine insufficiency (as revealed by TGR) to iodine sufficient nutriture (as revealed by median UIC levels).

Part 4: Iodine Nutritional Status amongst adolescent girls

1. Total Goiter Rate:

- According to WHO, 2007; TGR of ≥5% indicates iodine deficiency in the population studied.
- In the present study on adolescent girls, higher TGR was found in district Nainital (8.2%) followed by district Udham Singh Nagar (6.8%) and Pauri Garhwal (5.6%), respectively indicating mild iodine deficiency in all the three districts.
- It was found that the TGR of the adolescent girls increases till the age of 14-15 years and then further decline for 16-18 years.

2. Urinary iodine concentration level

- According to WHO (2007), median UIC level of <100µg/L amongst adolescent girls indicates iodine deficiency in the population studied.
- Further WHO (2007) also states that UIC level of >100µg/L among adolescent girls defines a population with no iodine deficiency i.e at least 50% of the samples should be above 100µg/L.
- In the present study on adolescent girls, median UIC level was found to be 250µg/L (Udham Singh Nagar), 200µg/L (Nainital) and 183µg/L (Pauri Garhwal), respectively indicating no biochemical deficiency of iodine in the subjects studied.
- UIC level with age: it was found that there was no association of age with UIC levels. With increasing age, UIC level doesn't increases or decreases.
- **In district Udham Singh Nagar:** It was also found that adolescent girls who were consuming salt with iodine intake ≥15ppm and <15ppm had median UIC level of 264µg/l and 226µg/l, respectively. **In district Nainital:** It was also found that adolescent girls who were consuming salt with iodine intake ≥15ppm and <15ppm had median UIC level of 200µg/l and 200µg/l, respectively. **In district Pauri Garhwal**: It was also found that adolescent girls who were consuming salt with iodine intake ≥15ppm and <15ppm had median UIC level of 200µg/l and 180µg/l, respectively.

3. Iodized Salt Intake

- National goal of iodized salt coverage is more than 90%, but in our present study none of the districts were consuming salt with iodine content of >15ppm in more than 90 percent of the population.
- It was found that higher percentage of families 59.5% (Udham Singh Nagar), 46.7% (Pauri Garhwal) and 44.0% (Nainital) were consuming salt with iodine intake of less than 15ppm.

4. The UIC level indicates the current iodine status and TGR indicates past chronic iodine status. Thus in the present study on adolescent girls, UIC levels were adequate and TGR was more than 5%, indicating that the three districts in Uttarakhand are in the transition phase from iodine insufficiency to iodine sufficiency.

5. The median UIC level is 200µg/L which is sufficient for this age group however, if these Adolescent girls enter pregnancy wherein the requirement is >150µg/L, these girls are likely to be iodine deficient as the pregnancy progresses which is also seen in our earlier results of Part 1.

6. Findings of the present study documented the successful implementation of national IDD control programme under which iodized salt is supplied to all three districts of Uttarakhand. There is a need of sustaining the efforts of universal salt iodization, so that the Adolescent girls have adequate iodine content in their diet. And they enter reproductive stage with sufficient iodine nutriture.

Part 5: Environmental Influences (Food and Water Samples)

1. Iodine content of water

The mean iodine content in water samples were 5.0µg/l (Udham Singh Nagar), 1.0µg/l (Nainital) and 3.5µg/l (Pauri Garhwal), respectively.

2. Iodine content in Food

The food samples analysed for iodine content were cereals and pulses locally grown in these districts of Uttarakhand.

The iodine content in foods of district Udham Singh Nagar ranges from: 3.1 µg per 100g (Rice) to 8.0 µg per 100g (Horse gram). Whereas the food samples of district Nainital and Pauri Garhwal ranges from 3.7(Rice) to 7.2(Black Soyabean) and 1.1 µg per 100g(Barley) to 8.3 µg per 100g (Baryard Millet).

The pooled mean of iodine content of food samples was 5.31±1.01µg per 100g (Udham Singh Nagar), 4.86±1.09µg per 100g (Nainital) and 4.46±1.62µg per 100g (Pauri Garhwal), respectively.

All the foods analyzed showed that the area is highly deficient in iodine with 100% of the foods falling below 10µg/100g sample.

CONCLUSION

Low median urinary iodine concentration level (<150µg/l) in pregnant mothers and high percentage of neonates with TSH level of >5mIU/L indicates iodine deficiency in all three districts studied. The school age children and adolescent girls were in a transition phase from iodine deficiency (as revealed by TGR) to iodine sufficiency (as revealed by median UIC level) in all the three districts of Uttarakhand state, India. Thus, there is a need for revitalizing the National IDD control program to ensure supply of salt with adequate iodine content of 15 ppm and more to achieve elimination of IDD in Uttarakhand state. Since, most vulnerable group for ID for health consequences is the fetus and hence the assessment of ID status of the Pregnant mothers should be included in the monitoring of IDD control program. Moreover, there is an urgent need of initiating a neonatal screening program for assessment of neonatal hypothyroidism and also for early detection of children with iodine deficiency.