RESULTS AND DISCUSSION

The results and discussion chapter is divided into 5 parts:

Part 1: Iodine Nutritional status amongst Pregnant Mothers

Part 2: Iodine Nutritional status amongst Neonates

Part 3: Iodine Nutritional status amongst School age Children (6-12 years)

Part 4: Iodine Nutritional status amongst Adolescent Girls (12-18years)

Part 5: Environmental Factors (Iodine Content in Water and Food samples)

4.1 PART 1: IODINE NUTRITIONAL STATUS AMONGST PREGNANT MOTHERS

This part is further divided into following sections:

General Characteristics of pregnant mothers enrolled in the study

Clinical Examination: Thyroid Size of pregnant mothers enrolled in the study

- **Prevalence of goiter as per clinical examination of thyroid size**
- **Age wise prevalence of TGR**
- **Trimester wise prevalence of TGR**
- **Cluster wise prevalence of TGR**

Biochemical Estimation of pregnant mothers enrolled in the study

- **Iodine deficiency status as per urinary iodine concentration level**
- **Iodine deficiency status as per urinary iodine concentration level in different age groups**
- **Iodine deficiency status as per urinary iodine concentration level in different trimesters**

Iodine content of salt amongst the household of pregnant mothers enrolled in the study

- **Iodized salt intake**
- **Iodized salt intake in different age groups**
- **Iodized salt intake in different trimesters**

Comparison of prevalence of iodine deficiency disorder based on TGR, UIC levels and iodized salt intake of pregnant mothers enrolled in the study

- **Prevalence of IDD based on TGR, UIC and salt in different age groups**
- **Prevalence of IDD based on TGR, UIC and salt in different trimesters**
- **Relationship between Goiter grade and UIC levels of pregnant mothers**
- **Relationship between Iodized salt intake and UIC levels of pregnant mothers**

Block wise prevalence of IDD of pregnant mothers based on TGR, UIC levels and iodized salt intake

RESULTS

4.1.1 General characteristics of pregnant mothers enrolled in the study

The distribution of pregnant mothers according to thirty clusters studied is depicted in **Table 13**.

The state of Uttarakhand has 13 districts (Dehradun, Uttarkashi, Chamoli, Pauri Garhwal, Tehri Garhwal, Rudraprayag, Haridwar, Almora, Pithoragarh, Nainital, Bageshwar, Champawat and Udham Singh Nagar) which are distributed in three 3 administrative and geographical regions namely i) Kumaon ii) Terai (Plain) and iii) Garhwal. One district was selected from each region i.e. Nainital, Udham Singh Nagar and Pauri Garhwal.

District Udham Singh Nagar is a plain area and is situated at an altitude of 1129ft above sea level. Whereas, districts Nainital and Pauri Garhwal is a hilly terrain and is situated at an altitude of 6837ft and 5951ft above sea level, respectively.

From district Udham Singh Nagar, seven blocks were selected, whereas from districts Nainital and Pauri Garhwal, eight and fourteen blocks were selected. Further categorization of pregnant mothers according to clusters selected is depicted in **Table 13**.

The pregnant mothers were selected by adopting two stage sampling technique. In each district, first 30 clusters (Villages) were identified by utilizing PPS methodology as recommended by WHO/UNICEF/ICCIDD. In the second stage, in each cluster (village), minimum of sixteen pregnant mothers who were attending the antenatal clinics were included.

Thus a total of 632 (Udham Singh Nagar), 614 (Nainital) and 481 (Pauri Garhwal) pregnant mothers were selected for the present study.

In district Nainital thirty one clusters were selected because the sample size could not be covered from thirty clusters.

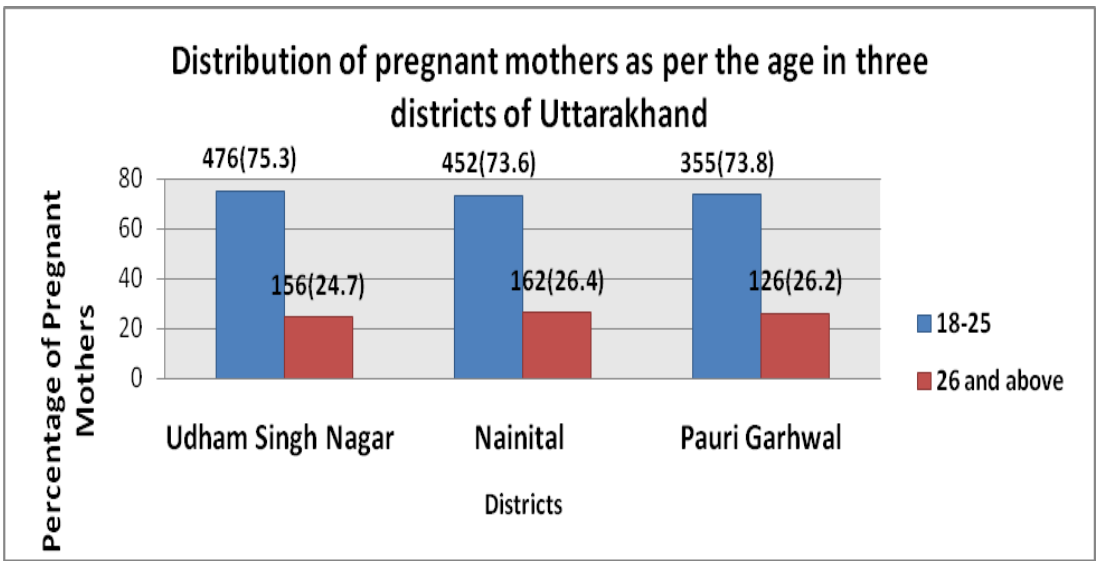
Table 13: Distribution of pregnant mothers according to clusters studied in three districts of Uttarakhand

	Udham Singh Nagar (N=632)		Nainital (N=614)		Pauri Garhwal (N=481)	
Cluster Numbers	**Name of the Blocks Surveyed**	**Pregnant Mothers Covered**	**Name of the Blocks Surveyed**	**Pregnant Mothers Covered**	**Name of the Blocks Surveyed**	**Pregnant Mothers Covered**
1	Khatima I	17	Betalghat I	17	Bironkhal I	17
2	Khatima II	34	Betalghat II	14	Bironkhal II	14
3	Khatima III	17	Bhimtal I	17	Bironkhal III	17
4	Sitarganj I	21	Bhimtal II	18	Duggada I	17
5	Sitarganj II	15	Dhari I	16	Duggada II	20
6	Sitarganj III	25	Dhari II	18	Duggada III	15
7	Sitarganj IV	23	Haldwani I	23	Dwarikhal I	15
8	Sitarganj V	27	Haldwani II	19	Dwarikhal II	15
9	Rudrapur I	26	Haldwani III	20	Ekeshwar	16
10	Rudrapur II	18	Haldwani IV	19	Jarikhal I	15
11	Rudrapur III	32	Haldwani V	35	Jarikhal II	15
12	Rudrapur IV	21	Haldwani VI	17	Pauri	16
13	Rudrapur V	18	Haldwani VII	17	Khirsu	14
14	Rudrapur VI	21	HaldwaniVII I	21	Kot	16
15	Gadarpur I	28	Haldwani IX	22	Nani danga I	15
16	Gadarpur II	12	Haldwani X	26	Nani danga II	16
17	Gadarpur III	15	Kotabagh I	20	Pabau I	16
18	Gadarpur IV	28	Kotabagh II	20	Pabau II	17
19	Bazpur I	19	Okhalkanda I	17	Pauri I	16
20	Bazpur II	21	Okhalkanda II	15	Pauri II	15
21	Bazpur III	15	Okhalkanda III	16	Dokhra	15
22	Bazpur IV	18	Okhalkanda IV	15	Rikhnikhal I	16
23	Bazpur V	17	Ramgarh I	17	Rikhnikhal II	14
24	Kashipur I	17	Ramgarh II	19	Thalisain I	18
25	Kashipur II	21	Ramnagar I	16	Thalisain II	17
26	Kashipur III	22	Ramnagar II	25	Thalisain III	17
27	Jaspur I	32	Ramnagar III	25	Thalisain IV	16
28	Jaspur II	15	Ramnagar IV	20	Yamkeshwar I	17
29	Jaspur III	25	Ramnagar V	24	Yamkeshwar II	17
30	Jaspur IV	12	Ramnagar VI	17	Yamkeshwar III	17
31			Bhimtal	29		
Total		**632**		**614**		**481**

4.1.1.1 Distribution of pregnant mothers as per the age groups

The distribution of pregnant mothers according to the different age groups is depicted in **Figure 21**. It was found that in all the three districts studied maximum number of pregnant mothers were in the age group of 18-25 years than 26 years and above. Thus it could be said that maximum number of pregnant mothers fall in the age group of 18-25 years in Uttarakhand state.

Figure 21: Distribution of pregnant mothers as per the different age groups in three districts of Uttarakhand



4.1.1.2 Distribution of pregnant mothers as per different trimesters of pregnancy

The distribution of pregnant mothers as per different trimesters of pregnancy is depicted in **Table 14**. It was found that in all the three districts studied the maximum number of pregnant mothers enrolled were in second trimester followed by third and then first trimester of pregnancy.

Table 14: Distribution of pregnant mothers as per different trimester of pregnancy in all the three districts of Uttarakhand

Duration of Pregnancy	**Udham Singh Nagar (N=632)**	**Nainital (N=614)**	**Pauri Garhwal (N=481)**
	n (%)	**n (%)**	**n (%)**
First Trimester (0-12 weeks)	78(12.3)	37(6.0)	25(5.2)
Second Trimester (13 to <28 weeks)	309(48.9)	344(56.1)	269(55.9)
Third Trimester (28 and above weeks)	245(38.8)	233(37.9)	187(38.9)
Total	**632**	**614**	**481**

Figures in parentheses denotes percentage

4.1.2 Clinical Examination: Thyroid Size of pregnant mothers enrolled in the study

4.1.2.1 Prevalence of goiter as per clinical examination of thyroid size

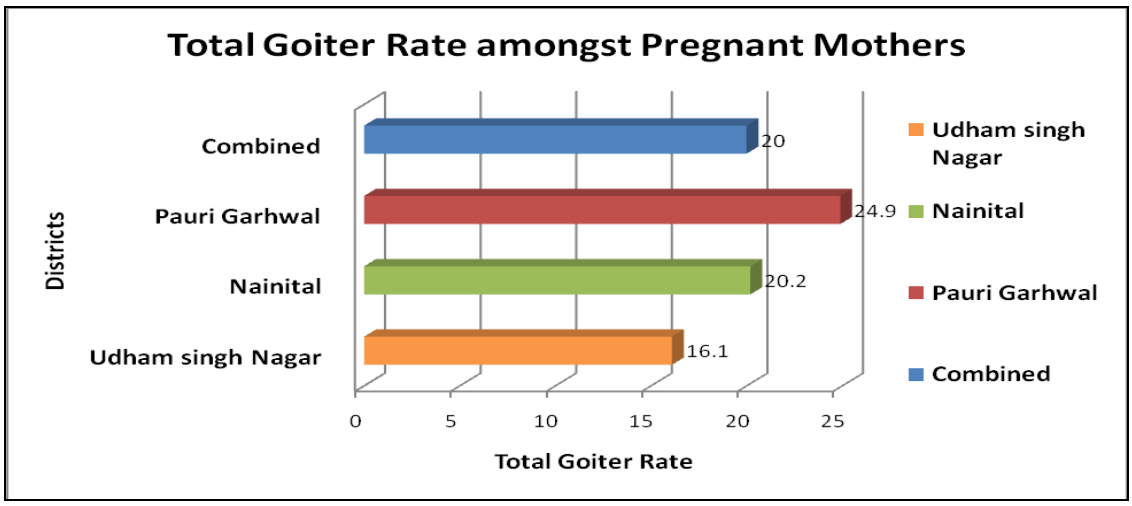
Prevalence of goiter as per clinical examination of thyroid size is depicted in **Table 15 and Figure 22**. The TGR was found to be 16.1% (Udham Singh Nagar), 20.2% (Nainital) and 24.9% (Pauri Garhwal), respectively indicating presence of mild iodine deficiency in district Udham Singh Nagar and moderate iodine deficiency in districts Nainital and Pauri Garhwal. Higher prevalence of iodine deficiency according to the TGR was found in districts Pauri Garhwal and Nainital followed by Udham Singh Nagar. Thus, it could be said that higher prevalence of iodine deficiency according to TGR was found in hilly terrain (Nainital and Pauri Garhwal) compared to plain area(Udham Singh Nagar). Whereas, the overall prevalence of goiter rate combining all the three districts was found to be 20.0% indicating presence of moderate iodine deficiency in Uttarakhand state. Moreover, according to WHO (2007), TGR of ≥5% indicates iodine deficiency in the population studied and signal the presence of a public health problem.

Table 15: Prevalence of goiter in all the three districts of Uttarakhand

	Udham Singh Nagar (N=632)	**Nainital (N=614)**	**Pauri Garhwal (N=481)**	**Combined (all the three districts) (N=1727)**
Goiter Grade	**n (%)**	**n (%)**	**n (%)**	**n(%)**
0	530 (83.9)	490 (79.8)	361(75.1)	1381(80.0)
I	96 (15.2)	121(19.7)	118(24.5)	335(19.4)
II	6 (0.9)	3 (0.5)	2 (0.4)	11(0.6)
Total Goiter Rate (Grade I+ Grade II)	**102 (16.1)** ↑	**124 (20.2)** ↑	**120 (24.9)** ↑	**346(20.0)** ↑

Figures in parentheses denotes percentage
WHO, 2007: TGR ≥5%: Iodine deficiency; TGR: 5.0-19.9% (Mild Iodine deficiency), 20-29.9% (Moderate) and >30% (Severe)

Figure 22: Total Goiter Rate amongst Pregnant Mothers



WHO, 2007: TGR ≥5%: Iodine deficiency; TGR: 5.0-19.9% (Mild Iodine deficiency), 20-29.9% (Moderate) and >30% (Severe)

4.1.2.2 Age wise prevalence of TGR

The age wise prevalence of TGR amongst pregnant mothers of three districts is depicted in **Table 16**.

It was found that TGR amongst pregnant mothers was found to be more in the age group of 18-25 years than ≥26 years. There was a decreasing trend of TGR with increasing age. However, no statistical significant difference was found between TGR and different age groups of the pregnant mothers studied in districts Udham Singh Nagar (p=0.109), Nainital (p=0.183). Whereas in district Pauri Garhwal a significant difference was found between age groups of the pregnant mothers and TGR (p=0.043). Comparing the three districts studied, higher prevalence was found to be in district Pauri Garhwal amongst pregnant mothers of both the age groups, followed by district Nainital and Udham Singh Nagar. When combining all the three districts higher prevalence was found to be amongst pregnant mothers in the age group of 18-25 years than ≥26 years. A statistical significant difference was found between TGR and age groups of the pregnant mothers studied (p=0.009).

Table 16: Prevalence of goiter as per age groups of pregnant mothers in three districts of Uttarakhand

Age groups (yrs)	Goiter Grade			Total Goiter Rate (Goiter Grade I + II)
	Udham Singh Nagar (N=632)			
	Goiter Grade 0 (n=530)	Goiter Grade I(n=96)	Goiter Grade II(n=6)	
18-25 (n=476)	391 (82.1)	81 (17.0)	4(0.9)	85(17.9) ↑
26 and above (n=156)	139(89.1)	15(9.6)	2(1.3)	17(10.9) ↑
p-value	0.102 NS			0.109 NS
	Nainital (N=614)			
	Goiter Grade 0 (n=490)	Goiter Grade I(n=121)	Goiter Grade II(n=3)	
18-25 (n=452)	353(78.1)	97(21.5)	2(0.4)	99(21.9) ↑
26 and above (n=162)	137(84.6)	24(14.8)	1(0.6)	25(15.4) ↑
p-value	0.452 NS			0.183 NS
	Pauri Garhwal (N=481)			
	Goiter Grade 0 (n=361)	Goiter Grade I(n=118)	Goiter Grade II(n=2)	
18-25 (n=355)	258(72.7)	95(26.8)	2(0.5)	97(27.3) ↑
26 and above (n=126)	103(81.7)	23(18.2)	0	23(18.2) ↑
p-value	0.107 NS			0.043*
	Combined (all the three districts) (N=1727)			
	Goiter Grade 0 (n=1381)	Goiter Grade I(n=335)	Goiter Grade II(n=11)	
18-25 (n=1283)	1002(78.1)	273(21.3)	8(0.6)	281(21.9) ↑
26 and above (n=444)	379(85.3)	62(14.0)	3(0.7)	65(14.7) ↑
p-value	0.065 NS			0.009**

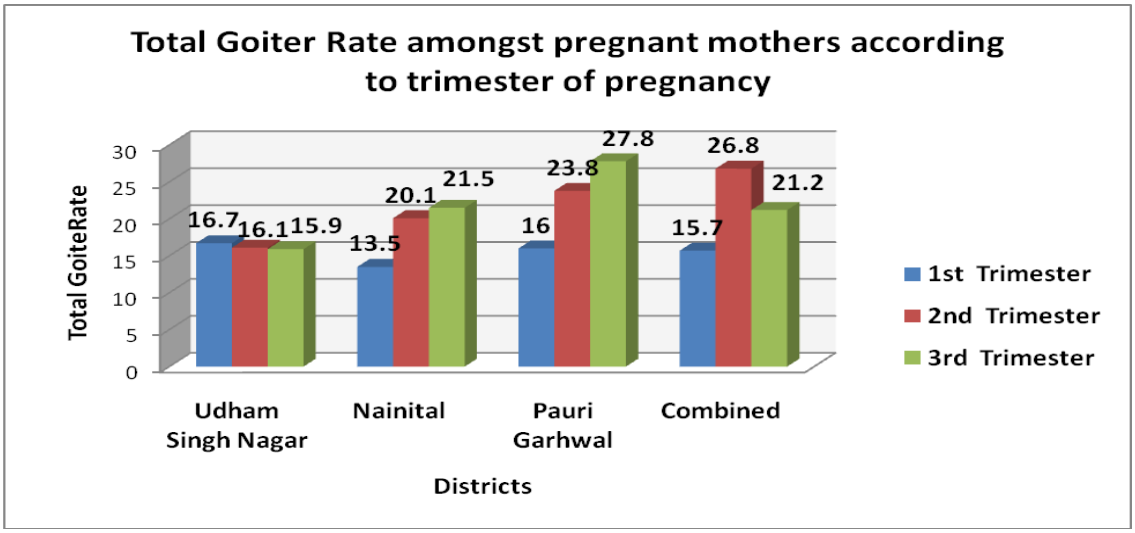
Figure in the parentheses indicates percentages
(WHO, 2007: TGR ≥5%: Iodine deficiency)

4.1.2.3 Trimester wise prevalence of TGR

The trimester wise (1st trimester: 0-12 weeks, 2nd trimester: 13-<28 weeks and 3rd trimester: 28 weeks and above) prevalence of TGR is depicted in **Figure 23**. It found that the goiter rate differs according to the different trimesters of pregnancy. Thus in districts Nainital and Pauri Garhwal it was found that as the trimester of pregnancy increases, the TGR also increases. Whereas, in district Udham Singh Nagar it was the reverse as found in other two districts. Thus goiter grade in Udham Singh Nagar district gradually increases from 1st trimester to the 3rd trimester of pregnancy. However, there was no statistical significant difference in the trimesters of pregnancy with TGR in all the three districts; Udham Singh Nagar (p=0.987), Nainital (p=0.533) and Pauri Garhwal (p=0.354).

Moreover when combining all the three districts studied, there was no statistical significant difference in the TGR and trimesters of pregnancy (p=0.330).

Figure 23: Total goiter rate amongst pregnant mothers according to trimester of pregnancy



WHO, 2007: TGR ≥5%: Iodine deficiency

MAJOR FINDINGS

- 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.
- Combining all the three districts the TGR was found to be 20 percent.
- Moreover, it could be said that higher prevalence of iodine deficiency according to TGR was found 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. Thus, it could be said that as the age of the pregnant mother increases the total goiter rate decreases. Combining all the three districts there was a statistical significant difference in the TGR and different 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 trimesters of pregnancy.

4.1.3 Biochemical Estimation of pregnant mothers enrolled in the study

4.1.3.1 Iodine deficiency status as per urinary iodine concentration level

The iodine deficiency status of pregnant mothers according to UIC levels is depicted in **Table 17**.

It was found that UIC level of <150µg/L was found in 54.3 (Udham Singh Nagar), 57.7 (Nainital) and 61.8 (Pauri Garhwal) percent of pregnant mothers indicating insufficient iodine intake by the population studied. Combining all the three districts UIC level of <150µg/L was found amongst 57.6% of the pregnant mothers studied indicating ID in all the three districts of Uttarakhand state.

Similarly, median UIC level was found to be 124µg/L (Udham Singh Nagar), 117.5µg/L (Nainital), 110µg/L (Pauri Garhwal, respectively, indicating presence of iodine deficiency amongst pregnant mothers in all the three districts. Combining all the three districts median UIC level was found to be 124µg/L indicating iodine deficiency or low intake of iodine by pregnant mothers in all the three districts of Uttarakhand state.

Comparing between the districts higher iodine deficiency was found in district Pauri Garhwal followed by district Nainital and then Udham Singh Nagar as depicted by median UIC level of <150µg/L. Thus it was found that hilly terrain (Nainital and Pauri Garhwal) reported higher prevalence of iodine deficiency compared to plain area (Udham Singh Nagar) of Uttarakhand state as depicted by median UIC level (<150µg/L) which is a good marker to assess iodine deficiency in the population **(Figure 24)**.

Similarly it was also found that the TGR was also 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 median UIC level.

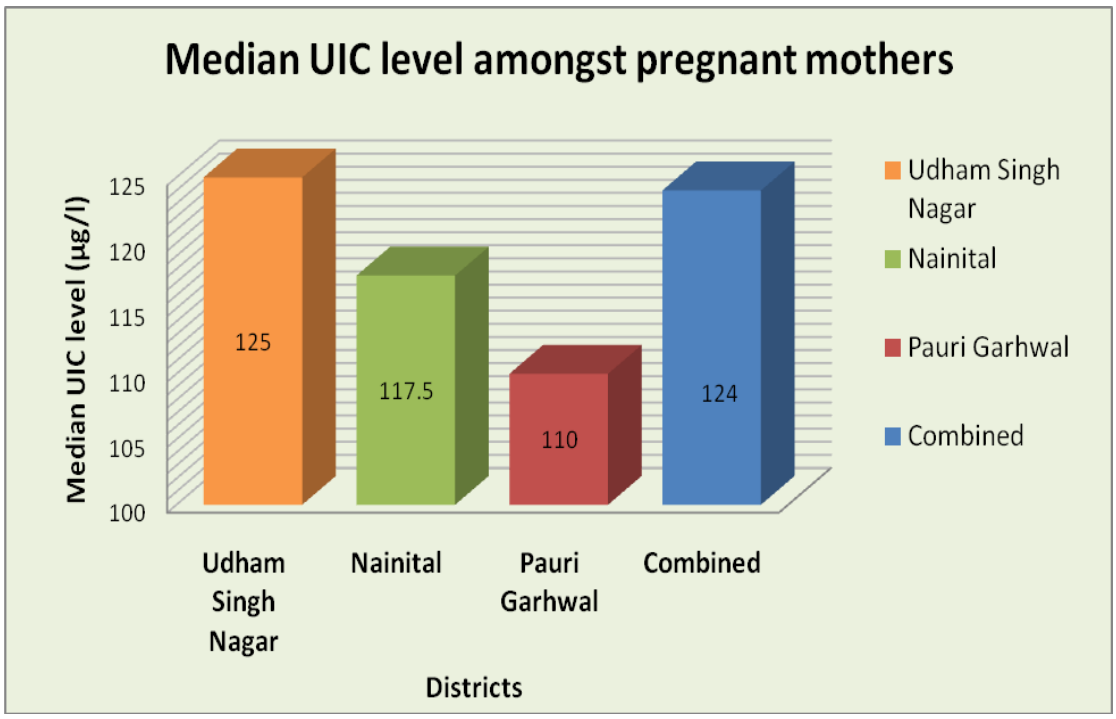
Table 17: Iodine deficiency status amongst pregnant mothers as per urinary iodine concentration level

UIC levels (µg/L)	Iodine Intake	Udham Singh Nagar (N=532)	Nainital (N=468)	Pauri Garhwal (N=404)	Combined (all the three districts) (N=1404)
		n(%)	n(%)	n(%)	n(%)
<50	Insufficient	62(11.6)	4(0.9)	97(24.0)	163(11.6)
50-99.9	Insufficient	102(19.2)	149(31.8)	85(21.0)	336(23.9)
100-149.9	Insufficient	125(23.5)	117(25.0)	68(16.8)	310(22.1)
150 and above	Adequate	243(45.7)	198(42.3)	154(38.1)	595(42.4)
Median UIC level		**124#**	**117.5#**	**110#**	**124#**

Figures in parentheses denotes percentage (Estimation: Wet digestion method)

 # WHO, 2007: median UIC level <150 µg/L indicates iodine deficiency

Figure 24: Median UIC level amongst pregnant mothers



WHO, 2007: median UIC level <150 µg/L indicates iodine deficiency

4.1.3.2 Iodine deficiency status as per urinary iodine concentration level in different age groups

Iodine deficiency status amongst pregnant mothers as per urinary iodine concentration level in different age groups is depicted in **Table 18**.

It was found that in all the three districts median UIC level was lesser (<150µg/l) in the age group of 18-25 years compared to pregnant mothers of 26 years and above indicating higher deficiency of iodine in the age group of 18-25 years. Increasing trend of median UIC level with age was observed from all the three districts of Uttarakhand. However, it was found that there was no statistical significant difference in the UIC levels with age groups of the pregnant mother studied in districts Udham Singh Nagar (p=0.490), Nainital (p=0.711) and Pauri Garhwal (p=0.752).

Similarly, when combining all the three districts studied median UIC level was less in the age group of 18-25 years compared to pregnant mothers of the age group 26 and above. Thus according to median UIC level of <150µg/l (WHO, 2007) for pregnant mothers all the districts studied were iodine deficient. Moreover, when combining all the three districts, no statistical significant difference was observed in the UIC levels and different age groups of the pregnant mother studied (p=0.484). It was also found that the higher percentage of pregnant mothers in the age group of 18-25 years had UIC level of <150 µg/l compared to pregnant mothers of 26 years and above in all the three districts.

Moreover, it was also found that TGR was also observed to be higher in the age group of 18-25 years compared to pregnant mothers of 26 years and above. Thus it could be said that higher prevalence of iodine deficiency amongst pregnant mothers was found to be in the age group of 18-25 years compared to pregnant mothers of 26 years and above as depicted by TGR and median UIC levels. 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.

Table 18: Iodine deficiency status amongst pregnant mothers as per urinary iodine concentration level in different age groups

UIC levels (µg/L)	Age groups of Pregnant Mother (yrs)		p-value
	Udham Singh Nagar (N=532)		
	18-25 (n=404)	**26 and more (n=128)**	
<50 (n=62)	47(11.7)	15(11.7)	**0.490** **NS**
50-99.9 (n=102)	83(20.6)	19(14.8)	
100-149.9(n=125)	94(23.1)	31(24.2)	
150 and above (n=243)	180(44.6)	63(49.2)	
Median UIC	**124**[#]	**136**[#]	
	Nainital (N=468)		
	18-25 (n=345)	**26 and more (n=123)**	
<50 (n=4)	3(0.9)	1(0.8)	**0.711** **NS**
50-99.9 (n=149)	112(32.5)	37(30.1)	
100-149.9 (n=117)	83(23.9)	34(27.6)	
150 and above (n=198)	147(42.7)	51(41.5)	
Median UIC	**117.5**[#]	**132.5**[#]	
	Pauri Garhwal (N=404)		
	18-25 (n=301)	**26 and more (n=103)**	
<50 (n=97)	76(25.2)	21(20.4)	**0.752** **NS**
50-99.9 (n=85)	61(20.7)	24(23.3)	
100-149.9 (n=68)	51(16.9)	17(16.5)	
150 and above (n=154)	113(37.5)	41(39.8)	
Median UIC	**100**[#]	**112.5**[#]	
	Combined (all the three districts) (N=1404)		
	18-25 (n=1050)	**26 and more (n=354)**	
<50 (n=163)	126(12.0)	37(10.4)	**0.484** **NS**
50-99.9 (n=336)	256(24.4)	80(22.6)	
100-149.9(n=310)	228(21.6)	82(23.2)	
≥150 (n=595)	440(42.0)	155(43.8)	
Median UIC	**117.5**[#]	**132.5**[#]	

Figures in parentheses denotes percentage

[#]***WHO, 2007: median UIC level <150 µg/L indicates iodine deficiency***

4.1.3.3 Iodine deficiency status as per urinary iodine concentration level in different trimesters of pregnancy

Iodine deficiency status as per urinary iodine concentration level in different trimesters of pregnancy in all the three districts of Uttarakhand is depicted in **Table 19** and **Figure 25**.

It was found that there was a decreasing trend of median UIC level with the increasing trimester of pregnancy in districts Nainital and Pauri Garhwal. But no trend was observed in district Udham Singh Nagar. In district Udham Singh Nagar, median UIC level in the first, second and third trimester was 133µg/L, 144.5µg/L and 116µg/L, respectively. Thus, indicating a rise from the first trimester to the second trimester, followed by a fall in the third trimester. But in district Nainital, median UIC in the first, second and third trimester was 135µg/L, 132.5µg/L and 117.5µg/L, respectively. In district Pauri Garhwal median UIC in the first, second and third trimester was 137.5µg/L, 111.5µg/L and 87.5µg/L, respectively. Thus, indicating that the median UIC level was decreasing with increase in trimesters of pregnancy in districts Nainital and Pauri Garhwal. Hence, there was a decreasing trend of median UIC level with increase in trimesters of pregnancy.

It was found that there was a statistical significant difference in the median UIC level and different trimesters of pregnancy of the subjects studied in district Udham Singh Nagar ($p=0.022$). Whereas, no statistical significant difference was found in districts Nainital ($p=0.801$) and Pauri Garhwal ($p=0.059$). When combining all the three districts there was also a decreasing trend of median UIC level with increase in trimester of pregnancy. Combining all the three districts surveyed, a statistical significant difference was observed in the median UIC levels and different trimesters of pregnancy of the subjects studied ($p=0.032$).

Moreover, when comparing district wise high iodine deficiency amongst pregnant mothers was observed in hilly terrain (Nainital and Pauri Garhwal) compared to plain area (Udham Singh Nagar).

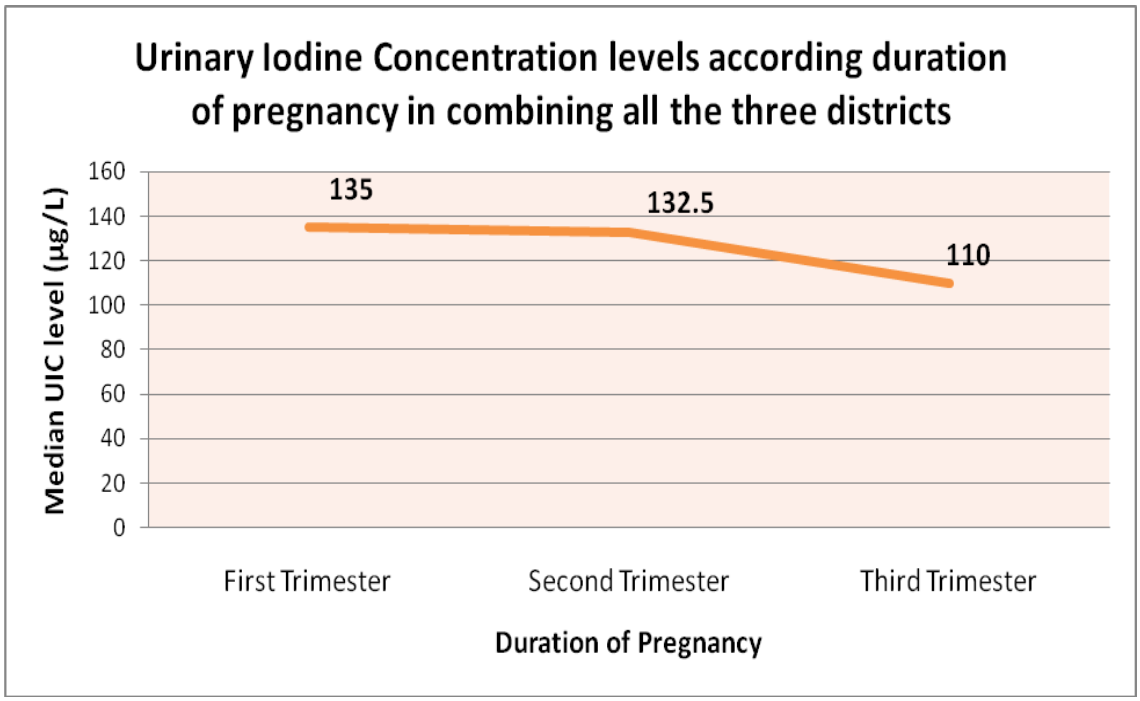
Table 19: Iodine deficiency status as per urinary iodine concentration level in different trimesters of pregnancy in all the three districts of Uttarakhand

UIC levels (µg/L)	Duration of Pregnancy			P-value
	Udham Singh Nagar (N=532)			
	First Trimester (0-12 Weeks) (n=67) n (%)	Second Trimester (13-<28 weeks) (n=264) n (%)	Third Trimester (28 weeks and above) (n=201) n (%)	
<50 (n=62)	3(4.5)	31(11.7)	28(13.9)	**0.004****
50-99.9 (n=102)	7(10.4)	46(17.5)	49(24.4)	
100-149.9(n=125)	25(37.3)	55(20.8)	45(22.4)	
150 and above (n=243)	32(47.8)	132(50.0)	79(39.3)	
Median UIC	**133**[#]	**144.5**[#]	**116**[#]	**0.022***
	Nainital (N=468)			
	First Trimester (0-12 Weeks) (n=31) n (%)	Second Trimester (13-<28 weeks) (n=260) n(%)	Third Trimester (28 weeks and above) (n=177) n (%)	
<50 (n=4)	1(3.2)	3(1.2)	0	**0.105** [NS]
50-99.9 (n=149)	10(32.2)	80(30.8)	59(33.3)	
100-149.9 (n=117)	5(16.2)	58(22.4)	54(30.5)	
150 and above (n=198)	15(48.4)	119(45.8)	64(36.2)	
Median UIC	**135**[#]	**132.5**[#]	**117.5**[#]	**0.801** [NS]
Pauri Garhwal (N=404)				
	First Trimester (0-12 Weeks) (n=18) n (%)	Second Trimester (13-<28 weeks) (n=241) n(%)	Third Trimester (28 weeks and above) (n=145) n (%)	
<50 (n=97)	2(11.1)	53(22.0)	42(29.0)	**0.442** [NS]
50-99.9 (n=85)	4(22.2)	48(20.0)	33(22.8)	
100-149.9 (n=68)	3(16.7)	44(18.2)	21(14.4)	
150 and above (n=154)	9(50.0)	96(39.8)	49(33.8)	
Median UIC	**137.5**[#]	**111.5**[#]	**87.5**[#]	**0.059** [NS]
	Combined (all the three districts) (N=1404)			
	First Trimester (0-12 Weeks) (n=116) n (%)	Second Trimester (13-<28 weeks) (n=765) n(%)	Third Trimester (28 weeks and above) (n=523) n (%)	
<50 (n=163)	6(5.2)	87(11.4)	70(13.4)	**0.004****
50-99.9 (n=336)	21(18.1)	174(22.7)	141(27.0)	
100-149.9(n=310)	33(28.4)	157(20.5)	120(22.9)	
≥150 (n=595)	56(48.3)	347(45.4)	192(36.7)	
Median UIC	**135**[#]	**132.5**[#]	**110**[#]	**0.032** [*]

Figures in parentheses denotes percentage

[#]***WHO, 2007: median UIC level <150 µg/L indicates iodine deficiency***

Figure 25: Urinary Iodine Concentration level in different trimesters of pregnancy combining all the three districts of Uttarakhand



WHO, 2007: median UIC level <150 µg/L indicates iodine deficiency

MAJOR FINDINGS

- 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. Combining all the three districts median UIC was found to be 124µg/L.
- 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 <150µg/L further indicating deficiency of iodine in the subjects studied.
- Similarly it was found that median UIC level 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 both 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 years 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.
- **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 decreased with increase in trimesters 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).

4.1.4 Iodine content of salt amongst the household of pregnant mothers enrolled in the study

4.1.4.1 Iodized salt intake

Iodized salt intake by pregnant mothers studied in all the three districts is depicted in **Table 20 and Figure 26-28**.

It was found that higher consumption of inadequately iodized salt (<15ppm) was in district Udham Singh Nagar followed by districts Pauri Garhwal and Nainital. Combining all the three districts 41.8% of pregnant mothers was consuming inadequately iodized salt.

Table 20: Iodized salt intake by pregnant mothers studied in all the three districts

Iodine Content of Salt (ppm)	Udham Singh Nagar (N=597)	Nainital (N=548)	Pauri Garhwal (N=349)	Combined (all the three districts) (N=1494)
	n (%)	n (%)	n (%)	
<15	297(49.7)	181(33.0)	147(42.1)	625(41.8)
15 and more	300(50.3)	367(67.0)	202(57.9)	869(58.2)

Figures in parentheses denotes percentage (Method of Estimation: Iodometric titration)

Figure 26: Iodine content of salt amongst the household of pregnant mothers enrolled from Udham Singh Nagar district

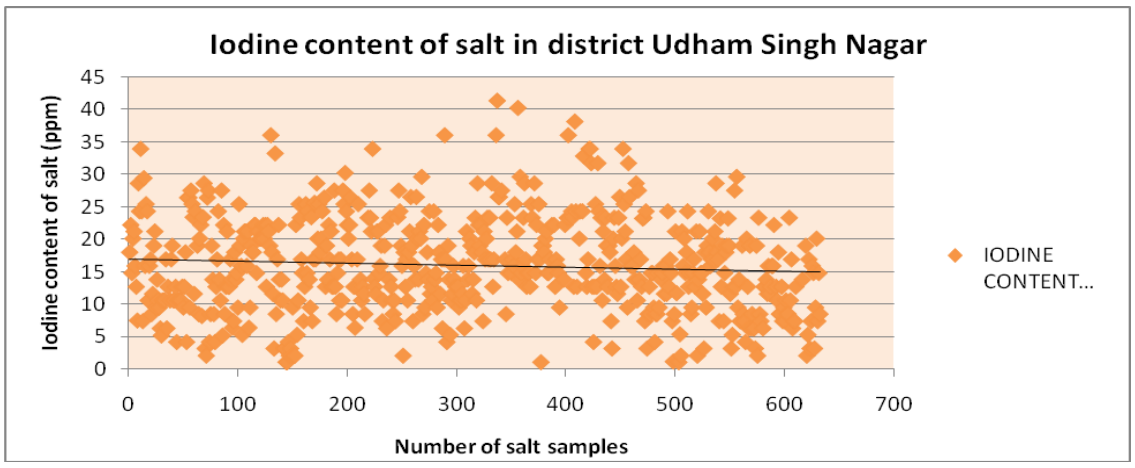


Figure 27: Iodine content of salt amongst the household of pregnant mothers enrolled from district Nainital

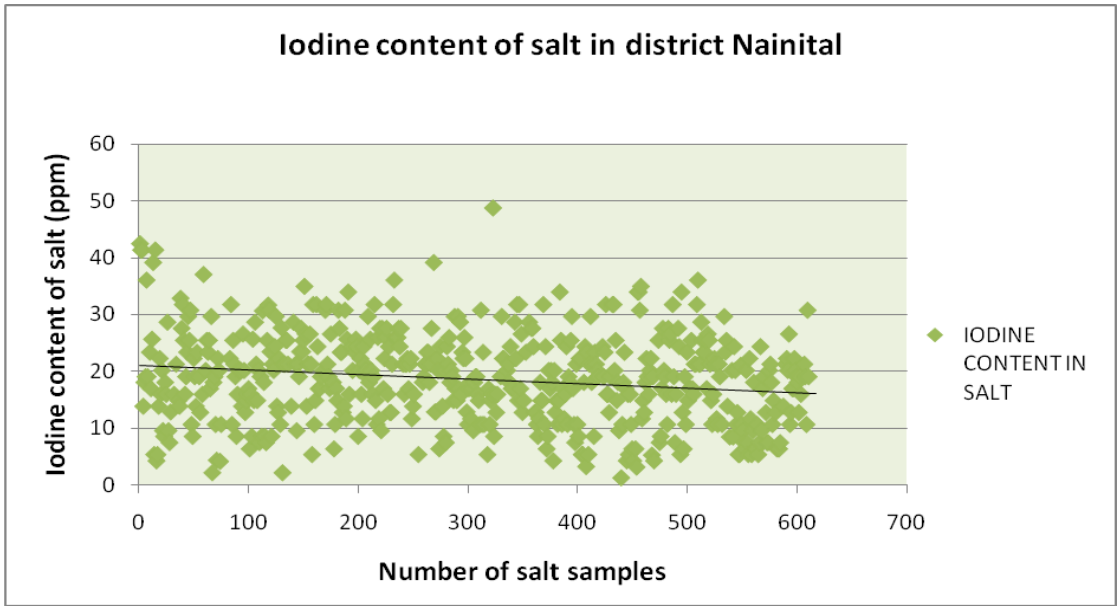
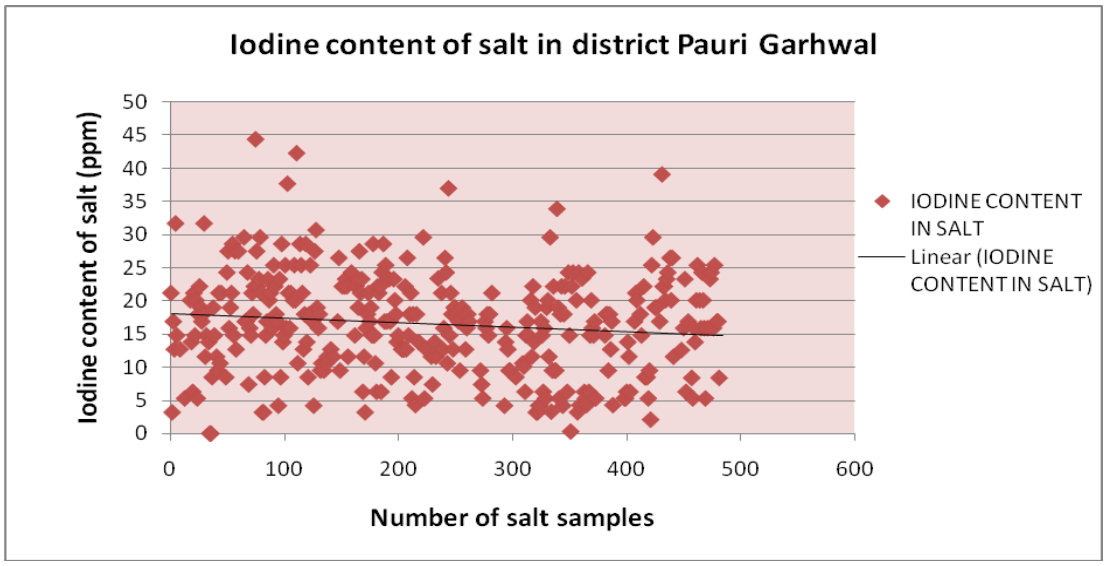


Figure 28: Iodine content of salt amongst the household of pregnant mothers enrolled from district Pauri Garhwal



4.1.4.2 Iodized salt intake in different age groups

The iodized salt intake in different age groups of pregnant mother is depicted in **Table 21**.

It was found that in districts Udham Singh Nagar and Nainital higher percentage of pregnant mothers in the age group of 18-25 years were consuming inadequately iodized salt (<15ppm) compared to pregnant mothers of 26 years and above. However 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. It was found that there was no significant difference in the the age groups of pregnant mothers and iodized salt intake level in all the three districts studied.

But when combining all the three districts studied, higher percentage of pregnant mothers in the age group of 18-25 years 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.

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 inadequately iodized salt (<15ppm) was higher in the age group of 18-25 years and compared to pregnant mothers of 26 years and above.

Table 21: Iodized salt intake in different age groups of pregnant mothers in all the three districts

Age groups	Iodine content of salt		p-value
	Udham Singh Nagar (N=597)		
	<15ppm (n=297)	**≥15ppm (n=300)**	
18-25 (n=445)	228(51.2)	217(48.8)	**0.287** **NS**
26 and more (n=152)	69(45.4)	83(54.6)	
	Nainital (N=548)		
	<15ppm (n=181)	**≥15ppm (n=367)**	
18-25 (n=407)	136(33.3)	271(66.7)	**0.347** **NS**
26 and more (n=141)	45(31.9)	96(68.1)	
	Pauri Garhwal (N=349)		
	<15ppm (n=147)	**≥15ppm (n=202)**	
18-25 (n=265)	108(40.7)	157(59.3)	**0.359** **NS**
26 and more (n=84)	39(46.4)	45(53.6)	
	Combined (all the three districts) (N=1494)		
	<15ppm (n=625)	**≥15ppm (n=869)**	
18-25 (n=1117)	472(42.2)	645(57.8)	**0.381** **NS**
26 and more (n=377)	153(40.6)	224(59.4)	

Figures in parentheses denotes percentage

4.1.4.3 Iodized salt intake in different trimesters of pregnancy

The iodized salt intake in different trimesters of pregnancy is depicted in **Table 22**.

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 higher percentage of pregnant mothers in the 2nd trimester of pregnancy were consuming adequately iodized salt compared to other two districts. 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.

Table 22: Iodized salt intake in different trimesters of pregnancy in all the three districts

Duration of pregnancy	Iodine content of salt		P-value
	Udham Singh Nagar (N=597)		
	<15ppm (n=297)	**≥15ppm (n=300)**	
First Trimester (0-12 weeks) (n=76)	40(52.6)	36(47.4)	**0.535** **NS**
Second Trimester (13-<28 weeks)(n=289)	137(47.4)	152(52.6)	
Third Trimester (28 weeks and above) (n=232)	120(51.7)	112(48.3)	
	Nainital (N=548)		
	<15ppm (n=181)	**≥15ppm (n=367)**	
First Trimester (0-12 weeks) (n=35)	12(34.3)	23(65.7)	**0.423** **NS**
Second Trimester (13-<28 weeks) (n=303)	93(30.7)	210(69.3)	
Third Trimester (28 weeks and above) (n=210)	76(36.2)	134(63.8)	
	Pauri Garhwal (N=349)		
	<15ppm (n=147)	**≥15ppm (n=202)**	
First Trimester (0-12 weeks) (n=11)	6(54.5)	5(45.5)	**0.148** **NS**
Second Trimester (13-<28 weeks) (n=201)	76(37.8)	125(62.2)	
Third Trimester (28 weeks and above) (n=137)	65(47.4)	72(52.5)	
	Combined (all the three districts) (N=1494)		
	<15ppm (n=625)	**≥15ppm (n=869)**	
First Trimester (0-12 weeks) (n=122)	58(47.5)	64(52.5)	**0.023***
Second Trimester (13-<28 weeks) (n=793)	306(38.6)	487(61.4)	
Third Trimester (28 weeks and above) (n=579)	261(45.1)	318(54.9)	

Figures in parentheses denotes percentage
p<0.05

MAJOR FINDINGS

- National goal of adequately iodized salt coverage is to be more than 90%, but in our present study none of the districts were consuming salt with adequate iodine content of ≥15ppm.
- 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 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.
- **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.
- 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.
- **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.
- 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.

4.1.5 Comparison of prevalence of iodine deficiency based on Total Goiter Rate, Urinary Iodine Concentration levels and iodized salt intake

4.1.5.1 Prevalence of iodine deficiency based on median UIC level and salt intake in different age groups

The prevalence of IDD based on median UIC level and salt intake in different age groups is depicted in **Table 23.** It was found that in all the three districts the median UIC level increased with increasing age groups.

In district Udham Singh Nagar: median UIC level amongst pregnant mothers of different age groups were 124µg/l (18-25 years) and 136µg/L (more than 26 years of age) and median salt consumption was 14.8 and 16.9, respectively. **In district Nainital:** it was found to be 115µg/L (18-25 years) and 117.5µg/L (>26 years) and median iodized salt consumption was 19.0 and 19.0, respectively. **In district Pauri Garhwal:** it was found to be 100µg/L (18-25 years) and 112.5µg/L (>26 years) and median salt consumption was 16.9 and 15.9, respectively. Thus it was observed that the pregnant mothers in the age group of 18-25 years have lower median UIC level compared to pregnant mothers of the age 26 years and above. But the difference was not statistically significant. Whereas no statistical difference was found in the iodized salt intake with different age groups studied in all the three districts. Even when combining all the three districts no statistical significant difference was observed.

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 inadequately iodized salt (<15ppm) was higher in the age group of 18-25 years compared to pregnant mothers of 26 years and above.

Table 23: Prevalence of iodine deficiency disorder based on urinary iodine concentration level and iodized salt intake in different age groups in all the three districts

	Parameters	Age Group		p-value
		18-25 Median (min-max)	26 and above Median (min-max)	
Udham Singh Nagar	**Salt Intake (n=597)**	n=445 14.8 (1.1-14.3)	n=152 16.9 (1.1-40.2)	**0.401**^{NS}
	UIC (µg/l) (n=532)	n=404 124 (10-301)	n=128 136 (10-301)	**0.381** ^{NS}
Nainital	**Salt Intake (n=548)**	n=407 19 (2.1-48.7)	n=141 19 (1.2-34.9)	**0.922** ^{NS}
	UIC (µg/l) (n=468)	n=240 115 (49-201)	n=228 117.5 (49-201)	**0.625** ^{NS}
Pauri Garhwal	**Salt Intake (n=349)**	n=265 16.9 (0-44.4)	n=84 15.9 (4.2-39.1)	**0.691** ^{NS}
	UIC (µg/l) (n=404)	n=301 100 (49-201)	n=103 112.5 (49-201	**0.681** ^{NS}
Combined (all the three districts)	**Salt Intake (n=1494)**	n=625 16.9(0-48.7)	n=869 17.2(1.1-40.2)	**0.381** ^{NS}
	UIC (µg/l) (n=1404)	n=1050 117.5(10-301)	n=354 132.5(10-301)	**0.484** ^{NS}

Figures in parentheses denotes percentage
WHO, 2007: median UIC level <150 µg/L indicates iodine deficiency

4.1.5.2 Prevalence of iodine deficiency based on Total Goiter Rate, Urinary Iodine Concentration levels iodized salt intake in different age groups

Prevalence of iodine deficiency disorder based on Total Goiter Rate, Urinary Iodine Concentration level and iodized salt intake in different age groups in all the three districts is depicted in **Table 24**.

It was found that 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. When 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.

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. But when combining all the three districts studied the percentage of inadequately iodized salt consumption was higher in the pregnant mothers of 18-25 years of age compared to pregnant mothers of 26 years and above.

Table 24: Prevalence of iodine deficiency based on Total Goiter Rate, Urinary Iodine Concentration levels and salt intake different age groups in all the three districts

Age wise	Population of pregnant mothers	TGR (goiter grade 1 and 2) n(%)	No. of Urine samples (n)	UIC <150(µg/l) n (%)	Median UIC level (µg/l)	No. of salt samples (n)	Salt intake(≥15 ppm) n (%)
Udham Singh Nagar							
18-25 years	476	85 (17.8)	404	224(55.4)	124	445	217 (48.8)
26 and above	156	17 (10.9)	128	65 (50.8)	136	152	83 (54.6)
Total	**632**	**102**	**532**	**289**		**597**	**300**
Nainital							
18-25 years	452	99 (21.9)	345	198(57.4)	117.5	407	271 (66.6)
26 and above	162	25 (15.4)	123	72 (58.5)	132.5	141	96 (68.1)
Total	**614**	**124**	**468**	**270**		**548**	**367**
Pauri Garhwal							
18-25 years	355	97(27.3)	301	188(62.4)	100	265	157(59.2)
26 and above	126	23 (18.2)	103	62(60.2)	112.5	84	45 (53.6)
Total	**481**	**120**	**404**	**250**		**349**	**202**
Combined (all the three districts)							
18-25 years	1283	281(21.9)	1050	610(58.1)	117.5	1117	645(57.7)
26 and above	444	65(14.6)	354	199(56.2)	132.5	377	224(59.4)

Figure in parentheses denotes percentage

WHO, 2007: TGR ≥5%: Iodine deficiency and median UIC level <150 µg/L indicates iodine deficiency

4.1.5.3 Prevalence of IDD based on UIC level and iodized salt intake in different trimesters

The prevalence of IDD based on UIC level and iodized salt intake in different trimesters of pregnancy is depicted in **Table 25**.

The present study reported that in district Udham Singh Nagar, UIC in the first, second and third trimester was 133µg/L, 144.5µg/L and 116µg/L, respectively. Thus, indicating a rise from the first trimester to the second trimester, followed by a fall in the third trimester. Similarly in district Nainital, UIC in the first, second and third trimester was 135µg/L, 132.5µg/L and 117.5µg/L, respectively. In district Pauri Garhwal UIC in the first, second and third trimester was 137.5µg/L, 111.5µg/L and 87.5µg/L, respectively. Thus, indicating that the median UIC level was decreasing with increase in trimesters of pregnancy in districts Nainital and Pauri Garhwal. There was statistical difference in the UIC level and gestational age in district Nainital.

It was found 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. A weak correlation was found between salt intake and UIC levels in districts Udham Singh Nagar ($r=0.224$, $p=<0.001$), Nainital ($r=0.188$, $p=<0.001$) and Pauri Garhwal ($r=0.173$, $p=<0.001$).

Table 25: Prevalence of Iodine deficiency disorder based on Urinary iodine Concentration level and salt intake in different trimesters of pregnancy in all the three districts

	Parameters	Duration of Pregnancy			p-value	Post hoc comparison		
		First Trimester (0-12 weeks) Median (min-max)	Second Trimester (13-<28 weeks) Median (min-max)	Third Trimester (28 and above weeks) Median (min-max)		1 vs 2	2 vs 3	1 vs 3
Udham Singh Nagar	**Salt Intake (n=597)**	n=76 14.8 (1.1-33.9)	n=289 15.9 (1.1-41.3)	n=232 14.8 (1.1-40.2)	0.292 NS	0.183 NS	0.245 NS	0.540 NS
	UIC (n=532)	n=67 133 (20-301)	n=264 144.5 (10-301)	n=201 116 (10-301)	0.028*	0.633 NS	0.024 *	0.024 *
Nainital	**Salt Intake (n=548)**	n=35 19 (5.3-36)	n=303 19 (2.1-41.3)	n=210 18 (1.2-48.7)	0.011*	0.545 NS	0.165 NS	0.854 NS
	UIC (n=468)	n=31 135 (49-201)	n=260 132.5 (49-201)	n=177 117.5 (50-201)	0.001**	0.478 NS	0.144 NS	0.836 NS
Pauri Garhwal	**Salt Intake (n=349)**	n=11 14.8 (4.3-22.2)	n=201 16.9 (0-44.4)	n=137 15.9 (0-42.3)	0.220 NS	0.445 NS	0.097 NS	0.918 NS
	UIC (n=404)	n=18 137.5 (49-201)	n=241 111.5 (49-201)	n=145 87.5 (49-201)	0.056 NS	0.192 NS	0.076 NS	0.041 *

Figures in parentheses denotes percentage
WHO, 2007: median UIC level <150 µg/L indicates iodine deficiency

4.1.6 Relationship between Goiter grade and UIC levels of pregnant mothers

Relationship between Goiter grade and UIC levels of pregnant mothers in all the three districts of Uttarakhand is depicted in **Table 26**. It was found that TGR was higher in the pregnant mothers of median UIC level of <150µg/l in all the three districts. And when combining all the three districts similar trend was observed. However the difference was not statistically significant.

Table 26: Relationship between Goiter grade and Urinary Iodine Concentration levels of pregnant mothers in all the three districts

Goiter Grade	**Urinary Iodine Concentration levels (µg/l)**		**p=value**
	Udham Singh Nagar (N=532)		
	<150 (n=289)	**≥150 (n=243)**	
Grade 0 (n=446)	246(55.2)	200(44.8)	**0.165**^{NS}
Grade I + II (n=86)	43(50.0)	43(50.0)	
	Nainital (N=468)		
	<150 (n=270)	**≥150 (n=198)**	
Grade 0 (n=366)	208(56.8)	158(43.2)	**0.816** ^{NS}
Grade I + II(n=102)	62(60.8)	40(39.2)	
	Pauri Garhwal (N=404)		
	<150 (n=250)	**≥150 (n=154)**	
Grade 0 (n=299)	181(60.5)	118(39.5)	**0.466** ^{NS}
Grade I + II (n=105)	69(65.7)	36(34.3)	
	Combined (all the three districts) (N=1404)		
	<150 (n=809)	**≥150 (n=595)**	
Grade 0 (n=1111)	635(57.2)	476(42.8)	**0.209** ^{NS}
Grade I + II (n=285)	174(61.0)	119(39.0)	

Figure in parentheses denotes percentage

4.1.7 Relationship between Iodized salt intake and UIC levels of pregnant mothers

Relationship of iodized salt intake and UIC levels of pregnant mothers in districts Udham Singh Nagar, Nainital and Pauri Garhwal is depicted in **Table 27**. It was found that the higher percentage of pregnant mothers consuming inadequately iodized salt (<15ppm) had low urinary iodine concentration level compared to pregnant mothers who 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.

Table 27: Relationship between Iodized salt intake and Urinary Iodine Concentration levels of pregnant mothers in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Urinary Iodine Concentration levels (µg/l)	**Salt Intake (ppm)**		**p=value**
	Udham Singh Nagar (N=505)		
	<15ppm (n=245)	**≥15ppm (n=260)**	
<150 (n=275)	155(56.4)	120(43.6)	**0.001****
≥150 (n=230)	90(39.1)	140(60.9)	
	Nainital (N=429)		
	<15ppm (n=150)	**≥15ppm (n=279)**	
<150 (n=243)	102(42.0)	141(58.0)	**0.001****
≥150 (n=186)	48(25.8)	138(74.2)	
	Pauri Garhwal (N=319)		
	<15ppm (n=132)	**≥15ppm (n=187)**	
<150 (n=200)	91(45.5)	109(54.5)	**0.053^{NS}**
≥150 (n=119)	41(34.4)	78(65.6)	
	Combined (all the three districts) (N=1253)		
	<15ppm (n=527)	**≥15ppm (n=726)**	
<150 (n=718)	348(48.5)	370(51.5)	**0.001****
≥150 (n=535)	179(33.5)	356(66.5)	

Figure in parentheses denotes percentage

MAJOR FINDINGS

- 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.
- 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 districts 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.
- It was found that the higher pregnant mothers consuming inadequately iodized salt (<15ppm) had low median urinary iodine concentration level compared to pregnant mothers who were consuming adequately iodized salt. A statistical significant difference between the salt intake and UIC levels was observed in districts 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.
- 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.
- Thus it indicates that the pregnant mothers in all the three districts of Uttarakhand were iodine deficient as indicated by low median UIC levels and lower consumption of adequately iodized salt.

4.1.8 Block wise prevalence of IDD based on Total Goiter Rate, Urinary Iodine Concentration levels and iodized salt intake

In district Udham Singh Nagar

The blockwise distribution of pregnant mothers studied with different parameters in district Udham Singh Nagar is depicted in **Table 28**. It was found that all the blocks studied (except in blocks Gadarpur and Jaspur) had inadequate iodine status amongst pregnant mothers as depicted by median UIC level of <150µg/l thus indicating biochemical deficiency of iodine in the all the blocks studied. The TGR was also higher in all the blocks studied indicating iodine deficiency in all the blocks. It was also found that pregnant mothers who were consuming salt with iodine intake of ≥15ppm and <15ppm had median UIC level of 150µg/l and 100µg/l, respectively. Thus it could be said that pregnant mothers who were consuming salt with adequate iodine content (>15ppm) had higher median UIC level as compared to pregnant mothers who were consuming salt with inadequate iodine content.

In district Nainital

The blockwise distribution of pregnant mothers studied with different parameters in district Nainital is depicted in **Table 29**. It was found that all the blocks studied (except in blocks Bhimtal and Rangarh) had inadequate iodine status as depicted by median UIC level of <150µg/l thus indicating biochemical deficiency of iodine in the all the other blocks studied. The TGR was also higher in all the blocks studied indicating iodine deficiency in all the blocks. It was also found that pregnant mothers who were consuming salt with iodine intake ≥15ppm and <15ppm had median UIC level of 135µg/l and 100µg/l, respectively. Thus it could be said that pregnant mothers who were consuming salt with adequate iodine content (>15ppm) had higher median UIC level as compared to pregnant mothers who were consuming salt with inadequate iodine content.

In district Pauri Garhwal

The blockwise distribution of pregnant mothers studied with different parameters in district Pauri Garhwal is depicted in **Table 30**. It was found that all the blocks (except in block Nanidanga) studied had inadequate iodine status as depicted by median UIC level of <150µg/l thus indicating biochemical deficiency of iodine in the all the other blocks studied. The TGR was also higher in all the blocks studied indicating iodine deficiency in all the blocks. It was also found that pregnant mothers who were consuming salt with iodine intake ≥15ppm and <15ppm had median UIC level of 125µg/l and 75µg/l, respectively. Thus it could be said that pregnant mothers who were consuming salt with adequate iodine content (>15ppm) had higher median UIC level as compared to pregnant mothers who were consuming salt with inadequate iodine content.

Table 28: Blockwise distribution of Total Goiter Rate, Urinary Iodine Concentration and salt intake in district Udham Singh Nagar

	Goiter (N=632)		UIC level (N=532)			Salt Intake (N=597)	
Block	**Population of pregnant mothers**	**TGR (goiter grade1 and 2) n (%)**	**No. of Urine samples (n)**	**UIC <150µg/l (n=622) n (%)**	**Median UIC level (µg/l)**	**No. of salt samples (n)**	**Salt intake (≥15ppm) n (%)**
Khatima	68	9(13.2)*	53	29(54.7)	124#	66	31(47.0)
Sitarganj	111	16(14.4)*	91	55(60.4)	100#	110	57(51.8)
Rudrapur	136	22(16.2)*	115	60(52.2)	139#	132	64(48.5)
Gadarpur	83	9(10.8)*	65	32(49.2)	150	71	51(71.8)
Bazpur	90	20(22.2)*	88	45(51.1)	133#	84	48(57.1)
Kashipur	60	10(16.7)*	55	36(65.4)	116#	59	30(50.8)
Jaspur	84	16(19.0)*	65	32(49.2)	150	75	19(25.3)
Total	**632**	**102**	**532**	**289**		**597**	**300**

Figure in parentheses denotes percentage
****WHO, 2007 TGR of ≥5% indicates iodine deficiency in a population***
 # WHO, 2007: Median UIC of <150µg/l indicates iodine deficiency

Table 29: Blockwise distribution of Total Goiter Rate, Urinary Iodine Concentration and salt intake in district Nainital

	Goiter (N=614)		UIC level (N=468)			Salt Intake (N=548)	
Blocks	**Population of pregnant mothers**	**TGR (goiter grade 1 and 2) n (%)**	**No. of Urine samples (n)**	**UIC <150µg/l n (%)**	**Median UIC level (µg/l)**	**No. of salt samples (n)**	**Salt intake (≥15ppm) n (%)**
Betalghat	31	8(25.8)*	25	16(64.0)	100#	28	18(64.3)
Bhimtal	64	11(17.2) *	28	10(35.7)	187.5	51	40(78.4)
Dhari	34	10(29.4) *	22	13(59.1)	113.7#	27	17(63.0)
Haldwani	219	45(20.5) *	177	106(59.9)	100#	201	148(73.6)
Kotabagh	40	7(17.5) *	38	28(73.7)	100#	31	24(77.4)
Okhalanda	63	21(33.3) *	54	40(74.1)	93.7#	60	33(55.0)
Rangarh	36	9(25.0) *	26	8(30.8)	162.5	33	21(63.6)
Ramnagar	127	13(10.2) *	98	49(50.0)	142.5#	117	66(56.4)
Total	**614**	**124**	**468**	**270**		**548**	**367**

Figure in parentheses denotes percentage
****WHO, 2007 TGR of ≥5% indicates iodine deficiency in a population***
 # WHO, 2007: Median UIC of <150µg/l indicates iodine deficiency

Table 30: Block wise distribution of Total Goiter Rate, Urinary Iodine Concentration and salt intake in district Pauri Garhwal

	Goiter (N=481)		UIC level (N=404)			Salt Intake (N=349)	
Block Pauri	**Population of pregnant mothers**	**TGR (goiter grade 1 and 2) n (%)**	**No. of Urine samples (n)**	**UIC <150µg/l n (%)**	**Median UIC level (µg/l)**	**No. of salt samples (n)**	**Salt intake ≥15ppm) n (%)**
Bironkhal	48	15(31.2) *	42	24(57.1)	125#	34	15(44.1)
Duggada	52	7(13.5) *	50	32(64.0)	108.7#	47	34(72.3)
Dwarikhal	30	4(13.3) *	28	19(67.8)	135#	28	23(82.1)
Ekeshwar	16	1(6.2) *	8	6(75.0)	80#	8	1(12.5)
Jarikhal	30	7(23.3) *	29	19(65.5)	125#	24	18(75.0)
Pauri	47	9(19.1) *	40	27(67.5)	117.5#	30	13(43.3)
Khirsu	14	6(42.8) *	10	5(50.0)	131.2#	11	5(45.4)
Kot	16	5(31.2) *	11	7(63.6)	90#	12	6(50.0)
Nani danga	31	9(29.0) *	23	10(43.5)	190	22	12(54.5)
Pabau	33	5(15.1) *	27	21(77.7)	70#	16	10(62.5)
Dokhra	15	8(53.3) *	10	9(90.0)	62#	15	6(40.0)
Rikhnikhal	30	10(33.3) *	27	16(59.2)	62.5#	25	14(56.0)
Thalisain	68	27(39.7) *	53	31(58.5)	75#	42	18(42.8)
Yamkeshwar	51	7(13.7) *	46	24(52.2)	115#	35	27(77.1)
Total	**481**	**120**	**404**	**250**		**349**	**202**

Figure in parentheses denotes percentage
****WHO, 2007 TGR of ≥5% indicates iodine deficiency in a population***
 # WHO, 2007: Median UIC of <150µg/l indicates iodine deficiency

4.1.9 Summary of iodine nutritional status amongst pregnant mothers

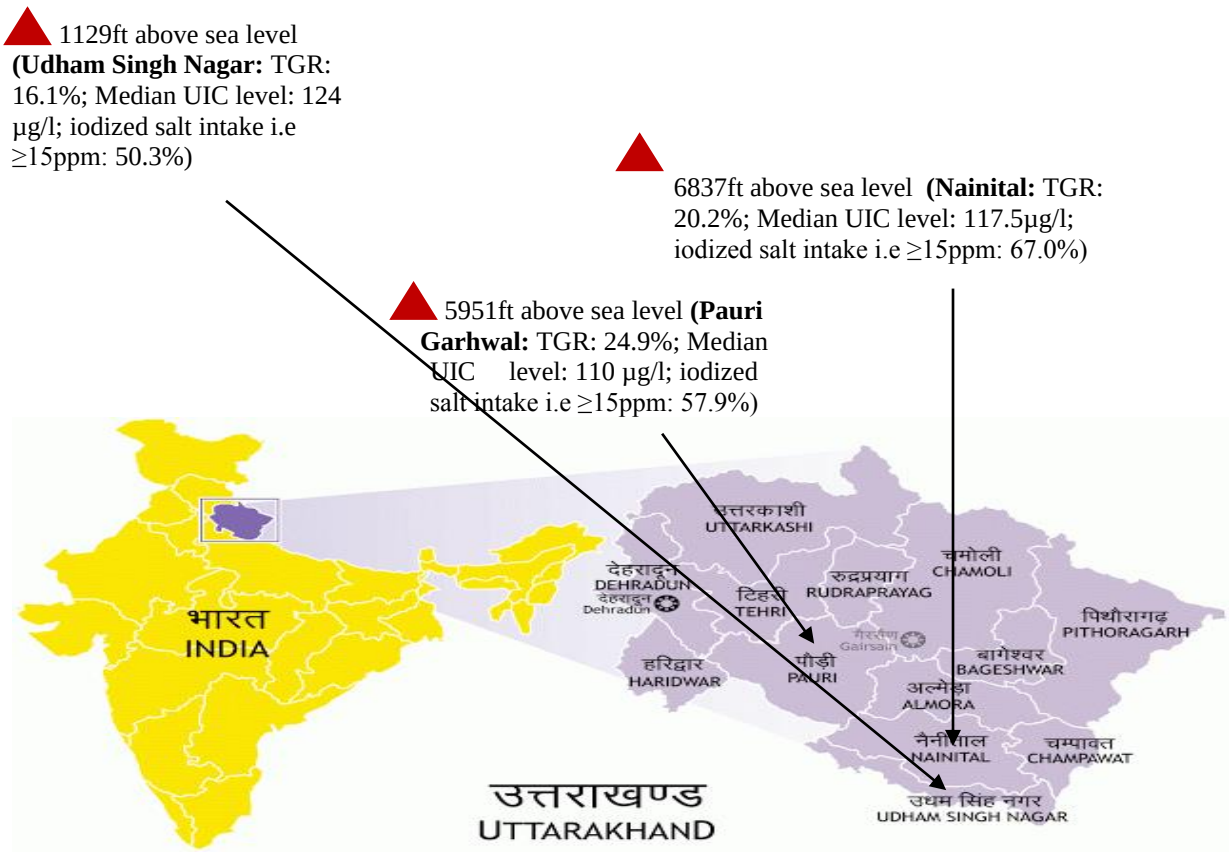
Table 31: Summary of iodine nutritional status amongst pregnant mothers in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Parameters	Udham Singh Nagar	Nainital	Pauri Garhwal	Combined (all the three districts)
TGR	**16.1(632)***	**20.2(614)***	**24.9(481)***	**20.0(1727) ***
Median UIC (µg/l)	**124(532)** #	**117.5(468)** #	**110 (404)**#	**124(1404)** #
UIC level <150(µg/l)	54.3(532)	57.7(468)	61.8(404)	57.6(1404)
Percentage consuming adequately iodized salt (≥15ppm)	50.3(597)	67.0(548)	57.9(349)	58.2(1494)

Figures in parenthesis denotes total samples analyzed

**WHO (2007): TGR of ≥5% and median UIC of <150µg/l indicates iodine deficiency*

Figure 29: Summary of iodine nutritional status amongst pregnant mothers in districts Udham Singh Nagar, Nainital and Pauri Garhwal



DISCUSSION OF RESULTS OF PRESENT STUDY WITH OTHER STUDIES

Iodine is an essential element in the synthesis of the thyroid hormones, thyroxine (T4) and triiodothyronine (T3), by the thyroid gland. Dietary intake is the sole source of iodine. Beginning in the first trimester of pregnancy, there is an increase in the requirement for maternal production of thyroid hormones and a resultant need for an increase in iodine uptake by the thyroid gland. After conception, maternal thyroid hormone production increases by about 50% (Glinoer et al, 2007). The requirement of a mother for iodine is increased during pregnancy as a result of at least three factors: (1) an increased requirement for thyroxine (T4) in order to maintain normal metabolism in the mother; (2) a transfer of T4 and iodide from the mother to the foetus; and (3) greater than normal loss of iodide through the kidneys due to an increase in the renal clearance of iodide (Glinoer, 1997). Because of these three factors, the recommended dietary intake of iodine during pregnancy is higher than the value of 150 mg/day (Dworkin et al, 1966) recommended for non-pregnant adults and adolescents (WHO, 2001; Institute of Medicine, Academy of Sciences, USA, 2000). When the intake is below the critical threshold of 150 mg/day (Dworkin et al, 1966), the iodine balance during pregnancy becomes negative (Dworkin et al, 1966). WHO, UNICEF and ICCIDD (WHO, 2001) recommend a daily iodine intake of 200 mg/day (Dworkin et al, 1966), by pregnant women, a 33% increase in the RDA.

Iodine also plays a role in neuropsychological development of the fetus throughout gestation and in the first two years of life. There is no or little change in thyroid volume observed in pregnant women in areas with sufficient dietary iodine intake (Glinoer 1997; Perez-Lopez, 2007; Zimmerman, 2009). The thyroid stores iodine from the diet and as such maternal iodine status is not entirely dependent on the current dietary intake during gestation. If preconception iodine nutrition is adequate there will be sufficient iodine stored by thyroid hormone to support the mother and foetus, at least in the first trimester. However if preconception dietary intake is deficient the increasing demands of later pregnancy may produce a deficit which untreated can result in a hypothyroxinaemic state (Smyth et al, 2006). There is some evidence suggesting that in areas of mild to moderate iodine deficiency, the maternal

thyroid is able to adapt to meet the increased thyroid hormone requirements of pregnancy (Zimmerman et al, 2009).

During the first two trimesters of pregnancy the foetus is entirely dependent on the maternal thyroid hormone supply as the foetal thyroid does not develop until 13-15 weeks gestation (Smyth et al, 2006; Glioner, 1997). As the foetus progresses into the third trimester, it develops the ability to produce its own thyroid hormones but it is still dependent on maternal iodine for hormone synthesis (Becks and Burrow, 2000). Breast fed infants are dependent on breast milk for iodine, and therefore on the maternal dietary iodine intake. Most infant formulas are supplemented with iodine, though concentrations vary significantly.

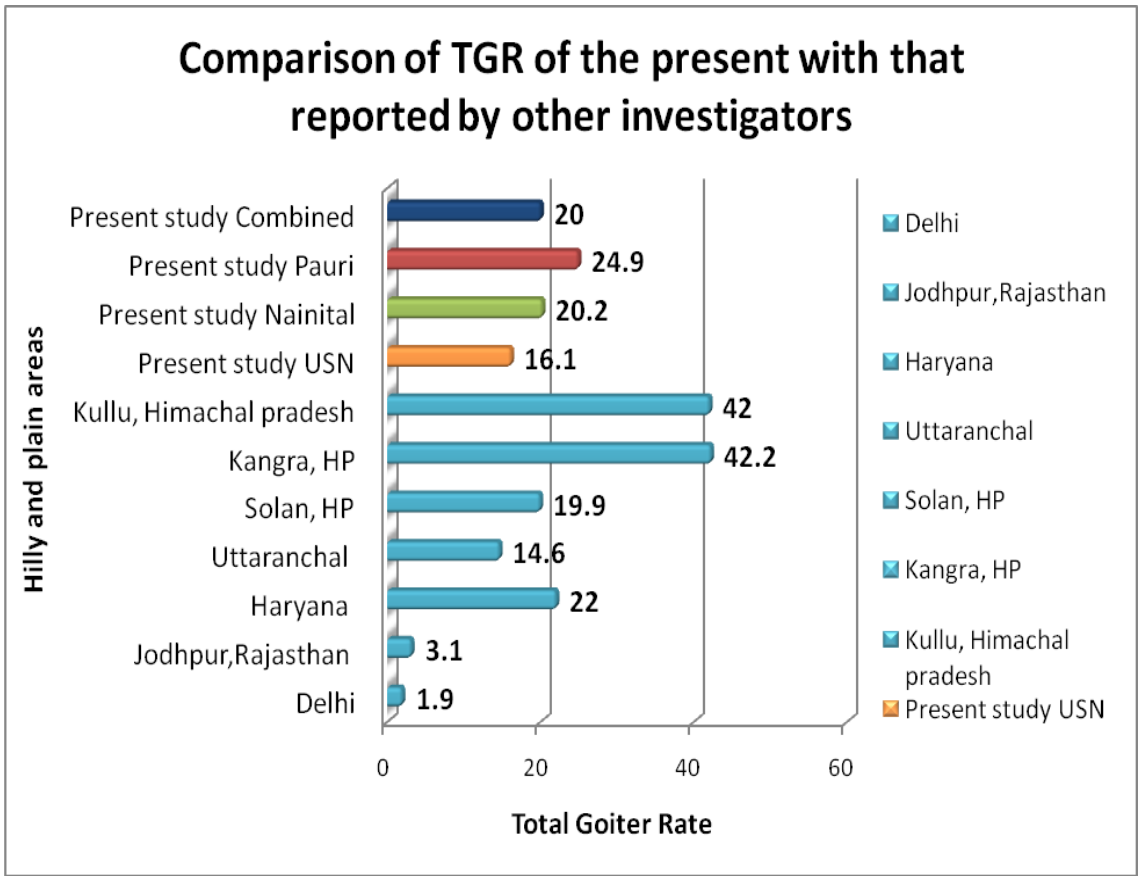
Comparison of prevalence of Total Goiter Rate in the present study with other studies

Pregnant women are of particular concern for iodine deficiency. Pregnant women are a prime target group for IDD control activities because they are especially sensitive to even marginal iodine deficiency. Often they are relatively accessible given their participation in antenatal clinics.

It is recommended that a total goitre rate or TGR (number with goitres of grades 1 and 2 divided by total examined) of 5% or more to be used to signal the presence of a public health problem. This recommendation is based on the observation that in normal, iodine-replete populations, the prevalence of goitre should be quite low. The cut-off point of 5% allows both for some margin of error of goitre assessment, and for goitre that may occur in iodine-replete pop- ulations due to other causes such as goitrogens and autoimmune thyroid diseases (WH0, 2007).

Figure 30 reveals the comparison of TGR of the present with that reported by other investigators.

Figure 30: Comparison of TGR of pregnant mothers of the present with that reported by other investigators



Source: Kangra, Kullu and Solan Himachal Pradesh: Kapil, 2014; Uttaranchal: Pathak et al, 2003; Haryana: Srinath et al, 2004; Rajasthan: Singh et al, 2009; Delhi; Kapil et al, 1999
WHO, 2007 TGR of ≥5% indicates iodine deficiency in a population

Our present study reported the prevalence of TGR as 16.1% (Udham Singh Nagar), 20.2% (Nainital) and 24.9% (Pauri Garhwal) and 20% (combined for all the three districts of Uttarakhand) amongst pregnant mothers indicating mild iodine deficiency in district Udham Singh Nagar and moderate iodine deficiency in districts Nainital and Pauri Garhwal.

Similar results were reported by Saira et al, 2014 which documented that 20.7% of pregnant mothers reported moderate prevalence of iodine deficiency in Pakistan. A recent study conducted by Kapil et al, 2014 in three districts of Himachal Pradesh amongst pregnant mothers reported the TGR as 42.2% (Kangra), 42.0% (Kullu) and

19.9% (Solan), respectively indicating mild iodine deficiency in district Solan and severe iodine deficiency in districts Kangra and Kullu.

A community based study conducted amongst pregnant mothers in Udham Singh Nagar, Uttaranchal reported the TGR as 14.6% indicating iodine deficiency in the district studied (Pathak et al, 2003).

A hospital based study conducted by Srinath et al, in 2004 amongst 400 pregnant mothers of Haryana reported the TGR as 22.0%. Other research studies conducted in Delhi and Mumbai amongst pregnant mothers reported the TGR as 1.9% and 45%, respectively (Kapil et al, 1999; Dodd et al, 1993). Another study by Singh et al, 2009 conducted amongst pregnant mothers in Rajasthan reported the TGR as 3.1% indicating adequate iodine nutritional status amongst pregnant mothers.

Thus the research studies conducted indicates that there is still a high prevalence of iodine deficiency amongst pregnant mothers of India.

Age wise prevalence of TGR

Our present study found that the TGR was higher amongst pregnant mothers in the age group of 18-25 years compared to pregnant mothers of 26 years and above. Similar results were reported by a study conducted by Abuye and Berhane amongst pregnant women of Ethiopia. It was found that the goiter rate decreased as the age categories increased. The highest (37%) total goiter rate was found in the 15–24 years old group. It was also found that the goitre was significantly ($X^2 = 68.8$; $p < 0.001$) frequent in pregnant and or lactating women than non-pregnant and non-lactating counter parts (Abuye et al, 2007).

Trimester wise prevalence of TGR

Many researchers have carried out studies to assess the iodine nutrition status of pregnant women globally at different point of gestation (Glinoer et al, 1990; Mehdi et al; 2009; Shamim et al, 2012). Globally the prevalence of iodine deficiency during pregnancy was and still is the area of concern from most of the developing countries and few of the developed countries

Present study found that there was no statistical difference in the trimester of pregnancy and TGR. Moreover no trend was observed between TGR and different trimester of pregnancy. Similar study was conducted by Saira et al, 2014 in Pakistan. It was found that in first trimester 16.6% had goiter grade I and none had goiter grade II. In the second trimester 17.8% subjects were found with goiter grade I and 1.1% with goiter grade II. In the third trimester 21% subjects were found with goiter grade I and 3.9% with goiter grade II. Total goiter rate gradually increased from the first trimester toward the third trimester. Overall goiter prevalence in pregnant women was 20.7% indicating moderate iodine deficiency in the pregnant women of the area. They found that severity of goiter as well as need for iodine increases with the gestational period;

However a study conducted in Cluj county of Romania showed no relation of gestational period with iodine status (Hazi et al, 2008).

Comparison of iodine deficiency status as per urinary iodine concentration level of the present study with other studies

Urinary iodine concentration is a universally accepted measure of iodine status. Urinary iodine concentration is a good indication of the previous day's dietary iodine intake as up to 90% of iodine is excreted in the urine (Travers et al, 2006). During pregnancy, median urinary iodine concentrations of between 150µg/l and 249µg/l define a population which has no iodine deficiency (WHO, 2007).

Assessing urinary iodine in women 15 to 44 years of age provides an opportunity to establish the iodine status of a group that is particularly crucial because of the susceptibility of the developing fetus to iodine deficiency. Antenatal clinics may have high use rates, and thus a sentinel sampling may provide a reasonable sample of pregnant women (WH0, 2007).

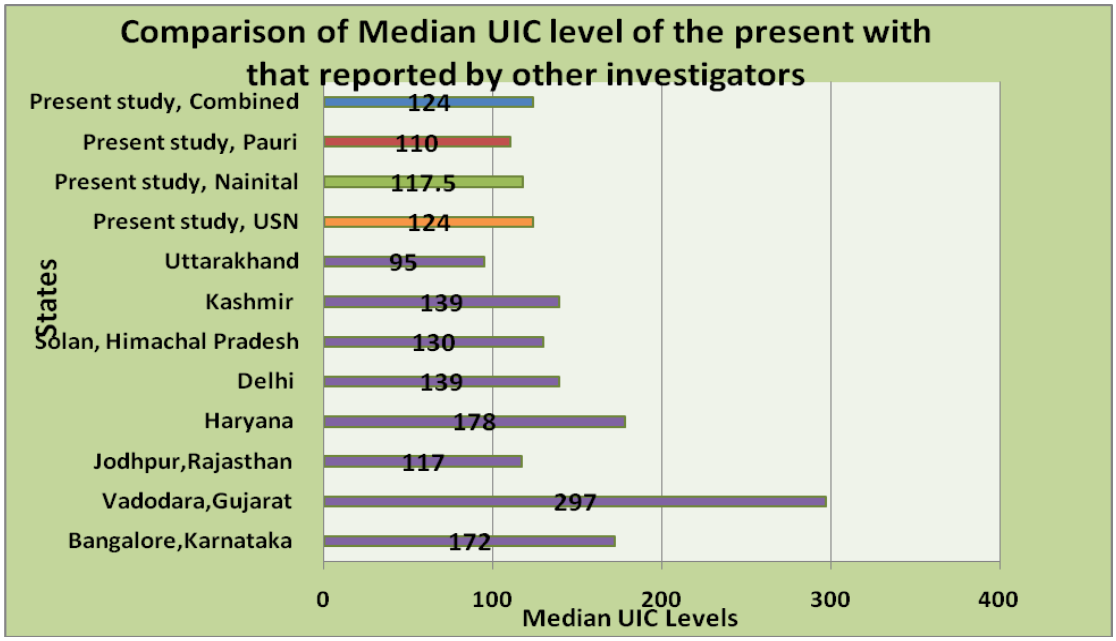
Severe iodine deficiency in pregnancy has the potential to cause both maternal and fetal hypothyroidism. Severe iodine deficiency is associated with poor obstetric outcomes including spontaneous abortion, prematurity, and stillbirth (WHO, 2007).

Thyroid hormone plays an essential role in neuronal migration, myelination, and synaptic transmission and plasticity (Escobar et al, 2007; Rapozo et al 2006). Animal models have demonstrated that even mild and transient maternal hypothyroxinemia during pregnancy can disrupt neuronal migration in the fetus, resulting in ectopic neurons in different cortical layers including the subcortical white matter and hippocampus (Aus´o et al, 2004). Therefore, iodine deficiency is associated with adverse effects on the fetus including congenital anomalies, decreased intelligence, and neurological cretinism (WHO, 2007). Despite global public health efforts, iodine deficiency remains the leading preventable cause of mental retardation worldwide (Pearce, 2009).

Studies on iodine nutrition in pregnancy, based on median urinary iodine concentration (MUI), have been far and few. The National Health and Nutrition Examination Survey (NHANES) I (1971-1974) showed the median UIC in pregnancy to be 327μg/L compared to 293μg/L in non-pregnant women (Hollowell JG et al, 1998). In the NHANES III (1988-1994), the median UIC in pregnancy was 141μg/L compared to 127μg/L in non-pregnant women, while in NHANES 2001-2002, the same were 172.6μg/L and 132μg/L, respectively. Consequently, the median UIC level in children cannot be used to define normal iodine nutrition in pregnancy. Based on these and other studies, the WHO revised the reference range of MUI for adequate iodine nutrition in pregnancy from 150 to 250μg/L and the Recommended Dietary Allowance (RDA) for iodine in pregnancy from 200 to 250μg (WHO, 2007).

The comparison of median UIC of the present with that reported by other investigators is depicted in **Figure 31**.

Figure 31: Comparison of median UIC level of pregnant mothers of the present with that reported by other investigators



Median Urinary iodine concentration (UIC) level of <150µg/L indicates iodine deficiency in the population

Source: Uttarakhand; Pathak et al, 2003; Kashmir; Charoo et al, 2013; Himachal Pradesh; Kapil et al, 2014; Delhi; Kant et al, 2003; Haryana; Srinath et al, 2004; Rajasthan; Singh et al, 2009; Gujarat; Joshi et al, 2014; Karnataka; Jaiswal et al, 2015

Iodine is an essential micronutrient throughout life. During pregnancy, various physiological changes result in increased iodine requirements. Increase in renal blood flow and GFR results in increased UIC, as most iodine is excreted by a passive process in the urine. Increased maternal thyroid hormone synthesis to maintain euthyroidism and provide thyroid hormones to the fetus as well as transfer of iodine to the fetus and to the increasing iodine requirements during pregnancy (Glinoer, 1997; Hollowell et al, 1998).

Recent data have suggested that the normal range for pregnant and lactating women should reflect their additional need and the risk that these needs may not be met if population levels are too low. However, this leaves a relatively narrow range for a median UIC level that will both meet the needs for pregnant/lactating women, and not be excessive for the remainder of the population (WHO, 2007).

Urinary iodine concentration is currently the most practical biochemical marker for iodine nutrition when carried out with appropriate technology and sampling. This approach assesses iodine nutrition only at the time of measurement, whereas thyroid

size reflects iodine nutrition over months or years. Therefore, even though populations may have attained iodine sufficiency on the basis of median urinary iodine concentration, goitre may persist (WHO, 2007).

In the present study the observed median UIC levels were found to be 124µg/l (Udham Singh Nagar), 117.5µg/l (Nainital), 110µg/l (Pauri Garhwal) indicating iodine deficiency in all the districts surveyed.

Similar findings were reported by Kapil et al, 2014 in a study conducted in three districts of Himachal Pradesh amongst pregnant mothers. The median UIC level was reported to be 200µg/l (Kangra), 149µg/l (Kullu) and 130µg/l (Solan), indicating that pregnant mothers in Kullu and Solan districts had iodine deficiency as indicated by a median urinary iodine concentration less than 150µg/l (Kapil et al, 2014). Another recent study conducted by Majumder et al, 2014 amongst 237 pregnant women of Kolkata reported that out of 237 pregnant mothers, 88 (37.0%) exhibited insufficient iodine nutrition (UIC <150 µg/l). A study conducted in United Kingdom has documented that children of mothers who had ID during pregnancy are more likely to have low verbal intelligent quotient and poor reading accuracy and comprehension (Bath et al, 2013).

A departmental study conducted (Nair and Sarraju 2008) in Vadodara, revealed prevalence of urinary iodine insufficiency amongst pregnant women was 62.1%. This depicted a very high prevalence of iodine insufficiency after two years of USI reimplementation. However, study conducted (2011) in Vadodara by Agarwal and Nair revealed prevalence of urinary iodine insufficiency to be <20%. This is suggestive of the success of their efforts towards improving salt iodization at production level and usage of iodized salt at consumer level amongst population in Vadodara city (Nair and Joshi, 2007-2011). Considering sustained salt iodization program in the city, there were 16.7% subjects found on insufficient levels of urinary iodine, which is significantly lower compared to previous study (2008).

Earlier community based study was conducted amongst pregnant mothers in Udham Singh Nagar, Uttaranchal reported the median UIC level as 95µg/l (Pathak et al, 2003). The study also reported that 57.4% of the pregnant mothers had UIC levels <100µg/l indicating iodine deficiency amongst pregnant mothers studied.

Another study conducted in Bombay amongst 429 pregnant mothers reported the median UIC level as <100µg/l (Dodd et al, 1993). Another hospital based study from West Bengal amongst full term pregnant women reported the median UIC as 144µg/dl (Chakraborty et al, 2006). A review study conducted by Yadav et al, 2012 reported that median urinary iodine levels of pregnant women in different states of India ranges from 95-178µg/l.

A community based study conducted in Jodhpur district; Rajasthan reported the median UIC level as 117µg/l (Singh et al, 2009). Another study from Rajasthan amongst pregnant mothers documented the median UIC as 127µg/l (Ategbo et al, 2008) indicating iodine deficiency amongst pregnant mothers in both the districts of Rajasthan.

A study by Kapil et al (1999) reported that 22.9% of the pregnant mothers in Delhi had urinary iodine concentration levels less than 100 µg/L. Another study found iodine deficiency in 9.5% of the PW as revealed by UIC levels less than 100 µg/L (Kapil et al, 1997).

Another recent study by Joshi et al, 2014 conducted in Vadodara district of Gujarat reported the median UIC amongst pregnant mothers as 297.14µg/l indicating adequate iodine nutritional status amongst pregnant mothers of Vadodara district. Similar findings i.e adequate iodine status amongst pregnant mothers was also reported from Bangalore (Jaiswal et al, 2015). A hospital based study conducted in Delhi amongst pregnant mothers also reported the adequate iodine status with median UIC level as 304µg/l (Grewal et al, 2013).

Comparison of results of iodine deficiency status as per urinary iodine concentration level in different trimesters of pregnancy of the present study with other studies

Trimester-specific MUI has been reported only in a few studies worldwide and from India (Kapil et al, 2014; Shamim et al, 2012; Mehdi et al; 2009; Glinoer et al; 1990). In pregnant women with iodine restriction, the UIC may transiently show an early increase, due to an increase in the glomerular filtration rate, and thereafter, a steady decrease in UIC from the first to the third trimesters of gestation, thus revealing the

underlying tendency toward iodine deficiency associated with the pregnant state, whereas, in iodine-sufficient areas there may be no decline (Grewal et al, 2013).

In the present study 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).

Studies in populations with mild iodine deficiency from communities in Switzerland, (Brander et al, 2003) United Kingdom, (Smyth et al, 1999) and Hong Kong, (Kung et al, 2000) which provide gestation-specific data, show an overall increase in ioduria in pregnancy, as compared to non-pregnant women of reproductive age.

In a prospective study from iodine-replete Iran, median UIC in the three trimesters were 193μg/L, 159μg/L, and 141μg/L, respectively, a decrescendo pattern, with significant inter-trimester variation and values reaching inadequate levels in the third trimester (Ainy et al, 2007). Another prospective study from the iodine-deficient Tasmania revealed that the median UIC declines initially up to week 22, and subsequently rises up to week 34, only to fall again till term; (Stilwell et al, 2008) the data from the iodine-sufficient Hong Kong, revealed an increasing level of ioduria with advancing gestation.

A study by Kung et al, 2000 found median UIC level of 285μg/L, 318μg/L and 304.5μg/L in the three trimesters; levels above normal in all trimesters, with a peak in mid-pregnancy. The explanation for these differences is unclear, but ethnic variation in the diet structure or degree of overall iodine deficiency may play a role. Although no reference ranges for trimester-specific median UIC are available; they need to be generated using an iodine-sufficient pregnant population. Such a population must have a median UIC at least similar to non-pregnant women, with values not declining during pregnancy. Taking these into consideration, our population can be termed as iodine-sufficient, as there has been no difference in the median UIC of the controls

and there has been no inter-trimester variation, without any values in the insufficient range (Kung et al, 2000).

A recent study was conducted by Kapil et al, 2014 amongst pregnant mothers of three districts namely: Kangra, Kullu and Solan, Himachal Pradesh state. They reported that the median UIC level in district Kangra was 200µg/L in first, second and third trimester of pregnancy. In district Kullu the median UIC level was 162.5µg/L (1st trimester), 140.0µg/L (2nd trimester) and 145.0µg/L (3rd trimester), respectively. Similarly, in district Solan, it was reported to be 123.7µg/L (1st trimester), 135.0µg/L (2nd trimester) and 132.5µg/L (3rd trimester) amongst pregnant mothers, respectively. Thus in district Kullu and Solan there was a rise in median UIC level from 1st trimester to 2nd trimester and further there was a decline in median UIC level from 2nd trimester to 3rd trimester of pregnancy (Kapil et al, 2014).

Similar results were reported by a study conducted by Grewal et al, 2013 amongst 50 pregnant mothers. They reported that UIC in the first, second and third trimester was 285µg/L, 318µg/L and 304µg/L, respectively. Thus indicating a rise from the first trimester to the second trimester, followed by a small fall again in the third trimester, but it was not statistically significant.

A study conducted by Majumder et al, 2014, reported that insufficient iodine nutrition was most prevalent in the 3rd trimester (40.0%). The figures for insufficient iodine nutrition increased from 30% in first trimester to 37.0% in second trimester and to 40% in third trimester. This is consistent with data showing that the requirement of iodine increases with the progression of pregnancy.

A study by Smyth et al, 1997, conducted amongst pregnant mothers of Ireland also reported the similar results. They reported that median UIC level in the first, second and third trimester was 150µg/L, 120µg/L and 115µg/L, respectively. Thus a decreasing trend of median UIC level was observed with the increase in gestational age.

In the study by Tahrim et al, 2009 in Bangladesh, it was found that the thyroid hormones (serum FT 3, FT 4) was decreased and serum TSH was increased significantly in 3rd trimester of pregnancy compared to 1st trimester. The study documented the changes in urinary iodine concentration and in thyroid hormones

during the course of pregnancy. These changes involving FT 3, FT4 TSH & urinary iodine are well harmonious with the speculated iodine deficiency and the consequent low thyroidal activity during normal pregnancy. It was also found that the median UIC level was found to be 143 (1st trimester), 132 (2nd trimester) and 120 (3rd trimester) of pregnancy. Thus, reporting a decreasing trend of median UIC level with increasing gestational age.

In different studies pregnant women was found to be iodine deficient progressively with advancing gestational age probably because of the failure of adequate dietary iodine intake particularly in advanced pregnancy. This could be due to the non appetizing and anorexic problems incident to the pathophysiological changes during pregnancy (Azizi et al, 2002; Eltom et al, 2000, Glinoer et al, 1995; Pathak et al, 2003; Caron et al, 1997; Dunn et al, 1998; Pedersen et al, 1993).

A study conducted by Glinoer et al, 1990 in Belgium amongst 230, 265 and 370 pregnant mothers reported the median UIC level as 58 μg/L (1st and 2nd trimester) and 53 μg/L (3rd trimester), respectively. Thus, indicating a decreasing trend of median UIC level with increase in gestational age.

A study by Saira et al, 2014 reported that the maximum population of pregnant women in 1st and 2nd trimester had urinary iodine concentration ranged from 100-199μg/L. In the 3rd trimester maximum population had urinary iodine concentration of 59.9μg/L. Overall median urinary iodine concentration in pregnant women was 89.5μg/L.

A recent study conducted by Shamim et al, 2012 in Bangladesh among pregnant women in early (≤16 weeks, n=1376) and late (≥32 weeks, n=1114) pregnancy reported that median urinary iodine concentrations were 66 and 55 μg/L in early and late pregnancy, respectively; urinary iodine <150 μg L^{-1} was found in ~80% of women at both times in pregnancy.

Comparison of results of iodized salt intake of pregnant mothers enrolled in the present study with other studies

In the present study 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.

Similar results were documented by the study conducted by Kapil et al, 2014 amongst pregnant mothers of Himachal Pradesh state. It was reported that the percentage of families consuming adequately iodized salt (>15ppm) were 68.3 (Kangra), 60.3 (Kullu district) and 48.5 (Solan district) percent, respectively.

A study conducted in Rajasthan by Singh et al, 2009 and Ategbo et al, 2008 reported that the percentage of pregnant mothers consuming adequately iodized salt (>15ppm) was 77.3% and 59.5%, respectively.

Other studies reported that the percentage of families consuming adequately iodized salt (>15ppm) were 58.9% (Raipur), 77.3% (Haryana), 95% (Delhi) and 89.0% (Delhi), respectively (Sinha et al, 2011; Srinath et al, 2004; Kant et al, 2003; Kapil et al, 1999).

A review study conducted by Kapil et al, reported that only five out of nine studies reported percentage of pregnant women consuming adequately iodized salt. The percentage of pregnant women consuming iodized salt ranged from 59.5 to 95% (Kapil et al, 2013).

Further comparison of results of the present study with other studies is depicted in **Table 32**.

Table 32: Comparison of results of the present study with other similar studies conducted in India

Author/ year	Study setting	Study Area	TGR (%)	Median UIC (µg/l)	Percentage consuming adequately iodized salt (≥15ppm)
Present study	**CB**	**Uttarakhand**	**16.1(Udham Singh Nagar) 20.2 (Nainital) 24.9(Pauri Garhwal)**	**124(Udham Singh Nagar) 117.5 (Nainital) 110(Pauri Garhwal)**	**50.3(Udham Singh Nagar) 67.0 (Nainital) 57.9(Pauri Garhwal)**
Jaiswal et al, 2015	CB	Bangalore		172	-
Joshi et al, 2014	CB	Vadodara, Gujarat	-	297.14	-
Kapil et al, 2014	CB	Himachal Pradesh	42.2(Kangra) 42.0 (Kullu) 19.9 (Solan)	200 (Ka) 149(Ku) 130 (S)	68.3 (Ka) 60.3 (Ku) 48.5 (S)
Charoo et al, 2013	CB	Kashmir	-	1st Trimester: 139.12 2nd: 143.78	-
Grewal et al, 2013	HB	North India	-	304	-
Menon et al , 2011	CB	Nagpur		1ST: 106 µg/L 2nd: 71 3rd: 69	
Sinha et al, 2011	CB	Raipur		0.17	58.9
Singh et al, 2009	CB	Jodhpur, Rajasthan	3.1	117.5	77.3
Ategbo et al, 2008	CB	Jodhpur, Rajasthan	-	127	59.5
Chakraborty et al, 2006	HB	WB	-	144	-
Srinath et al, 2004	HB	Haryana	22	178	64
Pathak et al, 2003	CB	Uttaranchal	14.6	95	-
Kant et al, 2003	CB	Delhi	-	139	95
Kapil et al, 1999	HB	Delhi	1.9	-	89
Kapil et al, 1997	HB	HP	-	20.4	-
Dodd et al, 1993	CB	Mumbai	45	-	-

WHO, 2007 TGR of ≥5% and Median UIC of <150µg/l indicates iodine deficiency

4.2 PART 2: IODINE NUTRITIONAL STATUS AMONGST NEONATES

This part is further divided into following sections:

General Characteristics of the neonates enrolled in the study

Iodine status of neonates by Thyroid Stimulating Hormone

Block wise prevalence of Iodine deficiency amongst neonates using TSH

Effect of other factors on TSH levels of the neonates

Effect of Gestational age on TSH levels

Effect of Gender on TSH levels

Effect of Birth Weight on TSH level

Neonatal Hypothyroidism

4.2.1 General Characteristics of the neonates enrolled in the study

In the present study a total of six hospitals were selected from each district for the collection of cord blood samples. District Udham Singh Nagar is a plain area and is situated at an altitude of 1129ft above sea level. Whereas, districts Nainital and Pauri Garhwal is a hilly terrain and is situated at an altitude of 6837ft and 5951ft above sea level, respectively.

A total of 649 (Udham Singh Nagar), 670 (Nainital) and 694 (Pauri Garhwal) neonates were selected for TSH estimation using cord blood samples. Thus a total of 2013 neonates were selected for estimation of TSH levels from all the three districts selected (**Table 33)**. One district hospital was selected from each district. In district Udham Singh Nagar, maximum samples were from district hospital Rudrapur. Whereas, in districts Nainital and Pauri Garhwal maximum samples were from CHC Haldwani and CHC Kotdwar, respectively.

Table 33: Health institutions included in districts Udham Singh Nagar, Nainital and Pauri Garhwal

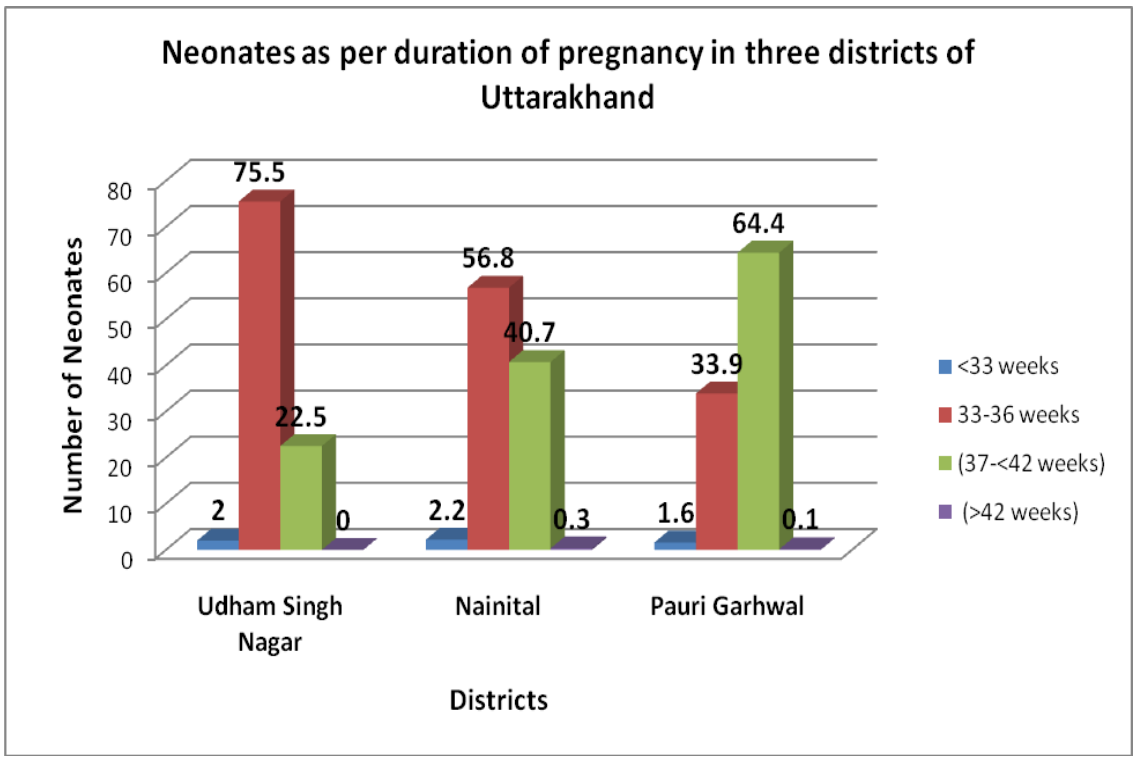
Udham Singh Nagar (N=649)		**Nainital (N=670)**		**Pauri Garhwal (N=694)**	
Hospital Names	**n (%)**	**Hospital Names**	**n (%)**	**Hospital Names**	**n(%)**
District Hospital Rudrapur	209 (32.2)	District Hospital Nainital	60 (8.9)	District Hospital Pauri	149 (21.5)
CHC, Khatima	60 (9.3)	CHC Bhimtal	36 (5.4)	CHC, Pabau	50 (7.2)
CHC, Gadarpur	50 (7.7)	CHC, Kaladungi	50 (7.5)	CHC, Patisain	49 (7.1)
CHC, Kashipur	170 (26.2)	CHC, Ramnagar	188 (28.0)	CHC, Satpuli	39 (5.6
CHC, Kichha	80 (12.3)	CHC, Kotabagh	49 (7.3)	CHC, Kotdwar	357 (51.4)
CHC, Sitargunj	80 (12.3)	CHC, Haldwani	287 (42.8)	CHC, Rikhnikhal	50 (7.2)
	649		**670**		**694**

Figures in parentheses denotes percentage; CHC: Community Health Center

4.2.1.1 Neonates as per duration of pregnancy

The distribution of neonates according to duration of pregnancy is depicted in **Figure 32**. It was found that 77.5 (Udham singh Nagar), 59.0 (Nainital) and 35.5 (Pauri Garhwal) percent of neonates were in <37 weeks, 22.5 (Udham singh Nagar), 40.7 (Nainital) and 64.4 (Pauri Garhwal) percent of neonates were in 37-<42 weeks. Only two subjects from Nainital and one from Pauri Garhwal were in ≥42 weeks.

Figure 32: Neonates as per duration of pregnancy in the three districts of Uttarakhand



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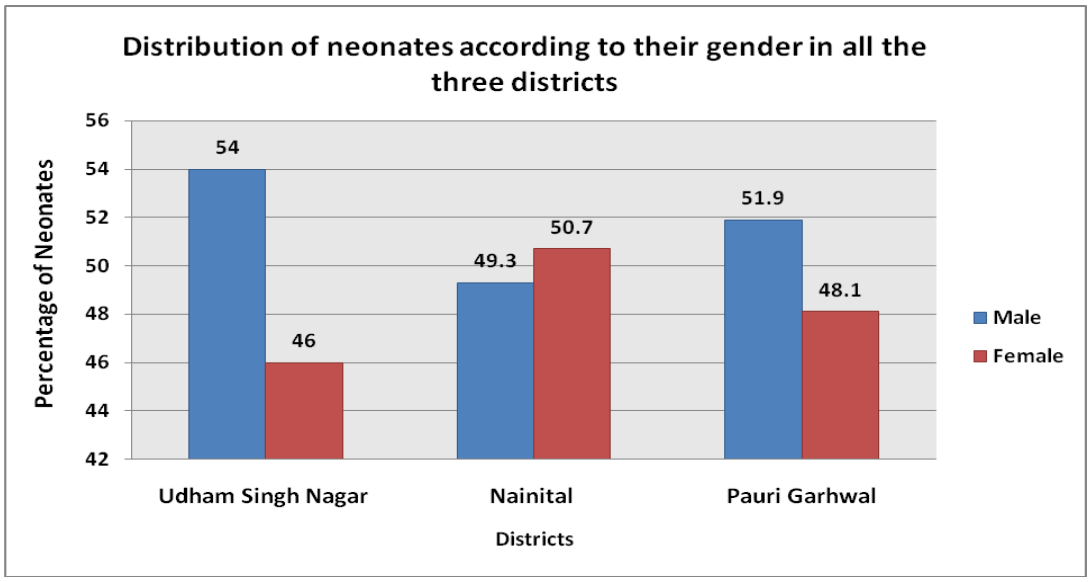
4.2.1.2 Neonates as per gender

The distribution of neonates according to gender is depicted in **Figure 33**.

It was found that the percentage of males was higher compared to females in districts Udham Singh Nagar and Pauri Garhwal, whereas in district Nainital, percentage of females was higher compared to males. Thus, out of 2013 neonates studied, the percentage of males (51.9%) was more compared to females (48.1%). The male to female ratio was 1:1.7 from the three districts selected for the study.

Figure 33: Distribution of neonates as per gender in all the three districts selected



4.2.1.3 Neonates as per birth weight

The number of neonates as per their birth weight is depicted in **Table 34**.

It was found that higher percentage of neonates was born with normal birth weight in all the three districts. Only two neonates from districts Nainital and Pauri Garhwal were born with very low birth weight. The mean birth weights of the neonates were found to be 2.8kg (Udham Singh Nagar), 2.9 kg (Nainital) and 2.8kg (Pauri Garhwal), respectively.

Table 34: Distribution of neonates according to birth weight in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Birth Weight	Category	Udham Singh Nagar (N=649)	Nainital (N=670)	Pauri Garhwal (N=694)
		n (%)	n (%)	n (%)
Very Low	<1.5 kg	0	2(0.2)	2(0.3)
Low	1.5- <2.5 kg	70 (10.8)	50(7.5)	48(6.9)
Normal	≥2.5kg	579(89.2)	618(92.3)	644(92.8)
Total		**649**	**670**	**694**

Figures in parentheses denotes percentage

4.2.2 Iodine status of neonates by Thyroid Stimulating Hormone

The distribution of neonates according to TSH levels is depicted in Table 35 and Figure 34. According to WHO (2007) >3% frequency of TSH concentrations above 5mIU/L indicates iodine deficiency in a population**.** It was found that higher percentage of neonates with TSH level >5µIU/L was found from district Nainital followed by districts Pauri Garhwal and Udham Singh Nagar. Thus indicating higher prevalence of iodine deficiency amongst neonates in all the three districts studied **(Table 35)**.

It could also be said that higher prevalence of iodine deficiency amongst neonates was observed from Hilly terrain (Nainital and Pauri Garhwal) compared to plain area (Udham Singh Nagar).

Combining all the three districts it was found that 68.3 percent of neonates had TSH level of >5µIU/L indicating iodine deficiency in the population studied **(Figure 34)**.

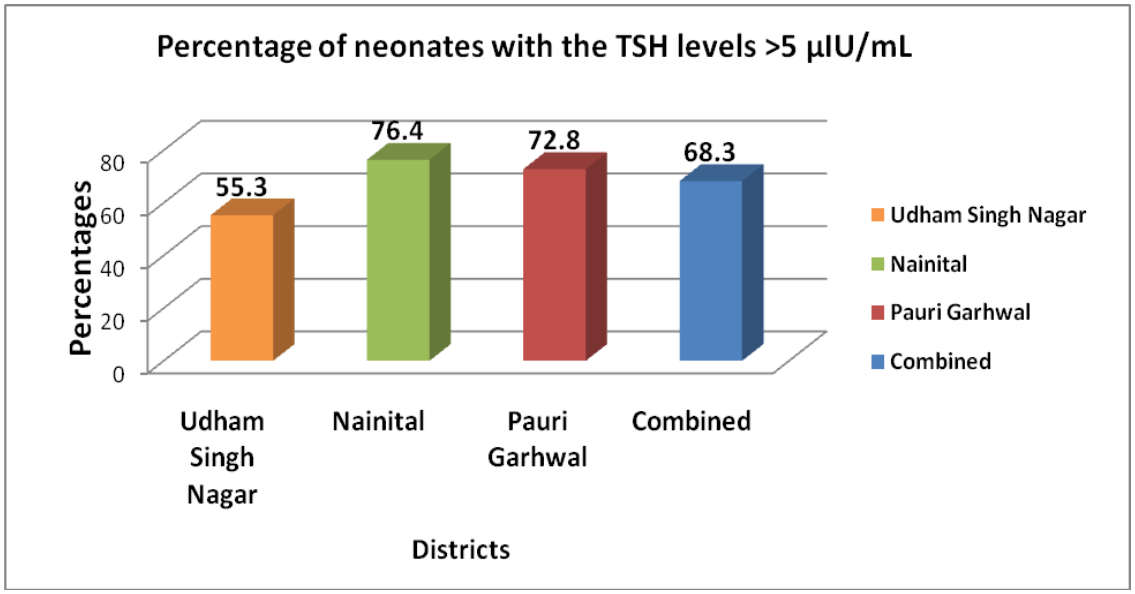
Table 35: Iodine status of neonates according to TSH levels in all the three districts

TSH Levels	Udham Singh Nagar (N=649)	Nainital (N=670)	Pauri Garhwal (N=694)	Combined (all the three districts) (N=2013)
	n (%)	n (%)	n (%)	n (%)
Less than 5µIU/L	290 (44.7)	158 (23.6)	189 (27.2)	637(31.6)
5- <10µIU/L	214 (33.0)	241 (36.0)	215 (31.0)	670(33.3)
10 -<20µIU/L	125 (19.3)	250 (37.3)	241 (34.7)	616(30.6)
20 and above µIU/L	20 (3.0)	21 (3.1)	49 (7.1)	90(4.5)
Total	**649**	**670**	**694**	**2013**

Figures in parentheses denotes percentage

WHO, 2007: >3% frequency of TSH concentrations above 5mIU/L indicates iodine deficiency in a population

Figure 34: Percentage of Neonates with TSH level >5mIU/L in all the three districts



**** WHO (2007): >3% frequency of TSH concentrations above 5mIU/L indicates iodine deficiency***

MAJOR FINDINGS

Thyroid Stimulating Hormone:

- According to WHO (2007), >3% frequency of TSH concentrations above 5mIU/L in samples collected 3-4 days after birth indicates iodine deficiency in a population.
- 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 ID in all the three districts.
- Comparing between the three districts, higher prevalence was reported from district Nainital which is at higher altitude, followed by districts Pauri Garhwal and Udham Singh Nagar. Thus higher the altitude of the district higher is the prevalence of ID amongst neonates could be observed.
- Moreover when combining all the three districts of Uttarakhand, it was found that 68.3% of the neonates had TSH level of >5mIU/L indicating iodine deficiency amongst the neonates studied.

4.2.3 Block wise prevalence of iodine deficiency amongst neonates using TSH levels

The blockwise distribution of TSH levels amongst neonates is depicted in **Table 36**. It was found that in district Udham Singh Nagar the highest percentage of neonates with TSH level >5µIU/L was from CHC Kashipur. Whereas in district Nainital, it was from CHC Haldwani and in district Pauri Garhwal, it was from CHC Kotdwar. This could be due to low availability and consumption of iodized salt in these areas compared to other areas selected.

Table 36: Block wise prevalence of iodine deficiency amongst neonates using TSH levels

Block	Neonates n (%)	TSH level (>5 µIU/L) n (%)
District Udham Singh Nagar		
District Hospital, Rudrapur	209 (32.2)	19 (5.3)
CHC, Khatima	60 (9.3)	56 (15.5)
CHC, Gadarpur	50 (7.7)	36 (10.0)
CHC, Kashipur	170 (26.2)	120 (33.3)
CHC, Kichha	80 (12.3)	59 (16.4)
CHC, Sitargunj	80 (12.3)	70 (19.5)
Total	**649**	**360**
District Nainital		
District Hospital Nainital	60 (8.9)	27 (5.3)
CHC Bhimtal	36 (5.4)	17 (3.3)
CHC, Kaladungi	50 (7.5)	21 (4.1)
CHC, Ramnagar	188 (28.0)	166 (32.4)
CHC, Kotabagh	49 (7.3)	40 (7.8)
CHC, Haldwani	287 (42.8)	241 (47.0)
Total	**670**	**512**
District Pauri Garhwal		
District Hospital Pauri	149 (21.5)	62 (12.3)
CHC, Pabau	50 (7.2)	25 (4.9)
CHC, Patisain	49 (7.1)	44 (8.7)
CHC, Satpuli	39 (5.6)	30 (5.9)
CHC, Kotdwar	357 (51.4)	312 (61.8)
CHC, Rikhnikhal	50 (7.2)	32 (6.3)
Total	**694**	**505**

Figures in parentheses denotes percentage

4.2.4 Effect of other factors on TSH levels of the neonates

4.2.4.1 Effect of gestational age on TSH levels

The effect of gestational age on TSH levels of neonates is depicted in **Table 37**.

It was found that in district Udham Singh Nagar, 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.

Thus it could be observed that in districts Udham Singh Nagar and Nainital, higher percentage of neonates with TSH level of >5µIU/L was from neonates with <37 weeks of gestation. But in district Pauri Garhwal higher percentage of neonates with TSH level >5µIU/l were term.

It was also found that there was no statistical significant difference in the TSH levels and gestational age 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 in the TSH levels and gestational age (p=0.001).

However, a weak correlation was found between gestational age and TSH levels in districts Udham Singh Nagar (r=0.023, p=0.542) and Pauri Garhwal (r=0.147, p=<0.001). A negative correlation was found between gestational age and TSH levels in district Nainital (r= -0.007, p=0.838). Combining all the three districts, a weak correlation was found between gestational age and TSH levels (r=0.098, p=<0.001). It was found that as the gestational age increases the mean TSH level also increases in all the three districts studied. The TSH levels of neonates according to gestational age and gender in all the three districts is depicted in **Table 38.**

Table 37: Relationship between gestational age and TSH levels of neonates in all the three districts

Duration of pregnancy	TSH levels (µIU/L)				p-value
	Udham Singh Nagar (N=649)				
	Less than 5 (n=289)	5- <10 (n=215)	10 -<20 (n=125)	20 and above (n=20)	
<37weeks (n=503)	227(35.0)	171(26.3)	93(14.3)	12(1.8)	0.223^{NS}
37-<42 weeks(n=146)	62(9.6)	44(6.8)	32(4.9)	8(1.2)	
42 and above weeks (n=0)	0	0	0	0	
--	Nainital (N=670)				
	Less than 5 (n=158)	5- <10 (n=241)	10 -<20 (n=250)	20 and above (n=21)	
<37 weeks (n=395)	107(16.0)	133(19.9)	145(21.6)	10(1.5)	0.092^{NS}
37-<42 weeks(n=273)	51(7.6)	106(15.8)	105(15.7)	11(1.6)	
42 and above weeks (n=2)	0	2(0.3)	0	0	
	Pauri Garhwal (N=694)				
	Less than 5 (n=188)	5- <10 (n=216)	10 -<20 (n=241)	20 and above (n=49)	
<37 weeks)(n=246)	97 (14.0)	70 (10.1)	62 (8.9)	17 (2.5)	0.001**
37-<42 weeks(n=447)	90 (13.0)	146 (21.0)	179 (25.8)	32 (4.6)	
42 and above weeks (n=1)	1(0.1)	0	0	0	
	Combined (all the three districts) (N=2013)				
	Less than 5 (n=635)	5- <10 (n=672)	10 -<20 (n=616)	20 and above (n=90)	
<37 weeks (n=1144)	431(37.7)	374(32.7)	300(26.2)	39(3.4)	0.001**
37-<42 weeks(n=865)	203(23.5)	295(34.1)	316(36.5)	51(5.9)	
42 and above weeks (n=4)	1(25.0)	3(75.0)	0	0	

Figures in parentheses denotes percentage

Table 38: TSH levels of neonates according to gestational age and gender in all the three districts

Gestational Age	Gender	n (%)	TSH (µIU/L) Mean±SD	TSH Median
Udham Singh Nagar (N=649)				
<37 weeks (n=503)	Male	270 (53.7)	7.49 ± 5.8	5.51
	Female	233 (46.3)	6.54 ± 4.4	5.10
	Total	**503(77.5)**	**7.26 ± 5.4**	**5.48**
37-42 weeks (n=146)	Male	81 (55.5)	7.49 ± 5.1	6.06
	Female	65 (44.5)	8.59 ± 6.9	6.43
	Total	**146 (22.5)**	**7.27 ± 5.4**	**5.46**
>42weeks (n=0)	Male	0	0	0
	Female	0	0	0
	Total	0	0	0
Nainital (N=670)				
<37weeks (n=395)	Male	198 (50.1)	9.58 ± 6.0	8.44
	Female	197 (49.9)	9.76 ± 6.2	8.37
	Total	**395 (58.9)**	**9.98 ± 6.3**	**8.52**
37-42 weeks (n=273)	Male	132 (48.3)	11.58 ± 7.9	9.67
	Female	141 (51.7)	9.80 ± 6.2	8.44
	Total	**273 (40.7)**	**10.08 ± 6.6**	**8.54**
>42weeks (n=2)	Male	0	0	0
	Female	2 (100.0)	0	0
	Total	**2 (0.3)**	**0**	**0**
Pauri Garhwal (N=694)				
<37 weeks (n=246)	Male	124 (17.9)	9.02 ± 7.6	6.61
	Female	122 (17.6)	8.38 ± 6.0	6.49
	Total	**246 (35.4)**	**10.17 ± 6.8**	**8.20**
37- 42 weeks (n=447)	Male	235 (33.9)	10.80 ± 6.3	9.39
	Female	212 (30.5)	11.17 ± 7.1	9.4
	Total	**447 (64.4)**	**10.18 ± 6.8**	**8.27**
>42weeks (n=1)	Male	1 (0.1)	0	0
	Female	0	0	0
	Total	**1 (0.2)**	**0**	**0**

Figures in parentheses denotes percentage

MAJOR FINDINGS

- In **district Udham Singh Nagar**, 42.5% (<37weeks) and 12.9% (37-42weeks) neonates had TSH level of >5µIU/L. Whereas, in **district Nainital**: 43.0% (<37weeks), 33.1% (37-42weeks) and 0.3% (>42 weeks) neonates had TSH level of >5µIU/L. Similarly in **district Pauri Garhwal**, 21.5% (<37weeks) and 51.4% (37-42weeks) 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 in <37weeks. But in district Pauri Garhwal higher percentage of neonates with TSH level >5µIU/l were in 37-42weeks.

- No statistical significant difference in the TSH levels and gestational age was found in districts Udham Singh Nagar (p=0.223) and Nainital (p=0.092). Whereas, a statistical significant difference between TSH levels and gestational age was found in district Pauri Garhwal (p=0.001).

- Combining all the three districts surveyed, a statistical significant difference was observed in the TSH levels and gestational age (p=0.001).

4.2.4.2 Effect of Gender on TSH levels

The TSH level of neonates according to the gender is depicted in **Table 39 and 40**. It was found that 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. Thus, it was found that higher percentage of males had TSH >5µIU/L compared to females in all the three districts studied. But there was no statistical significant difference between 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).

However, a correlation was found between gender and TSH levels in districts Udham Singh Nagar (r= -0.045, p=0.238), Nainital (r= -0.046, p=0.237) and Pauri Garhwal (r= -0.001, p=0.975). Combining all the three districts, a correlation was found between gender and TSH levels (r= -0.021, p=<0.328).

Table 39: Relationship between gender and TSH levels of neonates in all the three districts

TSH Cut offs (µIU/L)	Gender	
Udham Singh Nagar (N=649)		
	Male (n=351)	**Female (n=298)**
Less than 5 µIU/L (n=289)	150 (42.7)	139 (47.0)
5- <10 µIU/L (n=206)	116 (33.0)	90 (33.2)
10 -<20 µIU/L (n=125)	72 (20.5)	53 (17.8)
20 and above µIU/L (n=20)	13 (3.7)	7 (2.3)
p-value	**0.548^{NS}**	
Nainital (N=670)		
	Male (n=330)	**Female (n=340)**
Less than 5 µIU/L (n=168)	77 (23.3)	91 (27.2)
5- <10 µIU/L (n=213)	113 (34.3)	100 (29.9)
10 -<20µIU/L (n=246)	128 (38.8)	118 (35.3)
20 and above µIU/L (n=37)	12 (3.6)	25 (7.5)
p-value	**0.692 ^{NS}**	
Pauri Garhwal (N=694)		
	Male (n=360)	**Female (n=334)**
Less than 5µ µIU/L (n=178)	97 (26.9)	81 (23.8)
5- <10 µIU/L (n=244)	116 (32.2)	128 (37.6)
10 -<20µIU/L (n=245)	123 (34.2)	122 (35.9)
20 and above µIU/L (n=31)	24 (6.7)	7 (2.3)
p-value	**0.913 ^{NS}**	
Combined (all the three districts) (N=2013)		
	Male (n=1041)	**Female (n=972)**
Less than 5 µIU/L (n=635)	324 (51.0)	311 (48.9)
5- <10 µIU/L (n=672)	345 (51.3)	327 (48.7)
10 -<20µIU/L (n=616)	323 (52.4)	293 (47.6)
20 and above µIU/L (n=90)	49 (54.4)	41 (45.6)
p-value	**0.906 ^{NS}**	

Figures in parentheses denotes percentage

Table 40: Mean TSH levels according to gender of neonates in all the three districts

TSH levels	Gender	n(%)	Mean ± SD	Median
Udham Singh Nagar (N=649)				
Less than 5µIU/L (n=290)	Male	150 (51.7)	3.03 ± 1.06	2.9
	Female	140 (48.3)	3.18 ± 1.01	3.0
	Total	**290 (44.7)**	**3.10 ± 1.03**	**3.0**
5-<10µIU/l (n=214)	Male	116 (54.2)	7.14 ± 1.48	6.8
	Female	98 (45.8)	7.16 ± 1.48	7.0
	Total	**214 (33.0)**	**7.14 ± 1.48**	**6.9**
10 -<20µIU/l (n=125)	Male	72 (57.6)	14.4 ± 2.88	13.8
	Female	53 (42.4)	14.3 ± 2.96	14.1
	Total	**125 (19.3)**	**14.3 ± 2.90**	**13.8**
20 and above µIU/L (n=20)	Male	13 (65.0)	24.0 ± 5.52	21.0
	Female	7 (35.0)	24.7 ± 3.86	22.5
	Total	**20 (3.0)**	**24.2 ± 4.90**	**21.5**
Nainital (N=670)				
Less than 5µIU/L (n=158)	Male	77 (48.7)	3.2 ± 1.1	3.1
	Female	81 (51.3)	2.8 ± 1.1	2.5
	Total	**158 (23.6)**	**3.3 ± 1.3**	**3.1**
5-<10µIU/l (n=241)	Male	113 (46.9)	7.5 ± 1.4	7.7
	Female	128 (53.1)	7.4 ± 1.3	7.5
	Total	**241 (36.0)**	**7.5 ± 1.6**	**7.6**
10 -<20µIU/L (n=250)	Male	128 (51.2)	15.1 ± 2.9	15.7
	Female	122 (48.8)	15.3 ± 2.6	16.0
	Total	**250 (37.3)**	**14.6 ± 3.6**	**15.2**
20 and above µIU/L (n=21)	Male	12 (57.1)	32.4 ± 8.6	27.8
	Female	9 (42.9)	29.3 ± 5.4	27.8
	Total	**21 (3.1)**	**27.6 ± 8.2**	**26.2**
Pauri Garhwal (N=694)				
Lessthan 5µIU/L (n=189)	Male	97 (51.3)	3.0 ± 1.0	2.9
	Female	92 (48.7)	3.1 ± 1.0	2.9
	Total	**189 (27.2)**	**3.0 ± 1.0**	**2.9**
5- <10µIU/L (n=215)	Male	116 (54.0)	7.4 ± 1.4	7.3
	Female	99 (46.0)	7.0 ± 1.3	6.7
	Total	**215 (31.0)**	**7.2 ± 1.3**	**7.0**
10 -<20µIU/L (n=241)	Male	123 (51.0)	15.2 ± 2.4	15.1
	Female	118 (49.0)	14.8 ± 2.6	14.9
	Total	**241(34.7)**	**15.0 ± 2.5**	**15.0**
20 and above µIU/L (n=49)	Male	24 (49.0)	26.4 ± 4.7	24.8
	Female	25 (51.0)	26.1 ± 3.1	24.9
	Total	**49(7.1)**	**26.3 ± 3.9**	**25.0**

Figures in parentheses denotes percentage

MAJOR FINDINGS

- 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 in the TSH levels and gender in all the three districts; Udham Singh Nagar (p=0.548), Nainital (p=0.692) and Pauri Garhwal (p=0.913).

4.2.4.3 Effect of Birth Weight on TSH levels

Table 41 depicts the TSH levels of neonates according to the birth weight. It was found that only 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).

But, combining all the three districts studied, a statistical significant difference was observed in the TSH levels and birth weight (p=0.001).

However, a correlation was found between birth weight and TSH levels in districts Udham Singh Nagar (r= 0.884, p=<0.001). Whereas, a weak correlation was found in districts Nainital (r= 0.043, p=0.273) and Pauri Garhwal (r= 0.005, p=0.876).

Combining all the three districts, a weak correlation was found between birth weight and TSH levels (r=0.338, p=<0.001).

The TSH levels according to birth weight and gender in all the three districts is depicted in **Table 42.**

Table 41: Relationship of birth weight with TSH levels of neonates in all the three districts

Birth weight (Kg)	TSH Levels (µIU/L)				p-value
	Udham Singh Nagar (N=649)				
	Less than 5 (n=290)	5- <10 (n=214)	10 -<20 (n=125)	20 and above (n=20)	
Very Low (less than 1.5kg) (n=0)	0	0	0	0	0.152[NS]
Low (1.5-<2.5 kg) (n=70)	24(34.3)	26(37.1)	17(24.3)	3(4.3)	
Normal (2.5 kg and above) (n=579)	266(45.9)	188(32.5)	108(18.6)	17(2.9)	
	Nainital (N=670)				
	Less than 5 (n=158)	5- <10 (n=241)	10 -<20 (n=250)	20 and above (n=21)	
Very Low (less than 1.5kg) (n=2)	2(100)	0	0	0	0.001**
Low (1.5-<2.5 kg) (n=50)	49(98.0)	0	0	1(2.0)	
Normal (2.5 kg and above) (n=618)	107(17.3)	241(39.0)	250(40.4)	20(3.2)	
	Pauri Garhwal (N=694)				
	Less than 5 (n=188)	5- <10 (n=216)	10 -<20 (n=241)	20 and above (n=49)	
Very Low (less than 1.5kg) (n=2)	0	1(50.0)	1(50.0)	0	0.965[NS]
Low (1.5-<2.5 kg) (n=48)	14(29.2)	15(31.2)	15(31.2)	4(8.3)	
Normal (2.5 kg and above) (n=644)	174(27.0)	200(31.1)	225(34.9)	45(7.0)	
	Combined (all the three districts) (N=2013)				
	Less than 5 (n=635)	5- <10 (n=672)	10 -<20 (n=616)	20 and above (n=90)	
Very Low (less than 1.5kg) (n=4)	2(50.0)	1(25.0)	1(25.0)	0	0.001**
Low (1.5-<2.5 kg) (n=168)	87(51.8)	41(24.4)	32(19.0)	8(4.8)	
Normal (2.5 kg and above) (n=1841)	546(29.7)	630(34.2)	583(31.7)	82(4.4)	

Figure in the parenthesis indicate percentages

Table 42: TSH levels according to birth weight and gender in all the three districts

Birth Weight	Gender	n (%)	TSH (µIU/L) Mean± SD	TSH Median
Udham Singh Nagar (n=649)				
Low Birth Weight (<2.5Kg) (n=70)	Male	34 (48.6)	8.17 ± 4.9	7.01
	Female	36 (51.4)	8.0 ± 5.9	5.64
	Total	**70(10.8)**	**7.1 ± 5.3**	**5.45**
Normal Birth Weight (≥2.5Kg) (n=579)	Male	317 (54.7)	7.42 ± 5.7	5.48
	Female	262 (45.2)	6.85 ± 5.0	5.03
	Total	**579 (89.2)**	**7.26 ± 5.4**	**5.48**
Nainital (n=670)				
Low Birth Weight (<2.5Kg) (n=52)	Male	21 (40.4)	9.3 ± 5.8	7.39
	Female	31 (59.6)	8.7 ± 5.4	6.83
	Total	**52 (7.8)**	**1.71 ± 0.38**	**1.68**
-Normal Birth Weight (>2.5Kg) (n=618)	Male	309 (50.0)	10.4 ± 7.0	8.82
	Female	309 (50.0)	9.8 ± 6.3	8.44
	Total	**618 (92.2)**	**10.7 ± 6.2**	**9.07**
Pauri Garhwal (n=694)				
Low Birth Weight (<2.5Kg) (n=50)	Male	21 (3.0)	10.08 ± 7.0	7.81
	Female	29 (4.2)	9.85 ± 6.9	6.75
	Total	**50 (7.2)**	**10.33 ± 6.8**	**8.64**
Normal Birth Weight (>2.5Kg) (n=644)	Male	339 (48.8)	10.19 ± 6.8	8.36
	Female	305 (44)	10.18 ± 6.9	8.06
	Total	**644 (92.8)**	**10.17 ± 6.8**	**8.25**

Figures in parentheses denotes percentage

MAJOR FINDINGS

- Three 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 in the TSH levels and birth weight of the neonates (p=0.001).

Table 43: Summary of parameters affecting TSH levels on screening of neonates in all the three districts

	Parameter	Number	TSH (mIU/L) Mean(SD)	p-value
Udham Singh Nagar (N=649)	**Birth Weight** (<2.5kg vs ≥2.5kg)	70 ; 579	8.1 (5.6) ; 6.8 (5.5)	0.05[NS]
	Sex (Male vs Female)	351 ; 298	7.4 (5.6); 6.9 (5.1)	0.38 [NS]
	Gestational Age (<37 vs 37-42 weeks)	503 ; 146	7.0 (5.2): 7.9 (6.0)	0.20 [NS]
Nainital (N=670)	**Birth Weight** (<2.5kg vs ≥2.5kg)	52; 618	2.5 (0.3); 10.7 (6.2)	<0.01*
	Sex (Male vs Female)	330; 340	10.3 (6.9); 9.7 (6.2)	0.32 [NS]
	Gestational Age (<37 vs 37-42 weeks)	395; 275	9.6 (6.1): 10.6 (7.1)	0.09 [NS]
Pauri Garhwal (N=694)	**Birth Weight** (<2.5kg vs ≥2.5kg)	50; 644	9.9 (6.8); 10.1 (6.8)	0.75 [NS]
	Sex (Male Vs Female)	360; 334	10.1 (6.8); 10.1 (6.9)	0.85 [NS]
	Gestational Age (<37 vs 37-42 weeks)	246; 448	8.7 (6.9): 10.9 (6.7)	<0.001**

4.2.5 Neonatal Hypothyroidism

In the present study, neonates with TSH levels 20mIU/l and higher were identified and were recalled for reassessment of TSH levels for confirmation of neonatal hypothyroidism. The venous blood was utilized for repeat TSH estimation.

In district Udham Singh Nagar: out of 23 samples with TSH level of 20mlU/l and higher only 12 were retested for TSH level and the remaining were loss to follow up. Similarly in district Nainital, out of 21 neonates, 20 were retested; one sample was rejected due to fungal growth. In district Pauri Garhwal, out of 49 subjects, only 35 were retested as remaining was loss to follow up or migrated from the study area and their repeat TSH levels could not be ascertained.

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 in districts Udham Singh Nagar and Pauri Garhwal **(Table 44)**.

Table 44: Neonates according to repeat TSH levels of neonates in all the three districts

	Udham Singh Nagar (N=12)		Nainital (N=20)		Pauri Garhwal (N=35)	
Repeat TSH levels	**n (%)**	**Mean ± SD**	**n (%)**	**Mean ± SD**	**n (%)**	**Mean ± SD**
Less than 5µIU/L	7 (58.3)	2.0 ± 1.1	15 (75.0)	2.6 ± 1.1	24 (68.6)	2.5 ± 1.3
5-<10µIU/l	5 (41.7)	8.5 ± 1.5	3 (15.0)	8.0 ± 2.3	11 (31.4)	7.0 ± 1.3
10 -<20µIU/L	0	0	2 (10.0)	11.9 ± 2.0	0	0
20 and above µIU/L	0	0	0	0	0	0
Total	**12**		**20**		**35**	

Figures in parentheses denotes percentage
In Udham Singh Nagar, 12 subjects were loss to follow up; In Nainital, 1 sample was rejected due to fungal growth; In Pauri Garhwal, *14 subjects were loss to follow up

MAJOR FINDINGS

- 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 in districts Udham Singh Nagar and Pauri Garhwal.
- Prevalence of neonatal hypothyroidism as 0.3% in Nainital district, indicating a need for initiating a neonatal screening program for assessment of neonatal hypothyroidism. This strategy can help in early detection of children with iodine deficiency.
- Findings of part 2 i.e. neonates indicates that the neonates in all the three districts of Uttarakhand were iodine deficient as indicated by higher TSH levels. Thus, there is also 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.

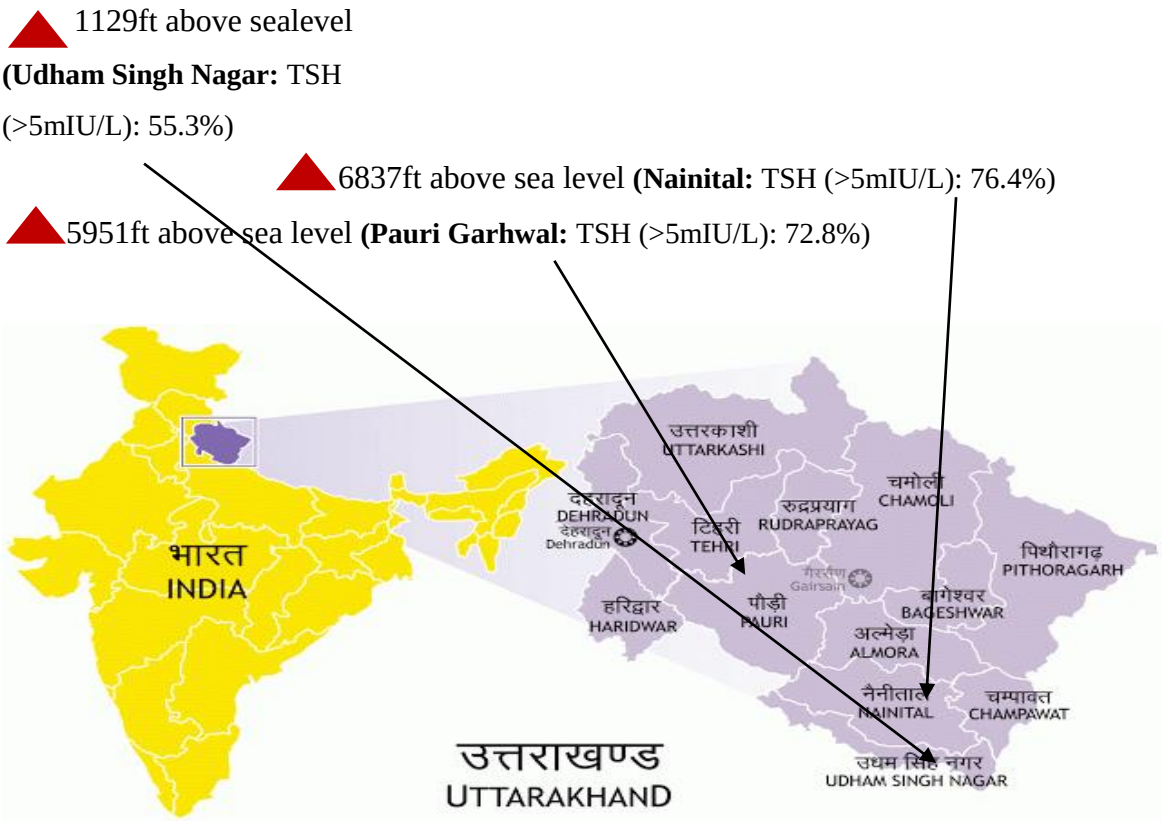
4.2.6 Summary

Table 45: Summary of iodine nutritional status amongst neonates in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Parameters	Udham Singh Nagar	Nainital	Pauri Garhwal	Combined
At screening: TSH (>5mIU/L)	55.3(649)	76.4(670)	72.8(694)	68.3(2013)
At recall: TSH (>10mIU/L)	0(12)	2(20)	0(35)	2(67)

Figures in parenthesis denotes total samples analyzed

Figure 35: Summary of iodine nutritional status amongst neonates in districts Udham Singh Nagar, Nainital and Pauri Garhwal



DISCUSSION OF RESULTS OF THE PRESENT STUDY WITH OTHER STUDIES

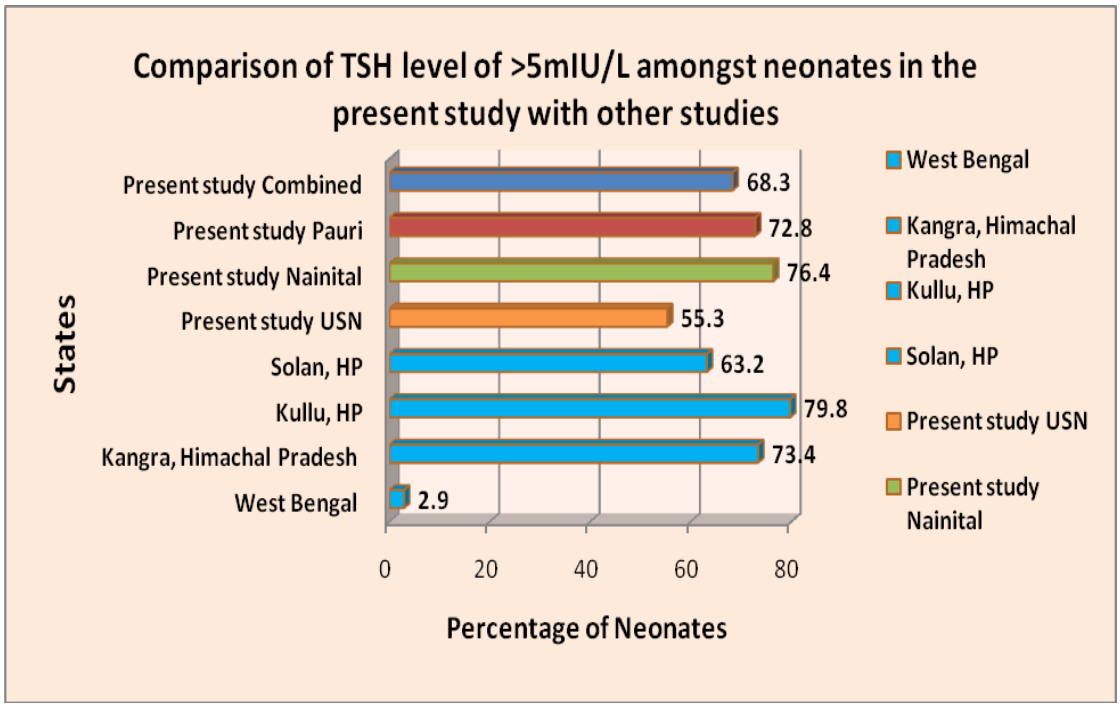
Iodine deficiency among neonates is one of the most common preventable causes of mental retardation. The complications of iodine deficiency amongst neonates results in intellectual impairment and neurodevelopmental delay present later in life when it is too late to be treated or reversed (Sareen et al, 2015). Timely treatment is very important to effect adequate neurocognitive development during the critical first 3 years of life. The earlier the treatment is started, the higher the IQ levels are achieved later in life (WHO, 2007). The neonatal brain is only a third of the size of the adult's brain, if iodine deficiency and neonatal thyroid failure continue for about 3months, this condition can lead to irreversible brain damage. Based on scientific data available, it is estimated that about 10% or more of newborns in severe goiter endemic areas are at risk of neonatal hypothyroidism and resulting compromised physical and mental development (Ramji et al, 1994). Infants born to mothers, who have thyroxin concentration below the 10^{th} percentile before the 13th week of gestation, have impaired neuropsychological development and maturation of the central nervous system (Kochupillai et al, 1983). The recognized role of thyroid hormones is in brain development and the irreparable brain damage caused by untreated hypothyroidism early in life (Fisher et al, 1979).

Comparison of Thyroid Stimulating Hormone levels amongst neonates in the present study with other studies

The TSH level is the preferred method for identifying neonates with ID. As assessing goitre is not feasible and practical among neonates, whether by palpation or ultrasound, the performance will be poor (WHO, 2007).

The comparison of neonates with TSH >5mIU/L in present study with other investigators is depicted in **Figure 36.**

Figure 36: Comparison of TSH level of >5mIU/L amongst neonates in the present study with other studies



According to WHO (2007) reported that a <3% frequency of TSH concentrations above 5mIU/L in samples collected indicates iodine sufficiency in a population.
Source: Solan HP; Kapil et al, 2014; Kullu; Kapil et al, 2014; Kangra; Kapil et al, 2014; West Bengal; Chakraborty et al, 2006

The prevalence of neonates with elevated TSH levels is a valuable indicator of the severity of ID in a given population. It has the additional advantage of highlighting the fact that ID directly affects the developing brain. In iodine-sufficient populations, about one in 4000 neonates has congenital hypothyroidism, usually because of thyroid dysplasia. Prompt correction with thyroid hormone is essential to avoid permanent mental retardation (WHO, 2007).

To detect congenital hypothyroidism and initiate rapid treatment, most developed countries conduct universal screening of neonates with bloodspot TSH taken on filter papers, or occasionally with blood spot T4 followed by TSH (WHO, 2007).

Neonatal TSH screening assesses the level of saturation in thyroid hormones of the brain cells and consequently measures the supply of thyroid hormones to the developing brain. Therefore elevated neonatal TSH is the only indicator which allows prediction of possible impairment of mental development (WHO, 2007). Neonatal

thyroid screening as an indicator of the degree of ID at a population level and as a monitoring tool in the programs of iodine supplementation has demonstrated its validity and usefulness. Neonatal TSH screening constitutes one of the indicators, recommended by WHO, UNICEF and ICCIDD for assessing IDD and its control. It is the single indicator that focuses on potential brain damage, the major impact of ID at population level (Delange et al, 1998).

While screening in developed countries it is directed at detecting neonates with TSH elevations which are 20mIU/l whole blood or higher, the availability of TSH assays sensitive to 5mlU/l permits detection of mild elevations above normal. This permits detection of transient hyperthyrotopinemia (Zimmermann, 2005).

The, TSH is relatively insensitive indicator of iodine nutrition in adults (WHO, 2007). In contrast, TSH is a sensitive indicator of iodine status in the newborn period (Delange et al, 1997). Compared to the adult, the newborn thyroid contains less iodine but has higher rates of iodine turnover. Particularly when iodine supply is low, maintaining high iodine turnover requires increased TSH stimulation. Serum TSH concentrations are therefore increased in iodine-deficient infants for the first few weeks of life, a condition termed transient newborn hypothyroidism (WHO, 2007).

In areas of iodine deficiency, an increase in transient newborn hypothyroidism, indicated by 43% of newborn TSH values above the threshold of 5mIU/L whole blood collected 3–4 days after birth, suggests ID in the population (Zimmermann, 2003; WHO, 1994). TSH is used in many countries for routine newborn screening to detect congenital hypothyroidism. If already in place, such screening offers a sensitive indicator of iodine nutrition (WHO, 2007). Newborn TSH is an important measure because it reflects iodine status during a period when the developing brain is particularly sensitive to ID.

WHO (2007), reported that a <3% frequency of TSH concentrations above 5mIU/L in samples collected 3-4 days after birth indicates iodine sufficiency 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 were consuming salt with iodine content of less than 15ppm (results of Part 1). Comparing between the three districts, higher prevalence was reported from district Nainital and Pauri Garhwal which are at higher altitude, followed by district Udham Singh Nagar. Thus higher the altitude of the district higher is the prevalence of ID amongst neonates could be observed.

Similar results were reported by a recent study conducted by Kapil et al, 2015 amongst neonates in the three districts (Kangra, Kullu and Solan) of Himachal Pradesh. It was reported that the TSH levels of more than 5mIU/L were found in 73.4 (Kangra), 79.8 (Kullu), and 63.2 (Solan) percent of neonates indicating high prevalence of ID in the population studied. Increasing trend of ID amongst neonates with increase in altitude of the district above sea level was also observed. Since district Kullu is at higher altitude above sea level, followed by districts Kangra and Solan. Thus in the study the prevalence of ID was observed to be more in district Kullu, followed by districts Kangra and Solan. Another similar study conducted in West Bengal has reported the TSH level of more than 5mlU/l in 2.95 % of the neonates (Chakraborty et al, 2006).

Several studies have attempted to apply the frequency of neonatal TSH values of more than 5mIU/L in determining population iodine status and monitoring intervention programmes. Studies conducted amongst neonates have documented that ID during the initial phase of life affects the developing brain (Ehrenkranz et al, 2011; Rahman et al, 2010; Jaruratanasirikul et al, 2009). Thyroid stimulating hormone affects proper development of the central nervous system (WHO, 2007).

A departmental study conducted by Rana et al, 2012 amongst neonates reported that 12.6% of the neonates had TSH level of more than 20mIU/L, 31.2% had TSH level of 10-20 mIU/L and 36.2% had TSH level of <10 mIU/L. Another departmental study conducted by Joshi et al, 2012 in Vadodara, Gujarat reported that 26.6 % of the neonates were observed having TSH of more than 10μIU/l which indicated moderate Iodine deficiency**.**

Studies conducted in different countries have reported the TSH level of more than 5mlU/l; Western Uganda (20-32%), Estonia (18.1%), Italy (14.4%), Spain (9.0%), Thailand (8.9%et), Australia (6.8%), Poland (3-5%) and Iran (3.6%), respectively (Ehrenkranz et al, 2011; Mikelsaar et al, 1999; Costante et al, 1997; Peris Roig et al, 2009; Jaruratanasirikul et al, 2009; Rahman et al, 2010; Ołtarzewski et al, 2003; Najafi et al, 2008).

The comparison of TSH levels amongst neonates in different states of India is depicted in **Figure 36**. It was found that higher percentage of neonates in the present study had iodine deficiency compared to other studies conducted. Thus it could be said that himalayan regions had higher prevalence compared to non-himalayan region.

Comparison of results of effect of other factors on TSH levels of the neonates of the present study with other studies

Various research studies have shown correlation between cord blood (CB) TSH levels and factors such as neonate gender, birth weight, mode of delivery, maternal age etc (Rashmi et al, 2007; Kim et al, 2005; Chan et al, 2001; Chan et al, 2006).

A recent study by Trumpff et al, 2015 reported that several factors are associated with changes in neonatal TSH levels: season of birth; pregnancy duration; maternal weight gain during pregnancy and lifetime smoking behavior up to child birth. In univariate analysis, higher TSH values were associated with the mother taking vitamins. However, in multiple linear regression, this association was no longer significant. A positive association was found between neonatal TSH level and pregnancy duration where preterm neonates (<37 weeks) were excluded.

Earlier studies have reported that pregnancy duration lower than 37 weeks (Rashmi et al, 2007) and pregnancy duration higher than 41 weeks are associated with higher incidence of congenital hypothyroidism (Medda et al, 2005). A study found no effect of gestational age when low birth weights were taken into account in the multivariate analysis (Ng et al, 2011).

Comparison of results of effect of gestational age on TSH levels of neonates of the present study with other studies

In the present study 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). However, it was found that as the gestational age increases the mean TSH level also increases in all the three districts studied. Simlar results were reported by a study conducted by Raj et al, reported that the CB TSH levels were also found to increase with increasing gestational age (p=0.001), unlike other studies which reported a negative correlation between gestational age and CBTSH levels (Raj et al, 2014).

A recent study conducted by Joshi et al, 2014 in Surat, Gujarat reported that mean TSH levels between preterm and term newborns and between term and post term newborns was statistically significant ($p<0.001$; $p<0.05$). However, mean TSH levels between pre-term and post term newborns was not significant ($p>0.05$). It is known that as gestational age increases, the fetus increases the synthesis of both T4 and TSH (Burrow et al, 1994). A study by Klein et al. (Klein et al, 1982) found a constant positive relationship between TSH and T4 until approximately 34 weeks gestation, at which time, none of the thyroid parameters varied with increasing age. Among infants who are born preterm, the hypothalamic–pituitary axis development is attenuated and therefore the TSH surge for preterm births is smaller and later (Murphy et al, 2004; LaFranchi et al, 1999). At birth, term newborns typically experience a surge in TSH, peaking at around 30 minutes after delivery and followed by a gradual rise in T4 over the first 24 hours of life (Fisher et al, 1981). It is known that there is a negative change in TSH and a positive change in T4 levels going from cord blood levels to neonatal heel prick bloodspot measurements (Wilker et al, 1984).

Various other studies conducted reported that gestational age were independently related to neonatal TSH levels in newborns without CH in the region of mild iodine deficiency (Mockute et al, 2010; Bėrontienė et al, 2002). A study by Korada et al, reported that gestational age was associated with increased TSH levels in multivariate

but not univariate models, but multiple regression analysis confirmed that this was a reflection of the close link between gestational age and birth weight. The correlation was observed between TSH and gestational age (rho=-0.05, p=0.008) (Korada et al, 2009). On the contrary, Herbstman et al. concluded that gestational age was independently associated with lower cord TSH, higher cord total T4, and higher neonatal and subsequent bloodspot total T4 (Herbstman et al, 2008).

In the study by Miyamoto et al, TSH levels varied widely and had no correlation with gestational age because they were affected by the mode of delivery (Miyamoto et al, 1991). It is known however, that as gestational age increases, the fetus elevates the synthesis of both T4 and TSH (Burrow et al¸1994). The statement was confirmed in the study by McElduf et al., where higher TSH values had been associated with older gestational age (McElduf et al¸2005). Studies of fetal and neonatal thyroid function show that thyroid hormone levels rise as pregnancy advances (Murphy et al, 2004; LaFranchi et al, 1999) with levels of TSH in cord blood and neonatal blood spot samples positively related to gestational age (Herbstman et al, 2008). Whereas on contrary, a cross sectional study by Rashmi et al 2007 amongst 1590 live born infants reported that there was a significant fall in CB TSH levels with increasing gestational age.

A study conducted by Desai et al 1994, reported increased levels of TSH in preterm rather than in term newborns. Whereas, Gupta et al, 2014; Kim et al, 2005; Armanian et al, 2013; did not find any influence of gestational age on TSH levels. Another study conducted by Gupta et al, 2014 amongst 952 live born infants reported that no correlation was found between CB TSH and gestational age (r=-0.0009).

A study conducted by Gopalakrishnan et al, 2014 in Uttar Pradesh reported that there was no effect of gestational age on TSH levels. Studies conducted reported that gestational age were independently related to neonatal TSH levels in newborns without CH in the region of mild iodine deficiency (Mockute et al, 2010; Bėrontienė et al, 2002).

A study conducted by Desai et al reported increased levels of TSH in preterm rather than in term newborns (Desai et al, 1994). Whereas, earlier studies conducted a study

did not find any influence of gestational age on TSH levels (Gupta et al, 2014; Kim et al, 2005; Armanian et al, 2013).

Comparison of results of the effect of gender on TSH levels of neonates in the present study with other studies

In a present study, 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). Similar results were reported by Gupta et al, 2014 who conducted a study amongst 1000 newborns. They reported that male neonates had slightly increased CB TSH than their female counterparts (P =0.031). A recent study conducted by Gopalakrishnan et al, 2014 in Uttar Pradesh reported that male neonates, had a significantly higher TSH.

A study conducted by Raj et al, 2014 in Kerala, amongst 218 males and 21 females reported that there was no significant difference in the CB TSH levels between male and females babies (p=0.814). Another study conducted by Rashmi et al 2007, reported that there was no significant difference in TSH levels between males and females.

A study conducted by Mockute et al, 2010 also reported that the distribution of TSH level was not significantly different between male and female newborns, although male newborns tended have higher median TSH levels (3.38 mIU/L compared with 3.12 mIU/L in females, p=0.054).

Most studies have reported that male infants generally have higher TSH levels, as measured in either cord blood or bloodspots as compared to females, a trend that is consistent with our analyses (Sullivan et al, 1997; Chan et al, 2001). Additionally, the Apgar score at 1 and 5 minutes have been reported to be inversely associated with cord blood and bloodspot TSH (Sullivan et al, 1997; Lao et al, 2002).

A study by Kirsten et al, 2000 reported that TSH is highly variable among healthy newborns; this is one of the factors contributing to the false positive rate for this test

when used in newborn screening programs. Additionally, TSH varies greatly by gestational age and birth weight and shows lower levels in premature or low birth weight newborns (Kirsten et al, 2000). Another study conducted by Korada et al, 2009 in England reported that the distribution of TSH was significantly different between males and females, with males having a higher median TSH (0.7 vs 0.6).

Comparison results of the effect of birth weight on TSH levels of neonates of the present study with other studies

In the present study, 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).

A study conducted by Korada et al, 2007 reported that correlation were shown between TSH and birth weight (rho= - 0.07, p=0.001). The functional form of the model suggested that higher TSH in the lowest birth weight categories was responsible for the association between TSH and birth weight.

A recent study conducted by Joshi et al, 2014; documented that cord blood TSH was not influenced by birth weight. But Desai et al, reported that cord TSH levels fell with increase in weight of newborns. A similar study conducted by Gupta et al, 2014 reported that no correlation was found between CBTSH and birth weight (r=-0.004).

A study by Herbstman, et al 2008 reported that infants born preterm had higher levels of TSH. Likewise, infants who were born with low birth weight (<2500 g) also had higher TSH. When birth weight was adjusted for gestational age, it was not independently related to TSH. Apgar scores at 1 minute were not related to neonatal thyroid hormone levels. However, infants with lower Apgar scores at 5 minutes had higher TSH values. Birth weight is so highly correlated with gestational age, it is not surprising that birth weight is also positively correlated with TSH and thyroid hormone measures in univariate analyses (Herbstman et al, 2008). Other studies have also reported an association between birth weight and TSH levels of neonates (Frank et al, 1996) but not independently of gestational age (Chan et al, 2003).

A study by Kirsten et al 2000, reported that TSH is highly variable among healthy newborns; this is one of the factors contributing to the false positive rate for this test when used in newborn screening programs. TSH varies greatly by and birth weight and shows lower levels in premature or low birth weight newborns (Kirsten et al, 2000). Another similar study conducted by Rashmi et al, 2007 amongst 1590 infants reported that there was a decline in TSH levels with increase in birth weight. A recent study conducted by Joshi et al, 2014 in Surat, Gujarat reported that TSH levels with different birth weight groups (1 kg,1-2 kg,2-3 kg, >3kg) was not significant ($p>0.05$).

A study conducted by Gopalakrishnan et al, 2014 in Uttar Pradesh reported that neonates with low birth weight had a significantly higher TSH. Birth weight was the only variable which had a significant (but weak) correlation with TSH ($r= -0.031$, $p<0.001$).

Comparison of results of the prevalence of Neonatal Hypothyroidism in the present study with other studies

Neonates are the most vulnerable group for iodine deficiency. Raised serum TSH in the neonates indicates insufficient supply of thyroid hormones to the developing brain (Delange et al, 1999). Cord blood sample is preferred for estimation of TSH levels in newborns because of its ease of collection, higher rate of coverage, more practical for mothers with short hospital stay following delivery and its utility as an indicator of the prevalence of IDD.

Neonatal hypothyroidism (NH) is one of the most common preventable causes of mental retardation in children. The complications of NH such as intellectual impairment and neurodevelopment delay present later in life when it is too late to be treated or reversed. Timely treatment is very important to effect adequate neurocognitive development during the critical first 3 years of life. The earlier the treatment is started, the higher the IQ levels are achieved later in life. The neonatal brain is only a third of the size of the adult's brain, if ID and neonatal thyroid failure continue for about 3 months, this condition can lead to irreversible brain damage. Based on scientific data available, it is estimated that about 10% or more of newborns in severe goiter endemic areas are at risk of NH and resultant compromised physical

and mental development (Ramji et al, 1994). Infants born to mothers, who have thyroxin concentration below the 10th percentile before the 13th week of gestation, have impaired neuropsychological development and maturation of the central nervous system (Kochupillai et al, 1983). The recognized role of thyroid hormones in brain development and the irreparable nature of brain damage caused by untreated hypothyroidism early in life (Fisher et al, 1979).

In the present study, neonates with TSH levels 20mIU/l and higher were identified and were recalled for reassessment of TSH levels for confirmation of 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 in districts Udham Singh Nagar and Pauri Garhwal.

Similar results were reported by a recent study conducted in district Kangra, Himachal Pradesh had reported that 4.4% of neonates were suffering from neonatal hypothyroidism (Kapil et al, 2014). Earlier studies conducted in India reported the incidence of congenital hypothyroidism (CH) as 1:476, 1:1700, and 1:2481, respectively (Rama Devi et al, 2004; Desai et al, 1987; Desai et al, 1994).

The incidence of neonatal hypothyroidism observed strikingly different in the endemic and non‐endemic areas. It has been observed that the incidence (4% or more) of NH in endemic goitrous areas of Gonda (UP) is 100–300 fold higher than reported from developed countries with no environmental ID (EID) or goiter (Lal et al, 1996). In areas with a high incidence of neonatal hypothyroidism and ID, a significant proportion of the population may have varying degrees of mental sub‐normality and sensory neural hearing loss (Sareen and Pradhan, 2015). Another study was conducted to re-evaluate the incidence of NH in the same three districts of UP in the postiodation phase. The results showed the incidence of NH was 16.17 and 9/1000 birth, respectively, which was impressively declined (Klett et al, 1997).

One of the studies conducted in Mumbai in which 12,407 neonates were screened over 26 months for their cord blood thyrotrophin level TSH, reveled a higher incidence (1:2481) of NH (Desai et al, 1987). Data on NS for NH with cord blood T4 studies on more than 25,000 newborns in the same area of Mumbai have shown the incidence of 1 in 2,804 (Desai et al, 1994).

A study conducted by Raj et al, 2014 in Kerala amongst neonates reported that one hundred twenty seven of the 430 neonates (29.06%) were found to have elevated CBTSH levels. Repeat TSH estimation was done on one third postnatal day in the 127 babies who had abnormal TSH levels revealed that only 5 (3.94%) babies had abnormal levels (>13.2miu/L). On further evaluation, 3 were confirmed as congenital hypothyroidism with serum T4 and TSH values along with radiograph (X-ray both knees). Maternal age, maternal hypothyroidism and gestational age of the babies were found to significantly influence the CBTSH levels. Other studies such as Manglik et al, reported 2 in 1200 (Manglik et al, 2005); Sanghvi et al 2008; 1 in 1000 from India. The worldwide incidence of Congenital Hypothyroidism (CH) is 1:3000–1:4000 (Klett et al, 1997). The incidence has racial and global topographic differences, being highest in Europe 1:3300 and as low as 1:5700 live births infants in Japan with an average of 1:4500 live births in most other parts of the globe (Kochupillai et al, 1993).

Neonatal thyroid screening in the United Kingdom has shown a significantly higher incidence of NH in Asian families in comparison with non‐Asians (1/918 in Asians compared 1/3391 within non‐Asians) (Rosenthal et al, 1988). The incidence is lower among African American newborns and higher among Hispanic newborns compared with the rate among white newborns (Olney et al, 2010). International studies have revealed that the incidence of NH is approximately 1:3500 in iodine sufficient areas (Jameson et al, 2010).

Incidence of neonatal hypothyroidism in several countries has been well documented. Earlier studies reported an Incidence of NH as 3:1207 (Ethiopia), 1:1446 (Italy), 1:1667 and 1:3670 (Latin America), and 1:4000 (United States), respectively (Mekonnen et al, 2003; Corbetta et al, 2009; Borrajo et al, 2007; Harris et al, 2007). Newborn screening in Brazil had revealed consistent lowering in the incidence of NH in 3 consecutive years (1:3616 in 2005, 1:1369 in 2006 and 1:1030 in 2007) (Botler et al, 2012). Thus, this high prevalence of NH is indicative of widespread IDD throughout the globe at different intensities.

The incidence of NH has been reported as 1 in 3,800–4,000 births worldwide with some racial and geographic variations (Fisher et al, 1983). Based on ongoing screening program, the incidence of NH in developed countries has proved to be high

and varies from 1 in 2,000 to 6,000 births (Klein et al, 1979).It has also been reported that the incidence of NH in developed countries without ID or endemic goiter varies from 1 in 3,000 to 1 in 12,000 births (Fisher et al, 1979; Delange et al, 1979; Klein et al, 1979). The worldwide incidence of NH was found to be one in 3000–4000 births, based on the results of screening in parts of the world where screening is mandatory (Klett, et al, 1997).

Data of an earlier study on NS have showed a prevalence of goitrous hypothyroidism in 10–15% of patients with primary CH approximating 1 in 30,000–50.000 live births in Europe and in North America (Newborn Committee of the European Thyroid Association, 1979). One of the studies conducted in the region of Sicily examined the cord blood samples of 180 newborns, and it showed that the prevalence of NH was 9.3% at birth with endemic goiter and cretinism (Sava et al, 1984). High incidences of NH in iodine deficient areas with endemic goiter and/or cretinism have been documented from other countries. Thilly et al. reported 10% incidence of NH in Zaire, as reflected in cord blood hormone levels during birth (Thilly et al, 1978). One of the studies conducted on 20107 newborns in Tehran and Damavand showed the estimated incidence of CH as one in every 914 births (Ordookhani et al, 2003). The routine cord blood thyrotrophin TSH screening of neonates at 6–10 days in Birmingham (England), reported the incidence of NH as 1:5540 (Hall et al, 1999).

One of the studies conducted in Saki (Nigeria), reported the incidence of neonatal chemical hypothyroidism as 14.7/1000 birth in the cord blood samples obtained from the babies at the time of delivery for thyroid function tests (Ojule et al, 1998). Another study conducted in Bhutan screened 650 newborns for TSH and results showed that the overall incidence of NH among newborns was 115/1000 births (Kochupillai et al, 1983).

Neonatal Hypothyroidism is the most treatable cause of mental retardation. A pilot neonatal hypothyroid screening program carried out in three areas of India showed that the incidence of NH in severely iodine deficient areas is between 4% and 15%. This is 80–300 times more than the reported average incidence of NH in medically advanced countries, which have eradicated endemic goiter, endemic cretinism and other effects of ID by effective iodine supplementation program (Sareen and Pradhan, 2015).

A study has reported that the incidence of NH as reflected in cord‐blood T4 and TSH levels in endemic goiter regions is more than a hundredfold higher than that observed in non‐endemic regions of India or reported from developed countries of the West. The reported incidence of NH in endemic regions of India and its neighboring countries ranges from 6 to 130/1000 births (Klett et al, 1997).

In areas with a high incidence of NH and ID, a significant proportion of the population may have varying degrees of mental sub‐normality and sensory neural hearing loss. These consequences are regarded as the hallmark of ID related brain damage. To be broadly applicable in a population, the screening must be universal, and not omit children born in remote or impoverished areas. For countries and regions that already have a system of universal neonatal screening with a sensitive TSH assay in place, the data can be examined and transient iodine deficiency recognized, usually without further surveying (WHO, 2007).

The findings of the present part documented the prevalence of neonatal hypothyroidism as 0.3% in Nainital district, indicating a need for initiating a neonatal screening program for assessment of neonatal hypothyroidism. This strategy can help in early detection of children with iodine deficiency.

4.3 PART 3: IODINE NUTRITIONAL STATUS AMONGST SCHOOL AGE CHILDREN

The result of this part is further divided into following sections:

General characteristics of school age children enrolled in the study

Clinical Examination: Thyroid Size school age children enrolled in the study

- **Prevalence of goiter as per clinical examination of thyroid size**
- **Age wise prevalence of TGR**
- **Gender wise prevalence of TGR**
- **Cluster wise prevalence of TGR**

Biochemical Estimation of school age children enrolled in the study

- **Iodine deficiency status as per urinary iodine concentration level**
- **Iodine deficiency status as per urinary iodine concentration level in different age groups**
- **Iodine deficiency status as per urinary iodine concentration level gender wise**

Iodine content of salt amongst the household of school age children enrolled in the study

- **Iodized salt intake**
- **Iodized salt intake in different age groups**
- **Iodized salt intake in gender wise**

Comparison of prevalence of IDD based on TGR, UIC levels and iodized salt intake

- **Prevalence of IDD based on TGR, UIC and salt in different age groups**
- **Prevalence of IDD based on TGR, UIC and salt gender wise**

Relationship between Goiter grade and UIC levels of school age children

Relationship between Iodized salt intake and UIC levels school age children

Block wise prevalence of IDD based on TGR, UIC levels and iodized salt intake

4.3.1 General characteristics of school age children enrolled in the study

In the districts selected, 30 clusters (schools) were identified by utilizing population proportionate to size sampling (PPS) methodology recommended by WHO (2007) for IDD survey. In each clusters, school age children (6-12 years) were covered. The children were covered by school based approach as more than 95% children attended the schools.

District Udham Singh Nagar is a plain area and is situated at an altitude of 1129ft above sea level. Whereas, districts Nainital and Pauri Garhwal is a hilly terrain and is situated at an altitude of 6837ft and 5951ft above sea level, respectively.

From districts Udham Singh Nagar and Nainital, seven blocks were selected. Whereas, from district Pauri Garhwal, thirteen blocks was selected. Further categorization of school age children according to clusters selected is depicted in **Table 46**.

Thirty clusters (schools) were selected in three districts of Uttarakhand. In districts Udham Singh Nagar, Nainital and Pauri Garhwal a total of 1807, 2269 and 2067 school age children in the age group of 6-12 years were selected from the government schools of Uttarakhand state.

Table 46: Distribution of school age children according to clusters in all the three districts

Cluster No.	Udham Singh Nagar (N=1807)		Nainital (N=2269)		Pauri Garhwal (N=2067)	
	Cluster Name (Village, Block)	Population of School Age Children	Cluster Name (Village, Block)	Population of School Age Children	Cluster Name (Village, Block)	Population of School Age Children
1	Nagwa Thagu, Khatima	60	Gangrati, Betalghat	56	Simdi, Bironkhal	70
2	Islaam nagar, Khatima	60	Karat, Betalghat	68	Padinda, Bironkhal	50
3	Pratappur, Khatima	60	Malital, Bhimtal	64	Panas, Bironkhal	61
4	Pachpeda, Sitarganj	60	Nokuchiyatal, Bhimtal	72	Motadhak, Dugadda	79
5	Milaknagar, Sitarganj	60	Kasnola, Dhari	59	Lakdi Padav, Dugadda	100
6	Sitarganj-1	60	Hotmungro, Dhari	71	Grastanganj, Dugadda	59
7	Pandri, Sitarganj	60	Rajpura, Haldwani	180	Kandakhal, Dwarikhal	61
8	Thakur nagar, Sitarganj	60	Barani, Haldwani	61	Birmoli, Dwarikhal	98
9	Kheda, Rudrapur	60	Chorgalia, Haldwani	95	Ransawa, Akeshwar	77
10	Malsi, Rudrapur	60	Gusaipur, Haldwani	59	Dhol Khatkhal, Jaiharikhal	54
11	Kiccha, Rudrapur	60	Jawar Jyoti, Haldwani	91	Mathalli walli, Jaiharikhal	69
12	Phol Bag, Rudrapur	60	Lalkuan gram, Haldwani	120	Kaligkhal, Pauri	60
13	Malsa Giradharpur, Rudrapur	61	Nawakhera, Haldwani	70	Sumadi, Khirsoo	66
14	Gaughat, Rudrapur	56	Ramriniam, Haldwani	118	Dehalchori, Pauri	81
15	Dineshpur, Gadarpur	59	Bishtdara, Haldwani	65	Dhangal Goun, Nainidanda	61
16	Vikram nagar, Gadarpur	60	Indranagar, Haldwani	60	Karana Badagad, Nainidanda	82
17	Maheshpur, Gadarpur	60	Ghughu, Kotabagh	58	Solana, Pauri	66
18	Gadarpur	60	Pratapur, Kotabagh	67	Vidoli, Pabau	74
19	Barheri, Bazpur	72	Chaksudela, Okhaikanda	58	Sindi, Pauri	58
20	Tanda Ameachard, Bazpur	60	Kalaagar, Okhaikanda	56	Pundori, Pauri	78
21	Birha, Bazpur	60	Jharguan, Okhaikanda	60	Gwani, Pokhra	76
22	Gajraula, Bazpur	59	Dhurakalaagar, Okhaikanda	68	Dikoliya, Rikhani khal	87
23	Ganeshpur, Bazpur	60	Sirsa, Ramnagar	60	Kilbaukhal, Rikhani khal	58
24	Kateya, Kashipur	60	Talla mona, Ramnagar	60	Dadoli, Thalisain	60
25	Jeitpur qhasi, Kashipur	60	Chhoi, Ramnagar	65	Ida Naugaon, Thalisain	56
26	Pratappur, Kashipur	60	Khatari, Ramnagar	123	Kainyur, Thalisain	74
27	Babar Khera, Jaspur	60	Peerumadara, Ramnagar	70	Museti, Thalisain	75
28	Shivrajpur, Jaspur	60	Swalde, Ramnagar	76	Badyun, Yumkeshwar	61
29	Jaspur	60	Shivnathpur, Ramnagar	71	Kimsar, Yumkeshwar	60
30	Bhagwantpur, Jaspur	60	Devipura, Ramnagar	68	Talla Banu, Yumkeshwar	56
Total		**1807**		**2269**		**2067**

4.3.1.1 Distribution of school age children according to age and gender

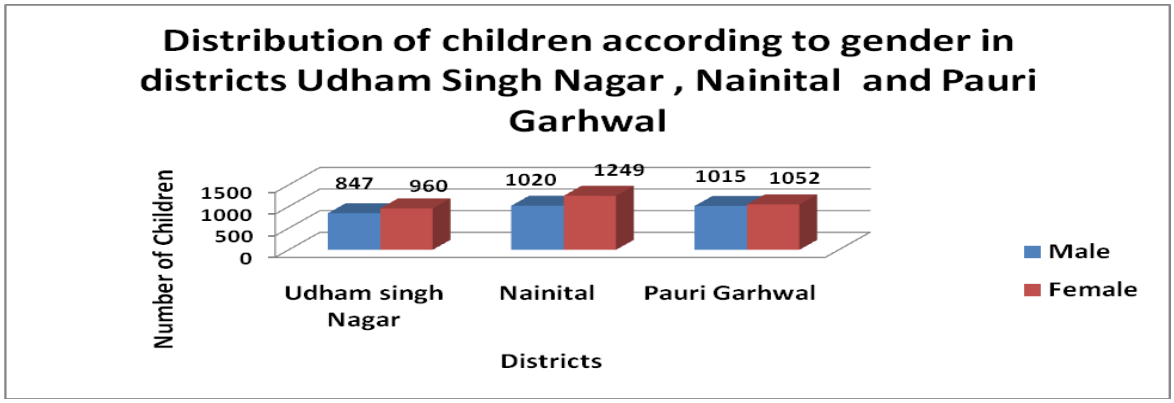
The distribution of school age children according to age and gender is depicted in **Table 47** and **Figure 37**. A total of 847 (Udham Singh Nagar), 1020 (Nainital) and 1015 (Pauri Garhwal) males were enrolled for the present study. And a total of 960 (Udham Singh Nagar), 1249 (Nainital) and 1052 (Pauri Garhwal) females were enrolled. The male to female ratio was 1:1. Thus a total of 6143 school age children (6-12 years) from all the three districts were selected for the present study.

Table 47: Distribution of school age children according to age and gender in all the three districts

	Udham Singh Nagar (N=1807)		Nainital (N=2269)		Pauri Garhwal (N=2067)		
Age (Years)	**Male n(%)**	**Female n(%)**	**Male n(%)**	**Female n(%)**	**Male n (%)**	**Female n(%)**	**Total**
6	120 (49.6)	122 (50.4)	148 (48.2)	159 (51.8)	151 (57.2)	113 (42.8)	813
7	152 (48.0)	165 (52.0)	155 (41.0)	224 (59.0)	130 (45.0)	159 (55.0)	985
8	142 (44.0)	181 (56.0)	171 (43.7)	220 (56.3)	182 (46.5)	209 (53.5)	1105
9	171 (46.3)	198 (53.6)	156 (40.5)	229 (59.5)	180 (48.6)	190 (51.3)	1124
10	161 (47.6)	177 (52.4)	220 (48.8)	231 (51.2)	185 (49.9)	186 (50.1)	1160
11	54 (45.0)	66 (55.0)	101 (44.7)	125 (55.3)	106 (52.7)	95 (47.3)	547
12	47 (48.0)	51 (52.0)	69 (53.0)	61 (47.0)	81 (44.7)	100 (55.3)	409
Total	**847**	**960**	**1020**	**1249**	**1015**	**1052**	**6143**

Figures in parentheses denotes percentage

Figure 37: Distribution of children according to gender in all the three districts



4.3.2 Clinical Examination: Thyroid Size school age children enrolled in the study

4.3.2.1 Prevalence of goiter as per clinical examination

Prevalence of goiter as per clinical examination of thyroid size in all the three districts is depicted in **Table 48**.

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.

Higher TGR amongst school age children was observed in district Pauri Garhwal followed by districts Nainital and Udham Singh Nagar. Proportion of Grade II goiter was low compared to Grade I goiter in all the three districts. There was a statistical significant difference of TGR between the three districts (p=0.003) **(Table 48).**

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. Districts Pauri and Nainital are hilly terrain whereas Udham Singh Nagar is a plain area. Thus, it could be concluded that hilly area could have higher TGR compared to plain area.

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 **(Figure 38)**.

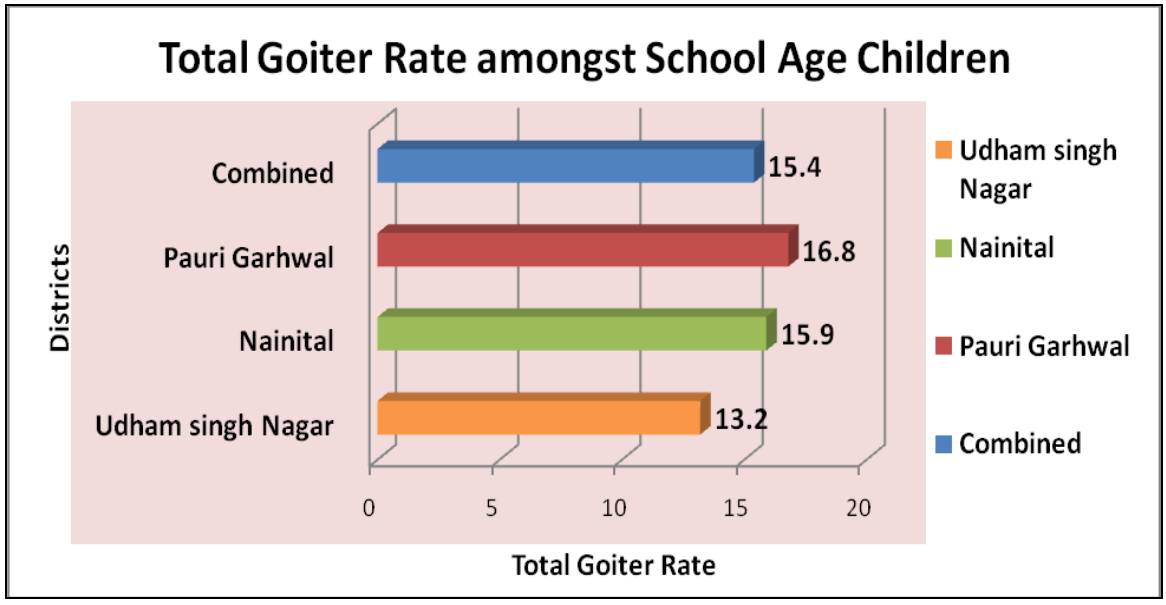
Table 48: Distribution of children according to various grades of goiter in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Goiter Grade	Udham Singh Nagar (N=1807)	Nainital (N=2269)	Pauri Garhwal (N=2067)	Combined (all the three districts) (N=6143)
0	1568(86.7)	1908(84.0)	1719(83.2)	5195(84.6)
I	235(13.0)	361(15.9)	346(16.7)	942(15.3)
II	4(0.2)	0	2(0.1)	6(0.1)
Total Goiter Rate (Grade I + Grade II)	**239(13.2)** ↑	**361(15.9)** ↑	**348(16.8)** ↑	**948(15.4)** ↑

**** Figures in parentheses denotes percentage***

WHO, 2007: TGR ≥5%: Iodine deficiency

Figure 38: Prevalence of TGR amongst school age children in all the three districts



WHO, 2007: TGR ≥5%: Iodine deficiency

4.3.2.2 Gender wise prevalence of TGR

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. Proportion of Grade II goiter was low compared to Grade I goiter in all the three districts studied.

According to WHO/UNICEF/ICCIDD, a total goitre rate of 5% or more in primary school children (6-12 yr) is used to signal the presence of a public health problem.

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. Moreover, when compared district wise TGR was higher in district Pauri Garhwal followed by Nainital and Udham Singh Nagar **(Table 49).**

Combining all the three districts the prevalence of TGR was found to be more in Males compared to females though the difference of prevalence of TGR with gender was not statistically significant (p= 0.063). Whereas, between the three districts, the difference among the gender was more prominent in district Pauri Garhwal compared to Nainital and Udham Singh Nagar.

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.

Table 49: **Prevalence of goiter according to gender in all the three districts**

Goiter Grade	**Gender**		**p-value**
Udham Singh Nagar (N=1807)			
Goiter Grade	**Male (n=847) n (%)**	**Female (n=960) n (%)**	
0 (n=1568)	735 (86.8)	833 (86.8)	0.997[NS]
I (n=235)	112 (13.2)	123 (12.8)	
II (n=4)	0	4(0.4)	
Total Goiter Rate (Grade I + Grade II)	**112 (13.2)** ↑	**127 (13.2)** ↑	0.166 [NS]
Nainital (N=2269)			
Goiter Grade	**Male (n=1020) n (%)**	**Female (n=1249) n (%)**	
0 (n=1908)	848 (83.1)	1060 (84.8)	0.262 [NS]
I ((n=361)	172 (16.8)	189 (15.1)	
II (n=0)	0	0	
Total Goiter Rate (Grade I + Grade II)	**172 (16.8)** ↑	**189 (15.1)** ↑	0.262 [NS]
Pauri Garhwal (N=2067)			
Goiter Grade	**Male (n=1015) n (%)**	**Female (n=1052) n (%)**	
0 (n=1719)	828 (81.6)	891 (84.7)	0.058 [NS]
I (n=346)	187 (18.4)	159 (15.1)	
II (n=2)	0	2(0.2)	
Total Goiter Rate (Grade I + Grade II)	**187 (18.4)** ↑	**161 (15.3)** ↑	0.052 [NS]
Combined (all the three districts) (N=6143)			
Goiter Grade	**Male (n=2882) n (%)**	**Female (n=3261) n (%)**	
0 (n=5195)	2411(83.7)	2784(85.4)	0.006*
I (n=942)	471(16.3)	471(14.4)	
II (n=6)	0	6(0.2)	
Total Goiter Rate (Grade I + Grade II)	**471(16.3)** ↑	**477(14.6)** ↑	0.063 [NS]

Figure in the parentheses indicate percentages

WHO, 2007: TGR ≥5%: Iodine deficiency

4.3.2.3 Age wise prevalence of TGR

It was found that the higher goiter grade was observed in district Pauri Garhwal in all the ages except children from 10 year of age. It was also observed that prevalence of goiter increases with age till 10 year of age and then there was a decline in the prevalence of goiter (Significant difference was observed between TGR and age of the children) (**Figure 39)**.

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=0.01), Nainital (p=0.001) and Pauri Garhwal (p=0.001) **(Table 50)**.

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).

Figure 39: Prevalence of goiter as per age of children in all the three districts

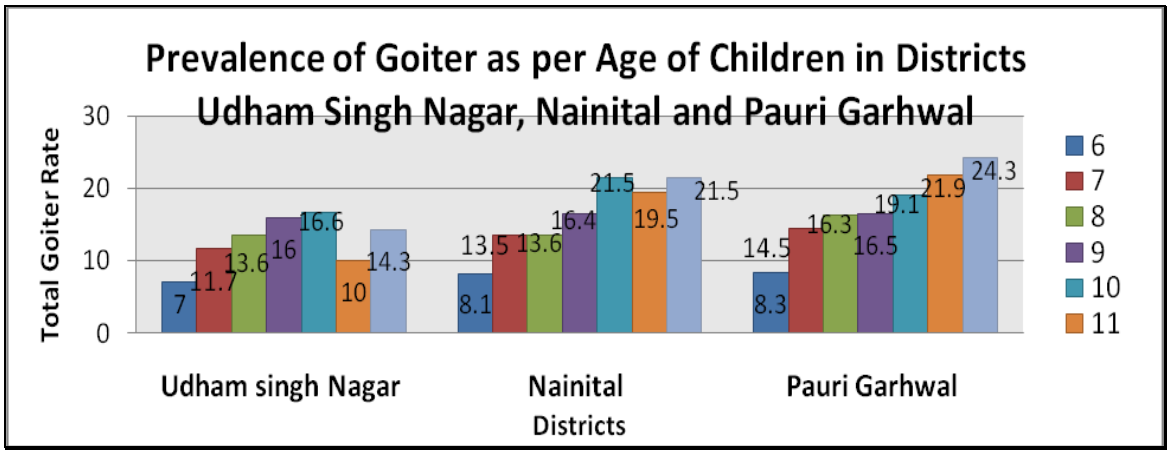


Table 50: Prevalence of goiter as per different age groups of children in all the three districts

Age groups (yrs)	Goiter Grade			Total Goiter Rate (Goiter Grade I + II)
Udham Singh Nagar (N=1807)				
	Goiter Grade 0 (n=1568)	**Goiter Grade I(n=235)**	**Goiter Grade II(n=4)**	
6-7 (n=559)	505(90.3)	54(9.7)	0	54(9.7)
8-9(n=692)	589(85.1)	102(14.7)	1(0.1)	103(14.8)
10-12(n=556)	474(85.2)	79(14.2)	3(0.6)	82(14.8)
p-value	**0.016^{NS}**			**0.01***
Nainital (N=2269)				
	Goiter Grade 0 (n=1908)	**Goiter Grade I(n=361)**	**Goiter Grade II(n=2)**	
6-7(n=686)	610(88.9)	76(11.1)	0	76(11.1)
8-9(n=776)	660(85.0)	116(14.9)	0	116(14.9)
10-12(n=807)	638(79.1)	169(20.9)	0	169(20.9)
p-value	**0.001****			**0.001****
Pauri Garhwal (N=2067)				
	Goiter Grade 0 (n=1719)	**Goiter Grade I(n=346)**	**Goiter Grade II(n=2)**	
6-7(n=553)	489(88.4)	64(11.6)	0	64(11.6)
8-9(n=761)	636(83.5)	123(16.2)	2(0.3)	125(16.5)
10-12(n=753)	594(78.9)	159(21.1)	0	159(21.1)
p-value	**0.001****			**0.001****
Combined (all the three districts) (N=6143)				
	Goiter Grade 0 (n=5195)	**Goiter Grade I(n=942)**	**Goiter Grade II(n=6)**	
6-7(n=1798)	1604(89.2)	194(10.8)	0	194(10.8)**
8-9(n=2229)	1885(84.6)	341(15.3)	3(0.1)	344(15.4)**
10-12(n=2116)	1706(80.6)	407(19.2)	3(0.2)	410(19.4)**
p-value	**0.001****			**0.001****

Figure in the parentheses indicate percentages

***** WHO, 2007: TGR ≥5%: Public Health Problem***

Major Findings:

- **Total Goiter Rate:** 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).

4.3.3 Biochemical Estimation of school age children enrolled in the study

4.3.3.1 Iodine deficiency status as per urinary iodine concentration level

It was found that moderate iodine deficiency was found in 6.0 (Udham Singh Nagar), 11.8 (Nainital) and 25.3 (Pauri Garhwal) percent of school age children. Similarly, mild iodine deficiency was found in 21.2 (Udham Singh Nagar), 24.9 (Nainital) and 17.2 (Pauri Garhwal) percent of children. And no case of severe iodine deficiency was observed **(Table 51).**

According to WHO, median urinary iodine concentration of >100µg/L amongst school age children defines a population with no iodine deficiency, *i.e.* at least 50 per cent of the samples should be above 100µg/L according to the epidemiological criteria for assessing iodine nutrition based on median urinary iodine concentration in children.

Median UIC level of 150µg/l (Udham Singh Nagar), 125µg/l (Nainital) and 115µg/l (Pauri Garhwal) was found thus indicating that no district has biochemical iodine deficiency as indicated by median UIC level of >100µg/l. And it was also found that, 72.7% (Udham Singh Nagar), 63.3% (Nainital) and 57.5% (Pauri Garhwal) of the subjects had UIC level of >100µg/L, further indicating no biochemical ID in the subjects studied.

Moreover, 6.0 (Udham Singh Nagar), 11.8 (Nainital) and 25.3 (Pauri Garhwal) percent of the samples had UIC level of <50µg/L. As according to WHO, if >20% of the samples had UIC level of <50µg/L, it indicates ID in the community. Thus according to this criteria only district Pauri Garhwal is iodine deficient.

Thus it was also found that higher percentage of children with UIC level <100µg/L were from district Pauri Garhwal (42.5%) followed by districts Nainital (36.7%) and Udham Singh Nagar (27.2%).

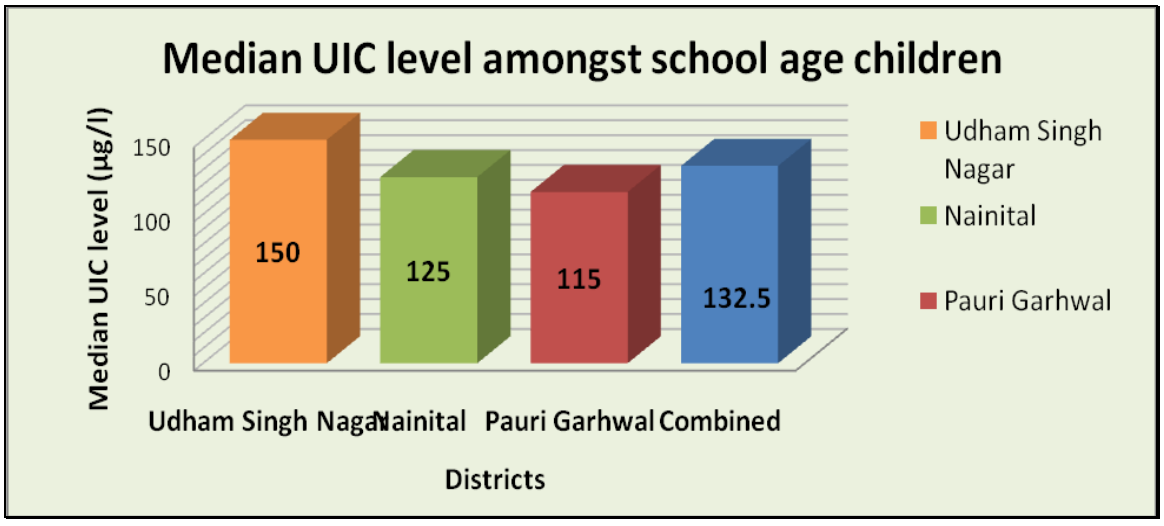
Table 51: Iodine deficiency amongst school age children according to Urinary Iodine Concentration levels in all the three districts

UIC levels (µg/L)	Iodine Intake	Iodine Status	Udham Singh Nagar (N=587) n (%)	Nainital (N=611) n(%)	Pauri Garhwal (N=580) n (%)	Combined (all the three districts) n (%) (N=1778)
<20	Insufficient	Severe Iodine Deficiency	0	0	0	0
20-49	Insufficient	Moderate Iodine Deficiency	35(6.0)	72(11.8)	147(25.3)	254(14.3)
50-99	Insufficient	Mild Iodine Deficiency	125(21.2)	152(24.9)	100(17.2)	377(21.2)
100-199	Adequate	Adequate Iodine Nutrition	201(34.2)	234(38.3)	197(34.0)	632(35.5)
200-above	Above Requirements	More than adequate	226(38.5)	153(25.0)	136(23.5)	515(29.0)
Median UIC(µg/l)			**150**	**125**	**115**	**132.5**
p-value			**0.001****			

Figure in the parentheses indicate percentages

WHO (2007): median UIC <100µg/L defines a population with iodine deficiency

Figure 40: Median UIC level amongst school age children



WHO (2007): median UIC <100µg/L defines a population with iodine deficiency

4.3.3.2 Iodine deficiency status as per urinary iodine concentration level gender wise

It was found that higher percentage of females had UIC level of <100µg/L as compared to male counterparts. In districts Udham Singh Nagar, Nainital and Pauri Garhwal; 33.5%, 41.5%, 44.2% of females had UIC level <100µg/L. Whereas, in males 20.2% (Udham Singh Nagar), 32.1% (Nainital) and 41.0% (Pauri Garhwal) had UIC level <100µg/L. Comparing between the districts; Pauri Garhwal has higher percentage of females and males with UIC level <100µg/L followed by district Nainital and Udham Singh Nagar **(Table 52)**.

There was a statistical significant difference in the median UIC level with gender in district Nainital (p=0.016). Whereas, in district Udham Singh Nagar (p=0.166) and Pauri Garhwal (0.552) there was no statistical significant difference between the UIC level with gender.

Combining median UIC levels in males and females (three districts), it was found that higher percentage of females had biochemical iodine deficiency compared to male counterparts **(Figure 41)**. There was a statistical significant difference in the UIC level with gender (p=0.001).

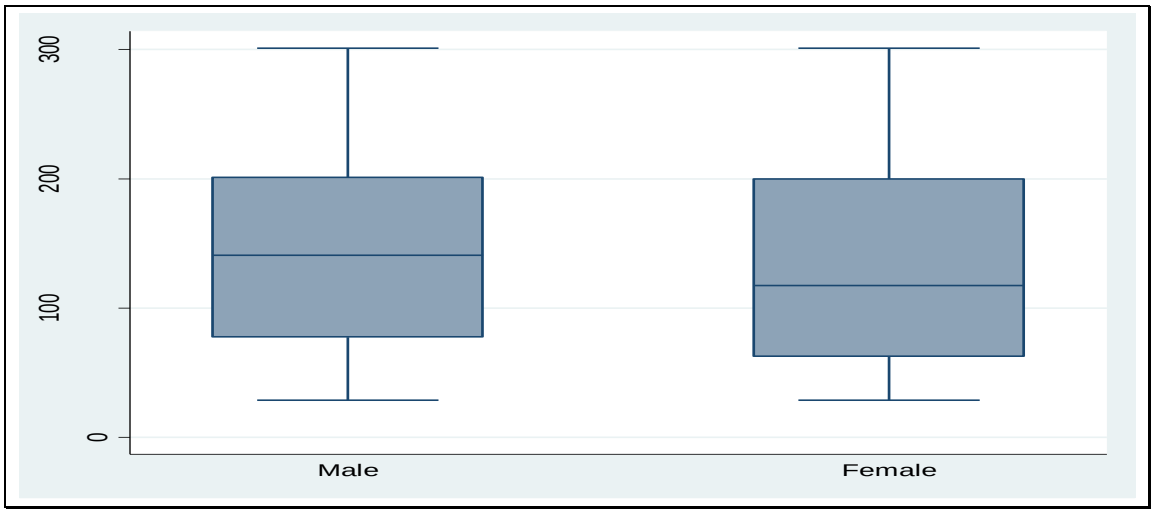
Table 52: Urinary Iodine Concentration levels amongst school age children according to gender in all the three districts

UIC levels (µg/l)	Gender		p-value
Udham Singh Nagar (N=587)			
	Male (n=277) f (%)	**Female (n=310) f (%)**	
<20(n=0)	0	0	0.001**
20-49(n=35)	13(4.7)	22(7.1)	
50-99(n=125)	43(15.5)	82(26.4)	
≥100(n=427)	221(79.8)	206(66.5)	
Median UIC	**165**	**133**	**0.166^{NS}**
Nainital (N=611)			
	Male (n=315) f (%)	**Female (n=296) f (%)**	
<20(n=0)	0	0	0.023*
20-49(n=72)	28(8.9)	44(14.9)	
50-99(n=152)	73(23.2)	79(26.7)	
≥100(n=387)	214(67.9)	173(58.5)	
Median UIC	**135**	**112.5**	**0.016***
Pauri Garhwal (N=580)			
	Male (n=300) f (%)	**Female (n=80) f (%)**	
<20(n=0)	0	0	0.692 ^{NS}
20-49(n=147)	72(24.0)	75(26.8)	
50-99(n=100)	51(17.0)	49(17.5)	
≥100(n=333)	177(59.0)	156(55.8)	
Median UIC	**121.2**	**111.2**	**0.552 ^{NS}**
Combined (all the three districts) (N=1778)			
	Male (n=892) f (%)	**Female (n=886) f (%)**	
<20(n=0)	0	0	**0.001****
20-49(n=254)	113(12.7)	141(15.9)	
50-99(n=377)	167(18.7)	210(23.7)	
≥100(n=1147)	**612(68.6)**	**535(60.4)**	
Median UIC	**141****	**117.5****	**0.001****

Figure in parentheses denotes percentages

$^{\#}$Median UIC level of ≥100: Iodine sufficiency

Figure 41: Combined UIC level of male and female in three districts of Uttarakhand



4.3.3.3 Iodine deficiency status as per urinary iodine concentration level in different age groups

Age wise distribution of UIC level of children in all the districts studied is depicted in **Table 53**. Urinary iodine concentration level was not affected by the different age groups of the children. Hence, no association was found between UIC levels and different age groups of the studied subjects **(Table 54)**. There was no statistical significant difference in the UIC level with age in districts Udham Singh Nagar (p=0.894) and Pauri Garhwal (p=0.552). No trend of UIC level with age was observed. Whereas, in district Nainital a significant difference (p=0.016) was observed between UIC level and different age groups of the children studied.

The age wise distribution of UIC level of children combining all the three districts is depicted in **Table 54**. When dividing it into three age groups, further no association of UIC level with age groups was observed. There was no statistical significant difference in the UIC level and different age groups of the subjects studied (p=0.461).

Table 53: Age wise distribution of UIC level of children in all the districts studied

Age (yrs)	Samples collected	Urinary Iodine Concentration levels (µg/l)				
		<20 n (%)	20-49 n (%)	50-99 n (%)	<100 n (%)	≥100 n (%)
Udham Singh Nagar (N=587)						
6yr	24	0	3(12.5)	4(16.7)	7(29.2)	17(70.8)
7yr	75	0	2(2.7)	20(26.7)	22(29.3)	53(70.7)
8yr	111	0	7(6.3)	17(15.3)	24(21.6)	87(78.4)
9yr	144	0	9(6.2)	33(22.9)	42(29.2)	102(70.8)
10yr	150	0	6(4.0)	33(22.0)	39(26.0)	111(74.0)
11yr	46	0	6(13.0)	11(23.2)	17(36.9)	29(63.1)
12yr	37	0	2(5.4)	7(18.9)	9(24.3)	28(75.7)
Total	**587**	**0**	**35(60.3)**	**125(21.3)**	**160(27.2)**	**427(72.8)**
Nainital (N=611)						
6yr	43	0	2(4.6)	11(25.9)	13(30.2)	30(69.8)
7yr	68	0	14(20.6)	15(22.0)	29(42.6)	39(57.4)
8yr	105	0	20(19.0)	29(27.6)	49(46.6)	56(53.3)
9yr	123	0	17(13.8)	30(24.4)	47(38.2)	76(61.8)
10yr	165	0	11(6.6)	38(23.0)	49(29.7)	116(70.3)
11yr	65	0	4(6.2)	21(32.3)	25(38.5)	40(61.5)
12yr	42	0	4(9.5)	8(19.0)	12(28.6)	30(71.4)
Total	**611**	**0**	**72(11.8)**	**152(24.9)**	**224(36.6)**	**387(63.3)**
Pauri Garhwal (N=580)						
6yr	28	0	8(28.6)	5(17.8)	13(46.4)	15(53.6)
7yr	41	0	11(26.8)	5(12.2)	16(39.0)	25(61.0)
8yr	96	0	24(25.0)	19(19.8)	43(44.8)	53(55.2)
9yr	118	0	34(28.8)	23(19.5)	57(48.3)	61(51.7)
10yr	177	0	34(19.2)	33(18.6)	67(37.8)	110(62.2)
11yr	69	0	22(31.9)	7(10.1)	29(42.0)	40(58.0)
12yr	51	0	14(27.4)	8(15.7)	22(43.1)	29(56.9)
Total	**580**	**0**	**147(25.3)**	**100(17.2)**	**247(42.6)**	**333(57.4)**

Figure in parentheses denotes percentage

Table 54: Urinary iodine concentration levels amongst school age children according to different age groups in all the three districts

Age groups (yrs)	UIC levels (µg/l)			
Udham Singh Nagar (N=587)				
	20-49 (n=35)	**50-99 (n=125)**	**≥100 (n=427)**	**Median UIC**
6-7 (n=99)	5(5.0)	24(24.2)	70(70.7)	141
8-9(n=255)	16(6.3)	50(19.6)	189(74.1)	150
10-12(n=233)	14(6.0)	51(21.9)	168(72.1)	150
p-value	**0.894^{NS}**			
Nainital (N=611)				
	20-49 (n=72)	**50-99 (n=152)**	**≥100 (n=387)**	**Median UIC**
6-7 (n=111)	16(14.4)	26(23.4)	69(62.2)	115
8-9 (n=228)	37(16.2)	59(25.9)	132(57.9)	117.5
10-12 (n=272)	19(7.0)	67(24.6)	186(68.4)	132.5
p-value	**0.016***			
Pauri Garhwal (N=580)				
	20-49 (n=147)	**50-99 (n=100)**	**≥100 (n=333)**	**Median UIC**
6-7 (n=69)	19(27.5)	10(14.5)	40(60.0)	110
8-9 (n=214)	58(27.1)	42(19.6)	114(53.3)	100
10-12 (n=297)	70(23.6)	48(16.2)	179(60.2)	125
p-value	**0.552 ^{NS}**			
Combined (all the three districts) (N=1778)				
	20-49 (n=254)	**50-99 (n=377)**	**≥100 (n=1147)**	**Median UIC**
6-7 (n=279)	40(14.3)	60(21.5)	179(64.2)	124.5
8-9(n=697)	111(15.9)	151(21.7)	435(62.4)	124.0
10-12(n=802)	103(12.8)	166(20.7)	533(66.5)	132.5
p-value	**0.461 ^{NS}**			

WHO (2007): if >20% of the samples had UIC level of <50µg/L, it indicates ID in the community and median UIC level <100 µg/L indicates iodine deficiency in the population

Major Findings:

- 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 >100 µg/L further indicating no biochemical deficiency of iodine.
- **UIC level with gender:** it was found that higher percentage of females had UIC level of <100µg/L compared to males.
- **UIC level with age:** it was found that there was no association of age with UIC levels. No trend of UIC level with age was observed.

4.3.4 Iodine content of salt amongst the household of school age children enrolled in the study

4.3.4.1 Iodized salt intake

WHO/UNICEF/ICCIDD (2007), further recommends that 90% of the household salts should get iodized at the recommended level of 15ppm but the present study shows only 50% of the households were consuming salt at adequate level (15ppm and more).

It was found that higher percentage of families in district Pauri Garhwal (59.6%) were consuming salt with iodine content of <15ppm followed by district Udham Singh Nagar (53.3%) and Nainital (42.3%) **(Table 55)**.

Combining all the three districts studied it was found that 51.4% of the subjects were consuming salt with iodine content of <15ppm.

Table 55: Iodized salt intake amongst school age children in all the three districts

Iodine Content of Salt (ppm)	**Udham Singh Nagar (N=660)**	**Nainital (N=642)**	**Pauri Garhwal (N=562)**	**p-value**	**Combined (all the three districts) (N=1864)**
	n (%)	**n(%)**	**n(%)**		**n(%)**
<15	352(53.3)	271(42.3)	335(59.6)	0.001	958(51.4)
15 and more	308(46.7)	371(57.7)	227(40.4)		906(48.6)
Total	**660**	**642**	**562**		**1864**

Figure in parentheses denotes percentage

4.3.4.2 Iodized salt intake in gender wise

Consumption of iodized salt according to gender in three districts of Uttarakhand is depicted in **Table 56**. 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). There was also no significant difference of salt intake with gender combining all the three districts (p=0.417).

Table 56: Iodized salt intake as per gender in all the three districts

Gender	**Iodine content of salt**		**p=value**
Udham Singh Nagar (N=660)			
	<15ppm (n=352)	**≥15ppm (n=308)**	
Male (n=311)	157(50.5)	154(49.5)	**0.166**^{NS}
Female (n=349)	195(55.9)	154(44.1)	
Nainital (N=642)			
	<15ppm (n=271)	**≥15ppm (n=371)**	
Male (n=299)	125(41.8)	174(58.2)	**0.846** ^{NS}
Female (n=343)	146(42.6)	197(57.4)	
Pauri Garhwal (N=562)			
	<15ppm (n=335)	**≥15ppm (n=227)**	
Male (n=267)	160(59.9)	107(40.1)	**0.884** ^{NS}
Female (n=295)	175(59.3)	120(40.7)	
Combined (all the three districts) (N=1864)			
	<15ppm (n=958)	**≥15ppm (n=906)**	
Male (n=877)	442(50.4)	435(49.6)	**0.417** ^{NS}
Female (n=987)	516(52.3)	471(47.7)	

Figure in parentheses denotes percentage

4.3.4.3 Iodized salt intake in different age groups

Age wise consumption of iodized salt in three districts of Uttarakhand is depicted in **Table 57**. 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.

Table 57: Consumption of iodized salt according to different age groups in all the districts

Age groups (yrs)	**Iodine content of salt**		**p=value**
	Udham Singh Nagar (N=660)		
	<15ppm (n=352)	**≥15ppm (n=308)**	
6-7 (n=112)	54(48.2)	58(51.8)	**0.366^{NS}**
8-9 (n=286)	160(55.9)	126(44.1)	
10-12 (n=262)	138(52.7)	124(47.3)	
	Nainital (N=642)		
	<15ppm (n=271)	**≥15ppm (n=371)**	
6-7 (n=123)	58(47.1)	65(52.8)	**0.259 ^{NS}**
8-9 (n=241)	105(43.6)	136(56.4)	
10-12 (n=278)	108(38.8)	170(61.2)	
	Pauri Garhwal (N=562)		
	<15ppm (n=335)	**≥15ppm (n=227)**	
6-7 (n=71)	43(60.6)	28(39.4)	**0.850 ^{NS}**
8-9 (n=212)	129(60.8)	83(39.2)	
10-12 (n=279)	163(58.4)	116(41.6)	
	Combined (all the three districts) (N=1864)		
	<15ppm (n=958)	**≥15ppm (n=906)**	
6-7 (n=306)	155(50.6)	151(49.3)	**0.396 ^{NS}**
8-9 (n=739)	394(53.3)	345(46.7)	
10-12 (n=819)	409(49.9)	410(50.1)	

Figure in parentheses denotes percentage

Major Findings:

- 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.
- **Salt intake with 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).
- **Salt intake with age groups:** There was no significant difference of salt intake with age 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 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.

4.3.5 Comparison of prevalence of Iodine deficiency disorders based on Total Goiter Rate, Urinary Iodine Concentration levels and iodized salt intake

4.3.5.1 Prevalence of IDD based on UIC level and iodized salt consumption in different age groups

The distribution of school age children according to different age groups with parameters studied is depicted in **Table 58.** It was found that in districts Udham Singh Nagar and Nainital, the median UIC level was increased with increasing age groups. But all the age groups had adequate iodine nutrition status as depicted by median UIC level >100µg/l. In district Pauri Garhwal, the median UIC level showed no trend with different age groups. Moreover, all the age groups had adequate iodine intake as depicted by median UIC level of >100µg/l.

In district Udham Singh Nagar: A weak correlation was found between salt intake and UIC levels (r=0.272; p=<0.001).The elimination of IDD from district Udham Singh Nagar can be achieved by continued and sustained supply of the iodized salt with adequate quantity of iodine to the entire population.

In district Nainital: A weak correlation was found between salt intake and UIC levels (r=0.228; p=<0.001).To eliminate iodine deficiency disorders, there is a need to monitor iodine content of salt regularly so that the entire population of the district receives adequately iodized salt.

In Pauri district: A weak correlation was found between salt intake and UIC levels (r=0.280; p=<0.001). Elimination of IDD from district Pauri Garhwal can be achieved by continued and sustained supply of iodized salt with adequate quantity of iodine to the entire population.

Age wise distribution of school age children of all the parameters studied in all the three districts were studied. In district Udham Singh Nagar, it was found that the increasing trend of median UIC level with age groups. Whereas TGR was found to be more in the

School age children of 8-9 years. Whereas in district Nainital; same increasing trend of median UIC levels with age groups was observed. But in district Pauri Garhwal, no trend was observed **(Table 59)**.

Iodine nutritional status of school age children of all the three districts surveyed is depicted in **Table 59.** It was found that combining all the 3 districts, the median UIC level in the age group of 6-7; 8-9 and 10-12 years were found to be 124, 124 and 132.7 µg/l, respectively. Thus it could be said that with increasing age, the median UIC level also increases. But there was no statistical difference observed between age groups and the median UIC levels. Moreover, no statistical difference was observed between different age groups and salt intake by the population. A weak correlation was found between salt intake and UIC levels ($r=0.248$; $p=<0.001$).

Table 58: School age children according to iodized salt intake and Urinary Iodine Concentration levels in different age groups in all the three districts

Parameters	Age Group			p-value	Multi comparison		
	6-7 Median (min-max)	8-9 Median (min-max)	10-12 Median (min-max)		1 vs 2	2 vs 3	1 vs 3
Udham Singh Nagar							
Salt Intake (n=660)	n=112 15.9 (1.1- 38.4)	n=286 14.8 (1.1 - 38.1)	n=262 14.8 (1.1-38.2)	0.289^{NS}	0.288 ^{NS}	0.465 ^{NS}	0.566 ^{NS}
UIC (n=587)	n=99 141 (34-301)	n=255 150 (29-301)	n=233 150 (29-301)	0.612 ^{NS}	0.077 ^{NS}	0.022 ^{NS}	0.023*
Nainital							
Salt Intake (n=642)	n=123 15.9 (2.3 -32.8)	n=241 16.9 (1.1 - 40.1)	n=278 18 (0-39.1)	0.145 ^{NS}	0.229 ^{NS}	0.426 ^{NS}	0.044*
UIC (n=611)	n=111 115 (49-201)	n=228 117.5 (49 - 201)	n=272 132.5 (49-201)	0.005*	0.966 ^{NS}	0.003*	0.021*
Pauri Garhwal							
Salt Intake (n=562)	n=71 12.7 (0-36)	n=212 13.8 (0- 44.4)	n=279 13.8 (0-31.7)	0.683 ^{NS}	0.408 ^{NS}	0.678 ^{NS}	0.552 ^{NS}
UIC (n=580)	n=69 110 (49-201)	n=214 100 (49-201)	n=297 125 (49-201)	0.120 ^{NS}	0.599 ^{NS}	0.413 ^{NS}	0.041*
Combined (all the three districts)							
Salt Intake	n=306 14.8 (0-38.4)	n=739 14.8 (0-44.4)	n=819 15.8 (0 -39.1)	0.594 ^{NS}	0.336 ^{NS}	0.482 ^{NS}	0.672 ^{NS}
UIC	n=279 124 (34-301)	n=697 124 (29-301)	n=802 132.7 (29-301)	0.149 ^{NS}	0.758 ^{NS}	0.106 ^{NS}	0.110 ^{NS}

Table 59: Age wise distribution of total goiter rate, urinary iodine concentration levels and iodized salt intake in all the three districts

Age wise	Population of School Age Children	TGR (goiter grade 1 and 2) n(%)	No. of Urine samples (n)	UIC <100 n (%)	Median UIC level	No. of salt samples (n)	Salt intake (≥15ppm) n (%)
Udham Singh Nagar							
6-7	559	54(9.6)	99	29(29.2)	100	112	58(51.7)
8-9	692	103(14.8)	255	66(25.8)	150	286	126(44.0)
10-12	556	82(14.7)	233	65(27.9)	150	262	124(47.3)
Nainital							
6-7	686	76(11.0)	111	42(37.8)	115	123	65(52.8)
8-9	776	116(14.9)	228	96(42.1)	117.5	241	136(56.4)
10-12	807	169 (20.9)	272	87(31.9)	132.5	278	170(61.1)
Pauri Garhwal							
6-7	553	64 (11.5)	69	29(42.0)	110	71	28(39.4)
8-9	761	125(16.4)	214	100(46.7)	100	212	83(39.1)
10-12	753	159(21.1)	297	118(39.7)	125	279	116(41.5)
Combined (all the three districts)							
6-7	1798	194(10.8)	279	100(35.8)	124.5	306	151(49.3)
8-9	2229	344(15.4)	757	172(22.7)	124	739	345(46.7)
10-12	2116	410(19.4)	802	270(33.7)	132.5	819	410(50.0)

Figure in parentheses denotes percentage

WHO (2007): TGR ≥5; median UIC <100µg/L defines a population with ID

4.3.5.2 Prevalence of IDD based on total goiter rate, urinary iodine concentration levels and iodized salt intake gender wise

It was found that in district Udham Singh Nagar: TGR and median UIC level was same in both males and females. In district Nainital: median UIC level was same but TGR was more in male compared to females. In district Pauri Garhwal: median UIC level was more in males, TGR was also higher in amle compared to females. TGR denotes past iodine status and median UIC level indicates current iodine status of the population. Hence accordingly; females in district Pauri Garhwal are more towards iodine deficiency compared to males **(Table 60)**.

Table 60: Gender wise distribution of total goiter rate, urinary iodine concentration level and iodized salt intake in all the three districts

Gender	Population of School Age Children	TGR (goiter grade 1 and 2) n(%)	No. of Urine samples (n)	UIC <100 n (%)	Median UIC level (n)	No. of salt samples (n)	Salt intake (≥15ppm) n(%)
Udham Singh Nagar							
Male	847	112(13.2)	277	56(20.2)	100	311	154(49.5)
Female	960	127(13.2)	310	104(33.5)	100	343	154(44.9)
Nainital							
Male	1020	172(16.8)	315	101(32.1)	100	299	175(58.5)
Female	1249	189(15.1)	296	123(41.5)	100	343	197(57.4)
Pauri Garhwal							
Male	1015	187(18.4)	300	123(41.0)	121.5	267	107(40.1)
Female	1052	161(15.3)	280	124(44.2)	111.2	295	120(40.7)
Combined (all the three districts)							
Male	2882	471(16.3)	**892**	280(31.4)	141	877	435(49.6)
Female	3261	477(14.6)	**886**	351(39.6)	117.5	987	471(47.7)

Figure in parentheses denotes percentage
WHO (2007): TGR ≥5; median UIC <100µg/L defines a population with ID

4.3.6 Relationship between Goiter grade and urinary iodine concentration levels of school age children

Table 61 depicts the relationship between goiter grade and UIC levels of school age children in all the three districts of Uttarakhand. It was found that TGR was higher in the school age children of median UIC level of <100µg/l in districts Udham Singh Nagar and Nainital. However, when combining all the three districts similar trend was observed. However the difference between the TGR and UIC level was not statistically significant.

Table 61: Relationship between Goiter grade and urinary iodine concentration levels of school age children in all the three districts

Goiter Grade	Urinary Iodine Concentration levels (µg/l)		p=value
	Udham Singh Nagar (N=587)		
	<100 (n=382)	**≥100 (n=205)**	
Grade 0 (n=480)	313(65.2)	167(34.8)	**0.887**^{NS}
Grade I + II (n=107)	69(64.5)	38(35.5)	
	Nainital (N=611)		
	<100 (n=345)	**≥100 (n=266)**	
Grade 0(n=465)	266(57.2)	199(42.8)	**0.511** ^{NS}
Grade I + II(n=146)	79(54.1)	67(45.9)	
	Pauri Garhwal (N=580)		
	<100 (n=303)	**≥100 (n=277)**	
Grade 0 (n=422)	227(53.8)	195(46.2)	**0.222** ^{NS}
Grade I + II (n=158)	76(48.1)	82(51.9)	
	Combined (all the three districts) (N=1778)		
	<100 (n=1030)	**≥100 (n=748)**	
Grade 0 (n=1367)	806(59.0)	561(41.0)	**0.108** ^{NS}
Grade I + II (n=411)	224(54.5)	187(45.5)	

Figure in parentheses denotes percentage

4.3.7 Relationship between iodized salt intake and urinary iodine concentration levels of children

Relationship of iodized salt intake and urinary iodine concentration levels of school age children in districts Udham Singh Nagar, Nainital and Pauri Garhwal is depicted in **Table 62**. It was found that the higher percentage of school age children consuming inadequately iodized salt (<15ppm) had low urinary iodine concentration level compared to school age children who were consuming adequately iodized salt. Moreover, a statistical significant difference between the salt intake and UIC levels was observed in all the three districts. Moreover, when combining all the three districts there was a statistical significant difference between the iodized salt intake levels and UIC levels of the school age children studied indicating that iodized salt intake affects the UIC levels of the school age children.

Table 62: Relationship between urinary iodine concentration levels and iodized salt intake of school age children in all the three districts

Urinary Iodine Concentration levels (µg/l)	**Salt Intake (ppm)**		**p=value**
	Udham Singh Nagar (N=529)		
	<15ppm (n=382)	**≥15ppm (n=205)**	
<100 (n=145)	100(69.0)	45(31.0)	**0.001****
≥100 (n=384)	175(45.6)	209(54.4)	
	Nainital (N=498)		
	<15ppm (n=201)	**≥15ppm (n=297)**	
<100 (n=189)	96(50.8)	93(49.2)	**0.001****
≥100 (n=309)	105(34.0)	204(66.0)	
	Pauri Garhwal (N=483)		
	<15ppm (n=284)	**≥15ppm (n=199)**	
<100 (n=209)	145(69.4)	64(30.6)	**0.001****
≥100 (n=274)	139(50.7)	135(49.3)	
	Combined (all the three districts) (N=1510)		
	<15ppm (n=760)	**≥15ppm (n=750)**	
<100 (n=543)	341(62.8)	202(37.2)	**0.001****
≥100 (n=967)	419(43.3)	548(56.7)	

Figure in parentheses denotes percentage

Major Findings:

- **In district Udham Singh Nagar:** It was also found that children who were consuming salt with iodine intake ≥15ppm and <15ppm had median UIC level of 200µg/l and 124µg/l, respectively.

In district Nainital: It was also found that children who were consuming salt with iodine intake ≥15ppm and <15ppm had median UIC level of 135µg/l and 100µg/l, respectively.

In district Pauri Garhwal: It was also found that children who were consuming salt with iodine intake ≥15ppm and <15ppm had median UIC level of 137.5µg/l and 90 µg/l, respectively.

- 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.

4.3.8 Block wise prevalence of iodine deficiency based on total goiter rate, urinary iodine concentration levels and iodized salt intake

Blockwise distribution of all the parameters was studied in districts Udham Singh Nagar, Nainital and Pauri Garhwal **(Table 63-65).**

Udham Singh Nagar: It was found that the lowest median UIC level was observed in the block Kashipur and highest median UIC level was in block Khatima. In Kashipur block it was also found that the TGR as 10.5% and UIC level of <100µg/l was found in 36.8% of the school age children studied. Moreover only 42.4% of the studied children were consuming adequately iodized salt **(Table 63)**.

Nainital: It was found that the low median UIC level was found in block Haldwani, followed by block Okhaikanda. These two blocks had higher iodine deficiency as depicted by the median UIC level of <100µg/l. moreover 71.6% (Okhaikanda) and 36.5% (Haldwani) of the school age children had UIC level of <100µg/l. it was also substituted by the low consumption of iodized salt in these two blocks. It was that only 33.3% of the subjects in block Okhaikanda were consuming salt with iodine content of ≥15ppm. Thus it could be said that the distribution and utilization of iodized salt in block Okhaikanda was poor compared to other blocks studied. This could be due to low availability of iodized salt in this block which could be due to poor transportation accessibility **(Table 64)**.

Pauri Garhwal: It was found that the low median UIC level was found in blocks Duggada and dwarikhal, followed by blocks Pokhara, Riknikhal, Thalisan, Birukhal and Naini danda. The consumption of iodized salt in all theses blocks is also low. This could be due to low availability of iodized salt in this block which could be due to poor transportation accessibility **(Table 65)**.

Table 63: Blockwise distribution of school age children according to total goiter rate, urinary iodine concentration level and iodized salt intake in district Udham Singh Nagar

	Goiter (N=1807)		UIC level (N=587)			Salt Intake (N=660)	
Block	**Population of School Age Children (n)**	**TGR (goiter grade 1 and 2) n (%)**	**No. of Urine samples (n)**	**UIC <100 n (%)**	**Median UIC level**	**No. of salt samples (n)**	**Salt intake (≥15ppm) n (%)**
Khatima	180	18(10)	60	8(13.3)	224	62	27(43.5)
Sitarganj	300	34(11.3)	100	24(24.0)	141.5	116	44(37.9)
Rudrapur	357	49(13.7)	117	14(12.0)	200	138	69(50.0)
Gadarpur	239	25(10.4)	79	32(41.8)	116	87	46(52.8)
Bazpur	311	39(12.5)	96	31(31.2)	133	102	68(64.5)
Kashipur	180	19(10.5)	57	21(36.8)	100	66	28(42.4)
Jaspur	240	55(22.9)	78	29(31.2)	124	89	26(29.2)
Total	**1807**	**239**	**587**	**160**		**660**	**308**

Figure in parentheses denotes percentage
WHO (2007): TGR ≥5%; median UIC <100µg/L defines a population with ID

Table 64: Blockwise distribution of school age children according to total goiter rate, urinary iodine concentration level and iodized salt intake in district Nainital

	Goiter (N=2269)		UIC level (N=611)			salt Intake (N=642)	
Blocks	**Population of School Age Children**	**TGR (goiter grade 1 and 2) n (%)**	**No. of Urine samples (n)**	**UIC <100 n (%)**	**Median UIC level**	**No. of salt samples (n)**	**Salt intake (≥15ppm) n (%)**
Betalghat	124	18(14.5)	43	14(32.5)	175	46	19(41.3)
Bhimtal	136	11(8.0)	54	9(16.6)	175	45	33(73.3)
Dhari	130	18(13.8)	42	16(38.0)	132.5	44	28(63.6)
Haldwani	919	163(17.7)	205	75(36.5)	62.5	218	123(49.2)
Kotabagh	125	17(13.6)	40	18(45.0)	100	43	36(83.7)
Okhaikanda	242	57(23.5)	74	53(71.6)	67.5	72	24(33.3)
Ramnagar	593	77(12.9)	153	39(38.5)	150	174	108(62.0)
Total	2269	361	611	224		642	371

Figure in parentheses denotes percentage

WHO (2007): TGR ≥5%; median UIC <100µg/L defines a population with ID

Table 65: Block wise distribution of school age children according to total goiter rate, urinary iodine concentration level and iodized salt intake in district Pauri Garhwal

	Goiter (N=2067)		UIC level (N=580)			salt Intake (N=562)	
Block Pauri	**Population of School Age Children**	**TGR (goiter grade 1 and 2) n (%)**	**No. of Urine samples (n)**	**UIC <100 n (%)**	**Median UIC level**	**No. of salt samples (n)**	**Salt intake (≥15ppm) n (%)**
Birukhal	181	25(13.8)	63	32(15.8)	87.5	59	27(45.7)
Dugadda	238	33(13.8)	63	24(38.0)	49	60	43(73.3)
Dwarikhal	159	33(20.7)	40	19(38.0)	49	33	17(28.3)
Eakeshwar	77	5(6.4)	16	7(43.7)	100	19	6(31.5)
Jerikhal	123	23(18.6)	39	17(43.5)	115	29	14(48.2)
Pauri	343	46(13.4)	99	39(39.3)	132.5	102	35(34.3)
Khirsu	66	12(18.1)	23	2(8.6)	167.5	23	3(13.0)
Naini danda	143	23(16.0)	39	21(53.8)	87.5	40	16(40.0)
Pabau	74	18(24.3)	19	5(26.3)	125	18	9(50.0)
Pokhara	76	23(30.2)	20	13(65.0)	58.7	24	2(8.3)
Riknikhal	145	21(14.4)	34	19(55.8)	75	32	7(21.8)
Thalisian	265	58(21.8)	68	38(55.8)	77.5	68	21(30.8)
Yamkeshwar	177	28 (15.8)	57	11(19.2)	150	55	27(49.0)
Total	2067	348	580	247		562	227

Figure in parentheses denotes percentage
WHO(2007): TGR ≥5%; median UIC <100µg/L, ID

4.3.9 Summary

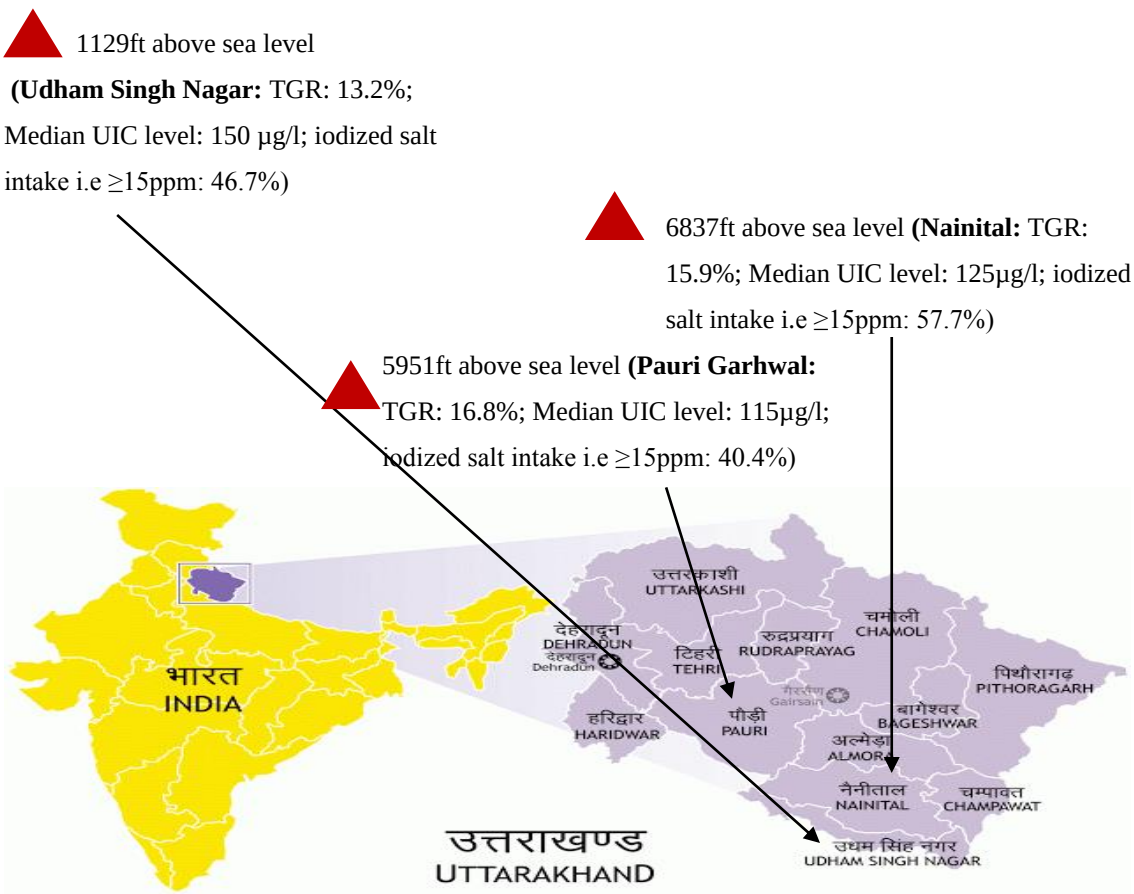
Table 66: Summary of iodine nutritional status amongst school age children in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Parameters	Udham Singh Nagar	Nainital	Pauri Garhwal	Combined
TGR	**13.2(1807)***	**15.9(2269)***	**16.8(2067)***	**15.4*(6142)**
Median UIC (µg/l)	150 (587)	125(611)	115(580)	132.5(1778)
Percentage consuming adequately iodized salt (≥15ppm)	46.7(660)	57.7(642)	40.4(562)	48.6(1864)

***Figures in parenthesis denotes total samples analyzed*

**WHO, 2007 TGR of ≥5% and median UIC of <100µg/l indicates iodine deficiency*

Figure 42: Summary of iodine nutritional status amongst school age children in districts Udham Singh Nagar, Nainital and Pauri Garhwal



DISCUSSION OF RESULTS OF THE PRESENT STUDY WITH OTHER STUDIES

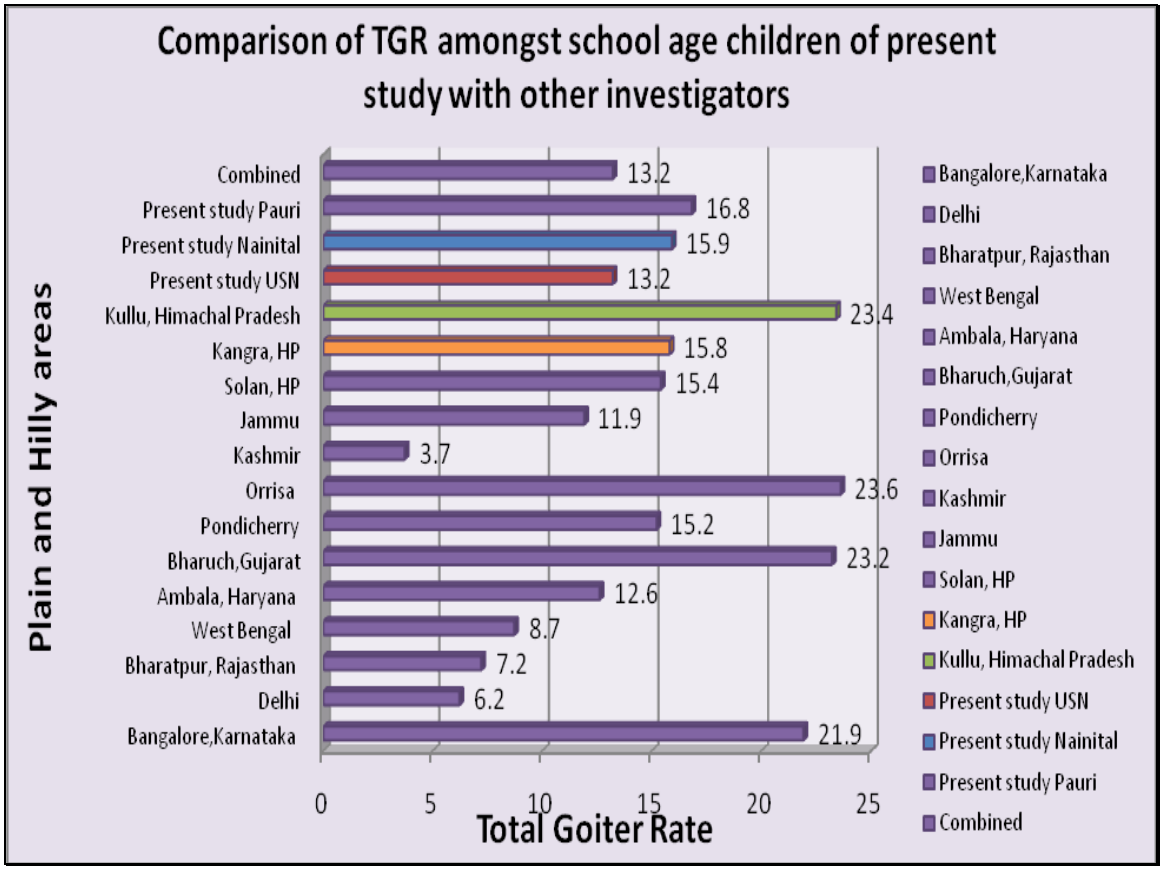
School-age children are a useful target group for IDD surveillance because of their combined high vulnerability, easy accessibility, and applicability to a variety of surveillance activities. Affected children can be readily examined in large numbers in school settings, and can be assessed for urinary iodine, thyroid size, and Tg. At the same time, other health concerns in this age group, including helminth infections, anaemia, and behavioural factors affecting health, can be assessed. Appropriate educational interventions can then be implemented (WHO, 2007).

Enlargement of the thyroid gland is the common manifestation of IDD and goiter survey is used as diagnostic tool to identify areas of IDD. Failure to undertake early detection and intervention measures results in secondary disabling conditions (Kamath et al, 2009).

Comparison of prevalence of TGR in the present study with other studies

School-age children (6–12 years) are the preferred group, as it is usually easily accessible. However, the highest prevalence of goiter occurs during puberty and childbearing age. Some studies have focused on children 8 to 10 years of age. There is a practical reason for not measuring very young age groups. The smaller the child, the smaller the thyroid, and the more difficult it is to perform palpation. If the proportion of children attending school is low, school children may not be the representative (WHO, 2007).

Figure 43: Comparison of TGR amongst school age children of present study with other investigators



#: Hilly areas, ##: Plain areas (#Kullu, HP: Chander et al, 2013; #Kangra, HP: Kapil et al, 2013; #Solan, HP: Kapil et al, 2013; #Jammu: Bhat et al, 2008; #Kashmir: Masoodi et al, 2014; ##Orrisa: Bulliyya et al, 2008, ##Pondicherry: Sarkar et al, 2007 ##Bharuch, Gujarat: Chandwani et al, 2012; ##Ambala Haryana: Chaudhary et al, 2013; ##West Bengal: Biswas et al, 2014; ##Bharatpur Rajasthan: Kapil et al, 2003; ##Delhi: Kapil et al, 2004; ##Karnataka: PVS et al, 2014)

In the present study in district Udham Singh Nagar, a TGR of 13.2% was found, indicating that population had mild iodine deficiency. Earlier study conducted amongst children of 10-12 years in Udham Singh Nagar had documented the prevalence of goiter as 38.1% (Mittal et al, 2000). In district Nainital, a TGR of 15.9% was found, indicating that the subjects had mild iodine deficiency. An earlier survey conducted in 2003 found a prevalence rate of TGR as 6.9% (National Goiter Control Programme, 2004). Another survey conducted amongst school age children documented the prevalence of IDD as 3.7% in district Nainital (mohfw.nic.in/NRHM/PIP_09_ 10/Utta rakhand/NIDDCP_ Text.pdf).

In district Pauri Garhwal, a TGR of 16.8% was found, indicating that the subjects had mild iodine deficiency. We could not compare our results with earlier studies as there is lack of scientific data on status of iodine deficiency in district Pauri.

A recent study conducted by Kapil et al in Himalayan belt reported similar results. It was found that the TGR among school age children (6-12 years) was 15.4 (Solan), 15.8% (Kangra) and 23.4% (Kullu), respectively (Kapil et al, 2013a; Kapil et al, 2013b; Chander et al, 2013). Earlier studies conducted from Himachal Pradesh also reported TGR as 11.3% (Solan), 9.6% (Kullu), 21.1% and 19.8% (Kangra), respectively (Sohal et al, 1999; Kapil et al, 2000; Kapil et al, 2007). Whereas, other similar studies conducted from Hilly terrain reported the TGR as: 3·7% (Kashmir), 11.9% (Jammu), 6.1% (Kinnaur), respectively (Masoodi et al, 2014; Bhat et al, 2008; Kapil et al, 1998).

A study by Toteja et al, 2004 on behalf of ICMR, reported an overall goiter prevalence of 4.7% in 15 districts of 10 states. Sahu et al, 2005 reported a goiter prevalence of 13.1% from Orissa. Biswas et al. reported a goiter prevalence of 19.3% from West Bengal (Biswas et al, 2008). Studies conducted in different regions of India reported the TGR as: 8.7% (West Bengal), 7.7% (Karnataka), 3.9% (8 states of India), 12.6% (Haryana), 23.2% (Gujarat), 26.3% (Uttar Pradesh), 23.6% (Orrisa), 15.2% (Pondicherry), 34.9% (Manipur), 24.3% (Delhi), 8.4% (Rajasthan), 7.0% (Kerala), 16.5% (Andaman and Nicobar), respectively (Biswas et al, 2014; Zama et al, 2013; Laxmaiah et al, 2013; Chaudhary et al, 2013; Chandwani et al, 2012; Chandra et al, 2009; Bulliyya et al, 2008; Sarkar et al, 2007; Chandra et al, 2006; Bakshi et al, 2003; Pradhan et al, 2002 ; Kapil et al, 2002; Mallik et al, 1998). Thus it could be observed that almost all the states in India are endemic to iodine deficiency disorder.

Comparison of prevalence of TGR as per Gender in the present study with other studies

According to WHO/UNICEF/ICCIDD, a total goitre rate of 5% or more in primary school children (6-12 yr) is used to signal the presence of a public health problem.

In the present study, 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. Proportion of Grade II goiter was low compared to Grade I goiter in all the three districts studied.

The TGR (Goiter grade I + Goiter Grade II) in males were found to be 13.2 (Udham Singh Nagar), 16.8 (Nainital) and 18.4 (Pauri Garhwal) percent, respectively. TGR in females were found to be 13.2 (Udham Singh Nagar), 15.1 (Nainital) and 15.3 (Pauri Garhwal) percent, respectively. Thus 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 non significant in districts Udham Singh Nagar; Nainital and Pauri Garhwal. Moreover, when compared district wise TGR was higher in district Pauri Garhwal followed by Nainital and Udham Singh Nagar.

Similar findings were reported by a recent study conducted by Khan et al, 2014 in which the overall prevalence of goiter was 21.2% among boys and 16.7% among girls. Thus prevalence of goiter was significantly higher among boys than girls. A study conducted by Zargar et al, 1997 in Baramulla district of Kashmir valley in 1997 found TGR to be 52.08%, with the higher prevalence among males (52.0%) than females (49.2%). Another study conducted by Zargar et al, 1995 amongst school children aged 5-15 years in Kashmir valley found a TGR of 45.2%. The TGR was 43.9% in boys and 46.2 in girls (37.7% of children had grade I goiter while as 7.4% had grade II goiter). A recent study conducted by Kousar et al, 2013, reported that the prevalence of goiter grade I in boys was higher (34.9%) than girls (25.1%) & prevalence of goiter grade II was 1.8% in boys and 2% in girls. Total goiter rate calculated by summing prevalence of goiter grade I and II was 36.7% in males which is more as compared to females (27.1%).

Whereas, other studies reported that TGR was higher among girls than boys (PVS et al, 2014; Chaudhary et al, 2013). Another similar result was reported by Makwana et al, 2013 that the overall prevalence of goiter was higher in females (5.1%) compared to males (4.6%). The difference of prevalence between sexes was not statistically significant. (χ 2 = 0.223, degree of freedom = 1, p- value = 0.63). The sex difference had no impact on the prevalence of goiter as it was 5.1% and 4.6% in males and females, respectively (p = 0.63).

A recent study by Ahmed et al, 2014 reported that higher prevalence of TGR among females than males, which was more evident in grade 2 goiter cases between the two districts, the difference among the sexes was more prominent in Mysore district than in Coorg district.

Another study by Zama et al, 2013 reported that Grade 1 goiter was more among females (51.16%) as compared to males (48.8%) though not statistically significant (p-value=0.733). However, with respect to grade 2 goiter the difference is significant (p-value=0.012). The overall prevalence of goiter is also higher among female children which is statistically significant (p=0.045). Another similar study by Chaudhary et al, 2013 also reported that prevalence was significantly higher among females than males (*p*=0.0003).

This is consistent with many other studies. A study conducted in Belgaum district of Karnataka, India by Kamath et al, 2009, showed higher prevalence of goitre among girls (21.1%) compared to boys (12.8%). Another study done in coastal district of Karnataka by Rao et al. 2002, showed similar result, with prevalence of goiter among male children being only 28% compared to 31.2% among female children. A study carried out in Kottayam district of Kerala reported a higher prevalence among girls (21.1%) compared to boys (12.8%) (Kapil et al, 2002). Sahu et al, 2005, reported a similar pattern in a study in Orissa: a prevalence of 23.1% in girls and 17.3% in boys. This may be attributed to the genetic predisposition among females to develop thyroid enlargement in response to iodine deficiency. Some studies also reported no significant difference in prevalence

of goiter between boys and girls (Masoodi et al, 2014; Das et al, 2005; Biswas et al, 2002).

Comparison of prevalence of TGR according to different age groups of the present study with other studies

Thus the present study found that as the age increases the TGR also increases. Similar results were reported by a study conducted by Ahmed et al, 2014 which reported an increasing trend of goiter rates in older children. Analyzing the relationship of the prevalence of goiter with age, increasing trend was observed. A similar pattern was found in a study by Bhat et al, 2008, 12.8% in 9 to 12-year-old children as against 10.6% in 6 to 8-year-old children. In a study conducted by Ramesh et al, 2013 in Kottayam, a higher prevalence was noted in older children being 12.3% in 10-12-year-olds as compared to younger children. A similar finding was noted in a study conducted in Bhubaneswar by Sethy et al, 2007, which showed significantly high prevalence of goiter in children aged from 10 to 12 years compared with those aged between 6 and 8 years. This relationship between age and the prevalence of goiter may be attributed to the increased demand for thyroid hormones during puberty. Another reason could be the long standing iodine deficiency manifesting ultimately as enlargement of thyroid gland in older age groups. In terms of the relationship of goitre prevalence with age, Zama et al, 2013 also found that the prevalence was higher in older children: 17.6% in class 7 and 10.9% in class 6, as compared to the younger children (classes 1 to 5) where it ranged from 4.8% to 7.1%.

Another study conducted by Chaudhary et al, 2013 in Ambala district of Haryana reported that prevalence of goitre increased with that of age. The highest prevalence (%) was observed in the age group of 11-12 years. Age-specific prevalence rate (ASPR) was higher in 9 to 12 yr age group as compared to 6 to 8 yr age group. No case of nodular goitre was observed. Chudasama et al, 2011 reported that as the age increased, the goitre prevalence also increased except in age group of 8 years. A study by Kamath et al, 2009 in Belgaum, Karnataka reported that the prevalence of goitre was found to be significantly high (18.1%) among children of the age group 11-13 yr. It was also observed that prevalence of goitre increases with age till 16 yr of age and then there was

a decline in the prevalence. Another study by Chandra et al, 2008, in North East India reported a progressive increase in goitre prevalence from the age group of 6 years till the age of 8 years followed by a short decline from the age of 9 to 10 yrs and then again increased upto 12 years. Zargar et al.1997 reported a similar pattern: a goiter prevalence of 30.2% in children less than 6-year old and 50.6% in children greater than 12-year old. Research studies also reported no association between the age of children and the high prevalence of goiter (Chandra et al, 2008; Misra et al, 2007).

As per the National Family Health Survey (NFHS)-3, the prevalence of goiter or other thyroid disorders was found to be 2.5 times higher in women than in men, and the number of persons with goiter or thyroid disorders increased with age, especially among women. However some studies reported that the TGR was non-significantly associated with age. A recent study conducted by P V S et al, 2014, Karnataka reported that overall age specific TGR among 8, 9 and 10 years old children were 7.84%, 7.85%, and 10.24% respectively; the difference was not statistically significant ($\chi^2 = 3.91, P = 0.141$). Another study by Masoodi et al, 2014 in Kashmir reported that there was no significant difference in prevalence of goiter in the 6-12 year age group (3·3% vs 4·0%, P > 0·1). There was a significant trend of increasing prevalence of goitre with age (P < 0·005). A study by Biswas et al, 2008 found overall age specific goitre prevalence among 8, 9 and 10 years old children were17.5%, 20.3% and 21.4% respectively; the difference was not statistically significant ($\chi 2 = 3.99$, d.f. = 2, p=0.136). The TGR increased with age, but difference was not statistically significant. One study by Chandwani et al, 2012 reported that as the age increased, the goiter prevalence decreased, except in the age group of nine years, in which goiter prevalence was the highest.

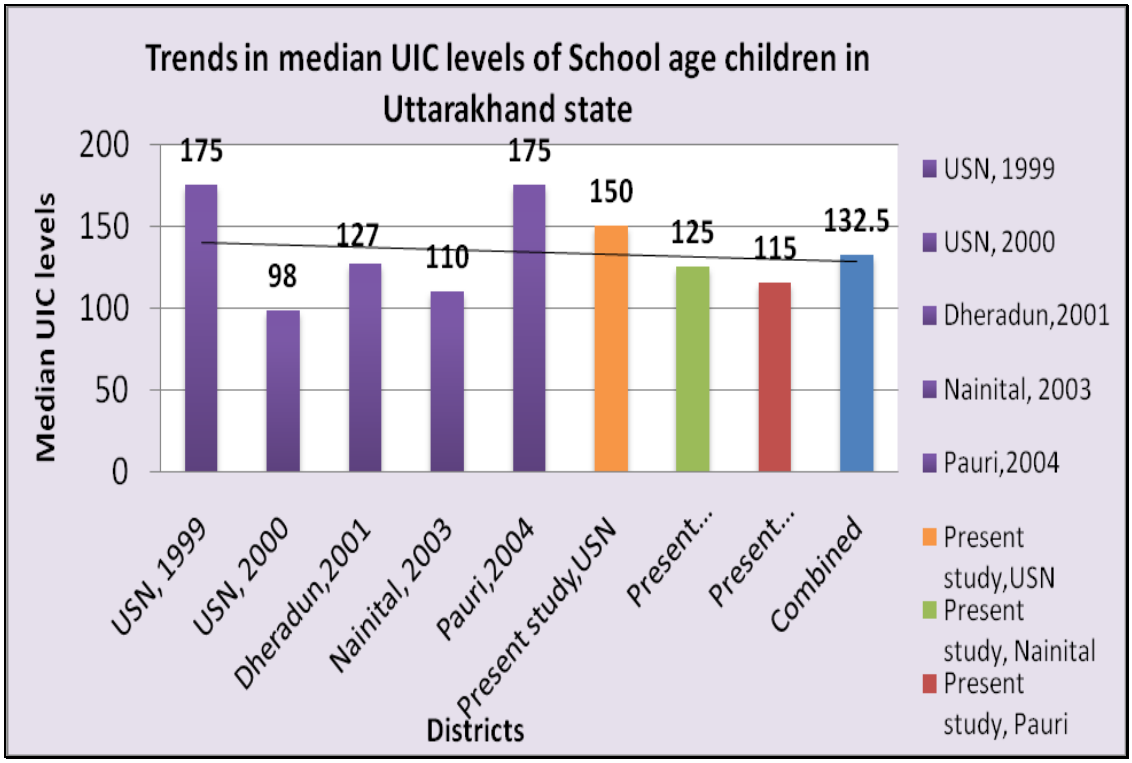
Comparison of iodine deficiency according to median UIC level of the present study with other studies

Most iodine absorbed in the body eventually appears in the urine. Therefore, urinary iodine concentration (UIC) is a good marker of very recent dietary iodine intake. In individuals, UIC can vary somewhat from day to day and even within a given day. However, this variation tends to even out among populations (WHO, 2007).

Studies have convincingly demonstrated that a profile of iodine concentrations in morning or other casual urine specimens (child or adult) provides an adequate assessment of a population's iodine nutrition, provided a sufficient number of specimens are collected. Round the clock urine samples are difficult to obtain and are not necessary. Relating urinary iodine to creatinine, as has been done in the past, is cumbersome, expensive, and unnecessary. Indeed, urinary iodine/ creatinine ratios are unreliable, particularly when protein intake – and consequently creatinine excretion – is low. Urinary iodine concentration is the most reliable indicator of IDD.

The trends in median UIC levels of school age children in Uttarakhand state is depicted in **Figure 44**. There is a decreasing trend of median UIC level amongst school age children of Uttarakhand state as results reported by earlier studies conducted.

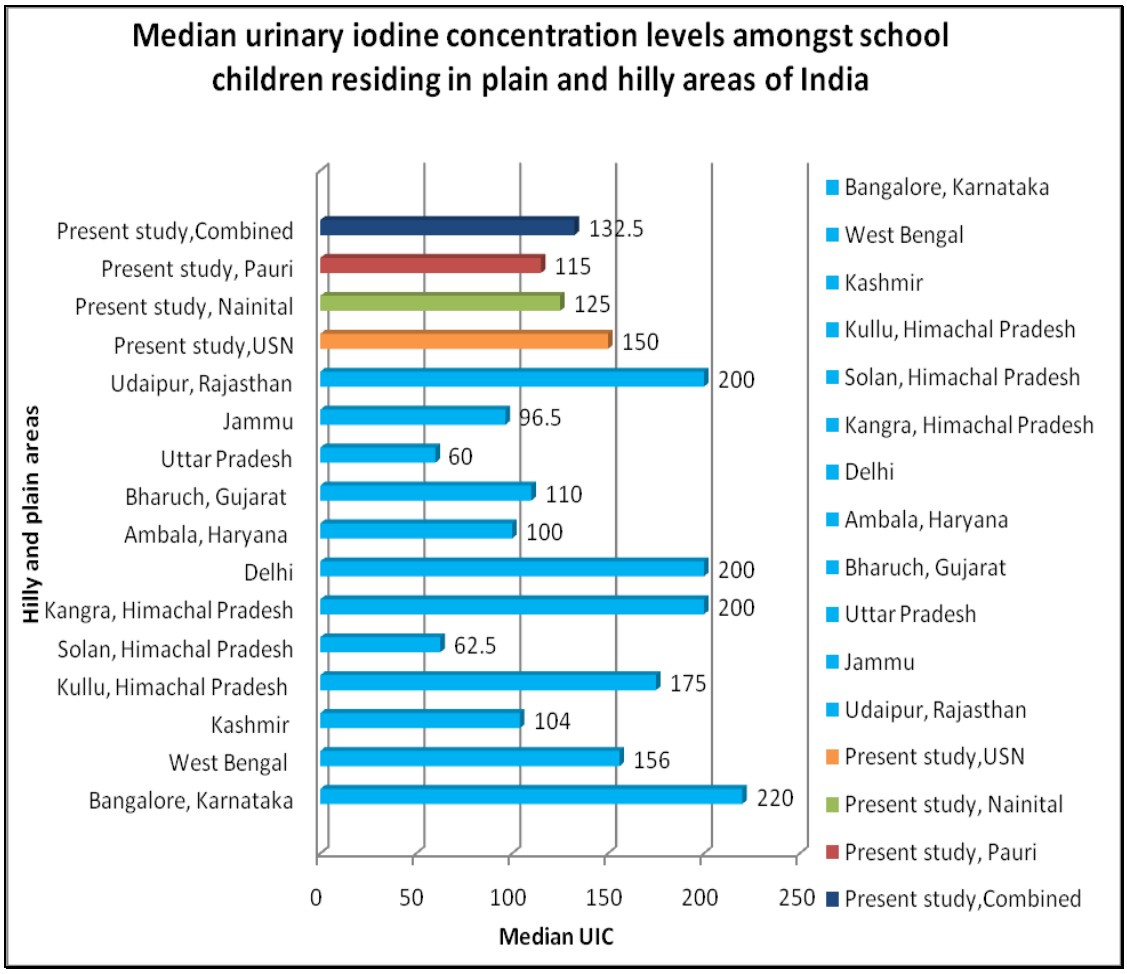
Figure 44: Trends in median UIC levels of school age children in Uttarakhand state



Median Urinary iodine concentration (UIC) level of <100µg/L indicates iodine deficiency in the population studied.
(Source: Udham Singh Nagar, 1999: Kapil et al, 1999; Udham Singh Nagar(USN), 2000; Kapil et al, 2000; Dheradun, 2001; ICMR; Nainital, 2003; WHO)

Median urinary iodine concentration levels amongst school children residing in plain and hilly areas of India is depicted in **Figure 45.**

Figure 45: Median urinary iodine concentration levels amongst school children residing in plain and hilly areas of India



[#]*Median Urinary iodine concentration (UIC) level of <100µg/L indicates iodine deficiency in the population studied, [#]Hilly areas [##]Plain areas
(Source: [##]Udaipur Rajasthan: Pradhan et al, 2003; [#]Jammu: Bhat et al, 2008; [##]Uttar Pardesh: Chandra et al, 2009; [##]Bharuch, Gujarat: Chandwani et al, 2012; [##]Ambala, Haryana: Chaudhary et al, 2013; Delhi: Kapil et al, 2013; [#] Solan, Kangra, Himachal Pradesh: Kapil et al, 2013; [#]Kullu, Himachal Pradesh: Chander et al, 2013, [#]Kashmir: Masoodi et al, 2013;, [##]West Bengal; Biswas et al, 2014; [##]Karnataka: Jaiswal et al, 2015)

In district Nainital, the median UIC level amongst the children studied was found to be 125µg/L, indicating that there was no biochemical deficiency of iodine. A weak correlation was found between UIC level and iodine content of salt ($r=0.23$, $p<0.001$).

According to WHO, global database on iodine deficiency amongst school age children in Nainital, the median UIC level was found to be 110µg/L (WHO global database). In district Udham Singh Nagar, Kapil et al, 1999 and Kapil et al, 2000 reported median UIC level as 175µg/L and 98µg/L, respectively indicating mild iodine deficiency according to the Kapil et al, 2000 study. Whereas in district Pauri Garhwal; no studies were conducted earlier on this aspect. Hence we could not compare the findings of the present district with other studies.

The trends in median UIC levels of school age children in Uttarakhand state compared to earlier studies conducted in Uttarakhand is depicted in **Figure 44**. Compared to the earlier studies conducted in Uttarakhand state, it was found that in districts Udham Singh Nagar, Nainital and Pauri Garhwal, the median UIC level has decreased amongst school age children.

A recent study conducted by Kapil et al, 2014 in Himachal Pradesh (hilly terrain) reported the median UIC level as 62.5µg/l (Solan), 175 µg/l (Kullu) and 200µg/l (Kangra), respectively. Thus, indicating iodine deficiency in district Solan. Whereas other studies from hilly terrain reported the median UIC level as: 104ug/l (Kashmir), 96.5ug/l (Jammu), 52.0ug/l (Kashmir), respectively (Masoodi et al, 2014; Bhat et al, 2008; Zargar et al, 1997).

Studies from other states of India (plain areas) reported the median UIC level as: 220µg/L (Bangalore), 179µg/L (Karnataka), 156µg/L (West Bengal), 200µg/L (Delhi), 100µg/L (Haryana), 110µg/L (Gujarat), 60µg/L (Uttar Pradesh), 115µg/L (West Bengal), 70µg/L (Gujarat), 85.6µg/L (Bihar), 200µg/L (Rajasthan), 70µg/L (Andaman and Nicobar), respectively (Jaiswal et al, 2015; P V S et al, 2014; Biswas et al, 2014; Kapil et al, 2013; Chaudhary et al, 2013; Chandwani et al, 2012; Chandra et al, 2009; Biswas et al, 2008; Misra et al, 2007; Sankar et al, 2006; Pradhan et al, 2003; Mallik et al, 1998).

A recent departmental study conducted by Joshi et al, 2014 amongst school age children (6-15 years) of Vadodara district of Gujarat reported the median UIC level of 145.9µg/L, indicating adequate iodine nutrition status amongst the studied population.

Thus it was found that hilly terrain reported higher prevalence of iodine deficiency compared to plain areas of India as depicted by median UIC level (<100µg/L) which is a good marker to assess iodine deficiency in the population **(Figure 45)**.

Comparison of iodine deficiency according to median UIC level gender wise of the present study with other studies

A present study found that higher percentage of females had UIC level of <100µg/L compared to males. A study by Damor et al, 2013 in Gujarat reported that the gender-wise distribution of urinary iodine excretion showed that the proportion of children with urinary iodine concentration >100µg/dl was almost similar among both the genders. Limited studies are available on association of UIC level with gender. Hence, we could not compare the findings of the present study with other similar studies.

Comparison of iodine deficiency according to median UIC level of the present study in different age groups with other studies

A present study found that there was no association of age with UIC levels. No trend of UIC level with age was observed. A study conducted by Damor et al, 2013 in Gujarat reported age-wise distribution of urinary iodine and found that the proportion of children with urinary iodine concentration of <100µg/l was lowest in the 6-year age, whereas the highest proportion was found in the 10-year age. Another study by Das et al, 2008 in West Bengal reported that there was significant negative correlation between UIC levels and the age. Limited studies have been conducted on UIC level specific to age; hence we couldn't compare the findings of the present study with other studies.

Comparison of iodized salt intake amongst school age children in the present study with other studies

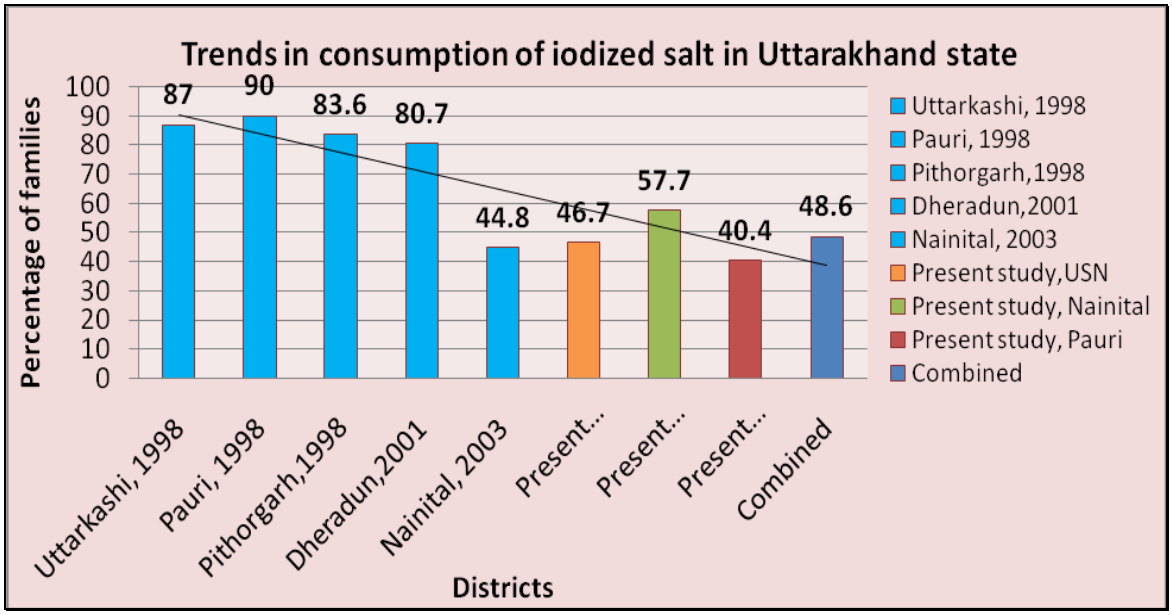
WHO/UNICEF/ICCIDD (WHO, 2007) recommend that, in typical circumstances, where the iodine lost from salt is 20% from production site to household, another 20% is lost during cooking before consumption, and average salt intake is 10g per person per day,

iodine concentration in salt at the point of production should be within the range of 20–40 mg of iodine per kg of salt (i.e., 20–40ppm of iodine) in order to provide 150 µg of iodine per person per day. The iodine should preferably be added as potassium iodate.

However, in some instances the quality of iodized salt is poor, or the salt is incorrectly packaged, or the salt deteriorates due to excessive long term exposure to moisture, heat, and contaminants. Iodine losses from point of production to consumption can then be well in excess of 50%. In addition, salt consumption is sometimes much less than 10 g per person per day. As a result, actual iodine consumption may fall well below recommended levels, leading to low urinary iodine values for the population (WHO, 2001).

WHO/UNICEF/ICCIDD further recommends that 90% of the household salts should get iodized at the recommended level of 15ppm but the present study shows only 50% of the households were consuming salt at adequate level (15ppm and more).

Figure 46: Trends in consumption of adequately iodized salt (>15ppm) in Uttarakhand state



Source: Uttarkashi, Pauri, Pithorgarh: Kapil et al, 2004; Dheradhun: ICMR, 2001; Nainital: NIN, 2003

In district Udham Singh Nagar, 53.3% of families were found consuming salt with iodine content of less than 15 ppm, which is below the stipulated level of iodine. However; an earlier study conducted in the district reported that only 4.4% of the families were consuming salt with less than 15 ppm of iodine (Mittal et al, 2000). Compared to earlier studies conducted there has been increase in percentage of the families who are consuming salt with iodine content of less than 15ppm.

In district Nainital, 42.3% of families were found consuming salt with iodine content of less than 15 ppm, which is below the stipulated level of iodine. An earlier study reported that 55.2% of the children were consuming salt with iodine content of less than 15 ppm (NIN, 2003). The increase in TGR could be due to consumption of salt with low iodine content by a higher percentage of population. In district Nainital, there has been decrease in the percentage of the families who are consuming salt with iodine content of less than 15ppm.

In district Pauri Garhwal, 59.6% of the children were found consuming salt with iodine content of less than 15ppm. We could not compare the findings of this district with earlier studies due to lack of studies from district Pauri.

In Uttarakhand the use of adequately iodized salt by the population has decreased from 60% in NFHS-2 (1989-99) to 46% in NFHS-3 (2005-06). Thus overall according to NFHS survey, there has been decrease in the percentage of the household consuming salt with adequate iodine content.

Thus overall 51.4% of the families combining all the three districts studied from Uttrakhand were consuming salt with iodine content of <15ppm. Hence, comparing it with NFHS-3 data, which reported 54% of the families were consuming salt with iodine content of <15ppm. Thus it could be easily observed that the consumption of iodized salt in Uttarakhand state is still lower than the national goal of 90% consumption of adequately iodized salt.

But the Iodized Salt Coverage Study (2010), shows that the availability of adequately iodized salt at households in Uttarakhand has improved substantially from 32.8% in NFHS 3 in 2005-2006 to 64.1% in 2010. Inadequately iodized salt also reduced partially from 30.4% to 29.7% during last five years. Non iodized salt has reduced drastically from 36.8% in NFHS 3 to only 6.2%. It was also found that most people in Uttarakhand (84.5%) use packaged crushed salt and 15.5% use loose crystal salt. Majority of the households purchased salt from the neighboring grocery store. And regarding storage of the salt, it was found that maximum number of household store salt in containers with lid. According to the survey, 65.3% of the households in Uttarakhand were aware of iodized salt. The average price paid for one kilogram of packaged crushed salt is Rs.10 (NFHS-3).

A recent study conducted by Kapil et al, 2014 in Himachal Pradesh state reported that 61.0% (Solan), 17.7 (Kangra) and 48.7% (Kullu) of the families consumed salt with iodine intake of less than 15ppm, which is less than the level recommended by government of India.

Studies conducted in other hilly terrains reported that 1.85 (Jammu), 36.0 (Kangra), 18.0 (Himachal Pradesh), 12.7 (Kangra), 10.0 (Kinnaur) percentage of the families were consuming salt with iodine intake less than 15ppm (Bhat et al, 2008; Kapil et al, 2007; Kapil et al, 2005; Kapil et al, 2000; Kapil et al, 1998). A study conducted by Toteja et al, 2004 in 15 districts of India reported that a total of 44.6% of the families in these districts consumed salt with iodine intake with less than 15ppm.

Whereas studies conducted in different plain terrains of the India reported that: 9.2% (Karnataka), 7.4% (West Bengal), 28.4% (Karnataka), 13.0%(Delhi), 12.0% (Haryana), 7.0% (Gujarat), 82.9% (Uttar Pradesh), 68.7% (Karnataka), 49.6% (West Bengal), 45.7% (Panchmahal, Gujarat), 59.9% (Bihar), 55.0% (Andhra Pradesh), 39.4% (Kerala), 17.5% (Andaman and Nicobar), 66.9% (Tripura) of the families were consuming salt with iodine content of <15ppm (P V S et al, 2014; Biswas et al, 2014; Zama et al, 2013; Kapil et al, 2013; Chaudhary et al, 2013; Chandwani et al, 2012; Chandra et al, 2009; Kamath, 2009;

Biswas et al, 2008; Misra et al, 2007; Sankar et al, 2006; Kapil et al, 2004; Kapil et al, 2002; Mallik et al, 1998; Chandra et al, 1997).

A study by Chandra et al. 2005 reported that more than 95% of the households were consuming salts at adequate level, while Kamath et al, 2009 and Biswas et al. 2008, reported that only 50% of the households were consuming salt at adequate levels, a finding which was very low). In a study conducted in Delhi (Kapil et al, 1993), it was noted that only 41% of the households consumed adequately iodized salt.

A study conducted by Ahmed et al, 2014 reported that in Mysore district, 54.0% of the salt samples had adequate iodine content (>15 ppm), whereas in Coorg district only 26.0% of the salt samples were adequately iodised. This pattern of consumption of iodized salt in the two districts was still lower than the national goal of 90% consumption of adequate iodized salt. Similar results were seen in other studies: National Family Health Survey-3, report showed that 51% population of the country was using adequately iodized salt (>15 ppm) (NFHS-3).

Taken together, these results suggested that there is a need to strengthen the system of monitoring the quality of salt, to ensure the availability of 15 ppm of iodine at the household level. Thus there is a need to strengthen the system of monitoring of quality of salt to ensure availability of 15ppm of iodine at the household level in Uttarakhand state.

Table 67: Comparison of results of the present study (school age children) with other studies conducted in India

Author/ year	Place	Age group	TGR (%)	Median UIC (ug/L)	Percentage of Iodine content of salt with less than 15ppm
Present study	**Districts: Udham Singh Nagar, Nainital and Pauri Garhwal, Uttarakhand**	**6-12**	**Udham Singh Nagar: 13.2 Nainital: 15.9 Pauri Garhwal: 16.8**	**Udham Singh Nagar: 150 Nainital: 125 Pauri Garhwal: 115**	**USN:53.3 Nainital:42.3 Pauri Garhwal: 59.6**
Manjunath et al, 2016	Bangalore, Karnataka	6-12	21.9	-	-
Jaiswal et al, 2015	Bangalore, Karnataka	3-15	-	220	-
P V S et al, 2014	Karnataka	6-15	0.12	179	9.25
Biswas et al, 2014	West Bengal	8-10	8.7	156	7.4
Ahmed et al, 2014	Karnataka (2 districts: Coorg and Mysore)	6-12	C-19.01 M-8.77	-	c-73.92 m-45.92
Masoodi et al, 2014	Kashmir	6-12	3·7	104	-
Zama et al, 2013	Karnataka	6-12	7.74	-	28.4
Chander et al, 2013	Kullu, Himachal Pradesh	6-12	23.4	175	48.7
Kapil et al, 2013	Delhi	6-11		200	13.0
Kapil et al, 2013	Solan, Himachal Pradesh	6-12	15.4	62.5	61.0
Kapil et al, 2013	Kangra, Himachal Pradesh	6-12	15.8	200	17.7
Laxmaiah et al, 2013	8 states of India	-	3.9	-	-
Chaudhary et al, 2013	Ambala, Haryana	6-12	12.6	100	12.0
Chandwani et al, 2012	Bharuch, Gujarat	6-12	23.2	110	7.0
Chudasama et al,2011	Kutch, Gujarat	6-12	11.2	110	7.7
Arlappa et al, 2011	West Bengal	6-12	9.0	-	-
Agarwal et al, 2011	Delhi	6-12		198·4	11.2
Chandra et al, 2009	Uttar Pradesh	6-12	26.3	60.0	82.9
Kamath et al, 2009	Belgaum, Karnataka	-	16.7	-	68.7
Biswas et al, 2008	West Bengal	8-10	19.7	115	49.6
Das et al, 2008	West Bengal	8-10	13.7	130	20.0
Bulliyya et al, 2008	Orissa	6-12	23.6	-	9.0 (>5ppm)
Bhat et al, 2008	Jammu	6-12	11.9	96.5	1.8
Chandra et al, 2008	Howrah, West Bengal	6-12	38	250.0	30.0
Misra et al, 2007	Panchmahal, Gujarat	6-12	20.5	70.0	45.7
Sarkar et al, 2007	Pondicherry	9-13	15.2	-	-
Kapil et al 2007	Kangra, Himachal Pradesh	6-12	19.8	200.0	36.0
Sankar et al, 2006	Bihar	6-12	-	85.6	59.9

Chandra et al, 2006	Imphal, Manipur	6-12	34.9	125-175	3.0
Biswas et al, 2006	Purulia, West Bengal	8-10	25.9	92.5	66.6
Das et al, 2005	Dakshin Dinajpur, West Bengal	8-10	18.6	160.0	32.6
Kapil et al, 2005	Himachal Pradesh	11-18	-	> 200	18.0
Chandra et al, 2004	Howrah, West Bengal	6-12	37.6	350.0	51.9
Kapil et al, 2004	Tamil Nadu	6-12	-	<100	62.3 (>5ppm)
Kapil et al, 2004	Delhi	6-11	6.2	200.0	16.0 (<5ppm)
Kapil et al, 2004	Andhra Pradesh	-	-	>100	55.0
Toteja et al, 2004	15 districts of India	6-12	4.7	-	44.6
Rao et al, 2003	Purnia, Bihar	10-12	11.6	-	-
Bakshi et al, 2003	Delhi	6-10	24.3	-	-
Pradhan et al, 2003	Udaipur, Rajasthan	6-12	8.4	200.0	15.0
Kapil et al, 2003	Bharatpur, Rajasthan	6-12	7.2	200.0	44.0
Biswas et al, 2002	Malda, West Bengal	8-10	11.3	150.0	14.9
Kapil et al, 2002	Kottayam District-Kerala	6-12	7.0	-	39.4
Chandra et al, 2001	Tripura	6-15	21.6	-	-
Gakkhar et al, 2001	Jabalpur	6-15	2.4	109	-
Kapil et al, 2000	Meerut, UP	6-10	11.6	150	53.0
Kapil et al, 1999	Delhi	-	-	-	41.0
Kapil et al, 1998	Kinnaur, HP	6-10	6.1	<100-17.7	10.0
Pandav et al, 1999	Maldives	6-12	23.6	67	92.0
Mallik et al, 1998	Andaman and Nicobar	7-18	16.5	70	17.5
Kapil et al, 1997	Bihar	6-12	11.6	100	29.5
Kapil et al, 1999	Delhi	-	-	-	41.0
Chandra et al, 1997	Tripura	-	13.9 to 30.9	-	66.9
Pandav et al, 1997	Delhi	-	20.5	198.0	-
Zargar et al, 1997	Baramulla , Kashmir	5-15	52.0	41.8	-
Kapil et al, 1996	Delhi	8-10	8.6	170.0	41.0
Chaturvedi et al, 1996	Delhi	-	16.0	--	-
Sankar et al, 1995	Sikkim	>14	73.5	4.13 ng/dl	-

4.4 PART 4: IODINE NUTRITIONAL STATUS AMONGST ADOLESCENT GIRLS

The result of this part is further divided into following sections:

General characteristics of adolescent girls enrolled in the study

Clinical Examination: Thyroid Size of adolescent girls enrolled in the study

Prevalence of goiter as per clinical examination of thyroid size
Age wise prevalence of TGR
Cluster wise prevalence of TGR

Biochemical Estimation of adolescent girls enrolled in the study

Iodine deficiency status as per urinary iodine concentration level
Iodine deficiency status as per urinary iodine concentration level in different age groups

Iodine content of salt amongst the household of adolescent girls enrolled in the study

Iodized salt intake
Iodized salt intake in different age groups

Comparison of prevalence of IDD based on TGR, UIC levels and iodized salt intake

Prevalence of IDD based on TGR, UIC and salt in different age groups
Relationship between Goiter grade and UIC levels of adolescent girls
Relationship between Iodized salt intake and UIC levels adolescent girls

Block wise prevalence of IDD based on TGR, UIC levels and iodized salt intake

4.4.1 General characteristics of adolescent girls enrolled in the study

In the districts selected, 30 clusters (schools) were identified by utilizing population proportionate to size sampling (PPS) methodology recommended by WHO for IDD survey (WHO, 2007). In each clusters, subjects (adolescent girls; 12-18 years) were covered. The adolescent girls were covered by school based approach as more than 90% adolescent girls attended the schools.

District Udham Singh Nagar is a plain area and is situated at an altitude of 1129ft above sea level. Whereas, districts Nainital and Pauri Garhwal is a hilly terrain and is situated at an altitude of 6837ft and 5951ft above sea level, respectively.

Thirty clusters (schools) were selected in three districts of Uttarakhand. In districts Udham Singh Nagar, Nainital and Pauri Garhwal a total of 1823, 1811 and 1796 adolescent girls in the age group of 12-18 years were selected from the government schools of Uttarakhand state **(Table 68).**

Table 68: Distribution of adolescent girls (12-18yrs) according to clusters in all the three districts

Cluster No.	Udham Singh Nagar (N=1823)		Nainital (N=1811)		Pauri Garhwal (N=1796)	
	Cluster Name	Population of adolescent girls	Cluster Name	Population of adolescent girls	Cluster Name	Population of adolescent girls
1	Matkota, Rudrapur	58	Nainital, Bhimtal	61	Paidul, Pauri	60
2	Fazilpur Mehrola, Rudrapur	60	Jeolikot, Bhimtal	60	Kandara, Pauri	61
3	Shantipur, Rudrapur	60	Patwadangar, Bhimtal	61	Nishi, Pauri	60
4	Brithnagar, Rudrapur	63	Bhowali, Bhimtal	60	Pauri	61
5	Kichha	60	Bhimtal	60	Doumatikhal, Pauri	60
6	Dineshpur, Gadarpur	61	Naukuchiyatal, Bhimtal	60	Kyark, Pauri	60
7	Gadarpur	60	Khurpatal, Bhimtal	61	Khandah, Khirsu	62
8	Sakaianya, Gadarpur	64	Mangoli, Bhimtal	60	Sueet, Khirsu	60
9	JAgnagar, Gadarpur	60	Sukhatal, Bhimtal	60	Srinagar, Khirsu	60
10	Jagdishpuri, Gadarpur	60	Bagoniyahaldu, Kotabagh	60	Chipal Ghat, Pabau	60
11	Kashipur	65	Kotabagh	60	Pabau	64
12	Partappur, Kashipur	60	Kaladungi, Kotabagh	60	Chopriyoun, Pabau	60
13	Mahuakhera GAnj, Kashipur	60	Bail Parou, Ramnagar	64	Kot	60
14	Banshkheda, Kashipur	60	Dhikoli, Ramnagar	60	Jamlakhal, Kot	60
15	Shivlapur, Kashipur	62	Ramnagar	60	Khota Chouri, Kot	60
16	Sitarganj	60	Karanpur, Ramnagar	60	Satpuli, Dwarikhal	60
17	Shaktifarm, Sitarganj	60	Maldhanchaour, Ramnagar	61	Ekshwar	61
18	Odali, Sitarganj	60	Thari, Ramnagar	60	Metakhund, Ekeshwar	60
19	Bijiti, Sitarganj	65	Dhela, Ramnagar	60	Naugaunkhal, Ekeshwar	61
20	Seisouna, Sitarganj	61	Chhoi, Ramnagar	60	Kirtikhaal, Dwarikhaal	60
21	Pratap pur, Khatima	61	Ganjani, Ramnagar	61	Riknikhal	46
22	Jhankat, Khatima	60	Haldwani, Nainital	62	Dugadda	61
23	Khatima	60	Chorgalia, Haldwani	60	MAtiyali, Dugadda	60
24	Bandiya, Khatima	60	Lamachodh, Haldwani	60	Kotdwar, Dugadda	60

25	Shripur Bichwa, Khatima	60	Dhola Khera, Haldwani	60	Kanav ghati, Dugadda	60
26	Berheni, Bazpur	60	Laluan, Haldwani	60	Kumbhichod, Dugadda	60
27	Kerla Kheda, Bazpur	60	Kusumkheda, Haldwani	60	Kalalghati, Dugadda	60
28	Haripurr Hassan, Bazpur	60	Banbhool Pura, Haldwani	60	Gamandpur , Dugadda	60
29	Bazpur	63	Haldu Chour, Haldwani	60	Jaidevpur, Dugadda	60
30	Sultanpuri, Bazpur	60	Katgharia, Haldwani	60	Padampur, Dugadda	59
Total		**1823**		**1811**		**1796**

4.4.1.1 Distribution of adolescent girls according to age

The distribution of adolescent girls according to age in three districts of Uttarakhand state is depicted in **Table 69**. The adolescent girls selected were in the age group of 12-18 years. Further the adolescent girls were divided into 3 groups: 12-13 years, 14-15 years and 16-18 years.

Table 69: Distribution of adolescent girls according to age in all the three districts

Age of Children (Years)	**Udham Singh Nagar (N=1823)**	**Nainital (N=1811)**	**Pauri Garhwal (N=1796)**	**Total**
	N (%)	**N (%)**	**N (%)**	
12	277(15.2)	129(7.1)	219(12.2)	625
13	349(19.2)	263(14.5)	257(14.3)	869
14	313(17.2)	310(17.1)	307(17.1)	930
15	306(16.8)	291(16.1)	290(16.2)	887
16	270(14.7)	365(20.2)	347(19.3)	982
17	253(13.9)	332(18.3)	294(16.4)	879
18	55(3.0)	121(6.7)	82(4.5)	258
Total	**1823**	**1811**	**1796**	**5430**

Figure in parenthesis denotes percentage

4.4.2 Clinical Examination: Thyroid Size of adolescent girls enrolled in the study.

4.4.2.1 Prevalence of goiter as per clinical examination of thyroid size

The proportion of Grade II goiter was low compared to Grade I goiter in all the three districts. Thus overall the TGR was found to be 6.8% (Udham Singh Nagar), 8.2% (Nainital) and 5.6% (Pauri Garhwal), respectively indicating presence of mild iodine deficiency in all the districts surveyed. As the TGR of ≥5.0% in a population indicates presence of iodine deficiency **(Table 70)**. It was found that the prevalence of TGR was more in district Nainital, followed by Udham Singh Nagar and Pauri Garhwal.

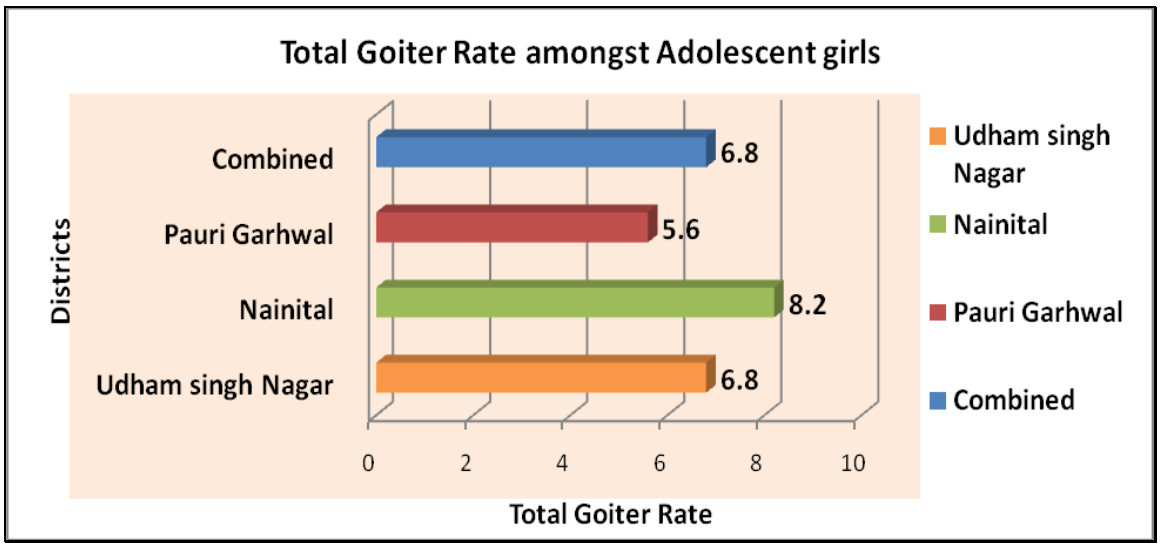
Combining all the three districts the prevalence of TGR was found to be 6.8% indicating presence of mild iodine deficiency amongst adolescent girls in three districts of Uttarakhand state **(Figure 47).**

Table 70: Prevalence of total goiter rate amongst adolescent girls in all the three districts

Goiter Grade	Udham Singh Nagar (N=1832)	Nainital (N=1811)	Pauri Garhwal (N=1796)	Combined (all the three districts) (N=5430)
	n(%)	n(%)	n(%)	n (%)
0	1699(93.2)	1662(91.8)	1695(94.4)	5056(93.1)
I	112(6.1)	142(7.8)	96(5.3)	350(6.4)
II	12(0.7)	7(0.4)	5(0.3)	24(0.4)
Total Goiter Rate (I+II)	**124(6.8)**	**149(8.2)**	**101(5.6)**	**374(6.8)**
p-value	0.471^{NS}			

Figure in the parentheses indicate percentages
WHO, 2007: TGR ≥5%: Iodine deficiency

Figure 47: Total goiter rate amongst adolescent girls of all the three districts



WHO, 2007: TGR ≥5%: Iodine deficiency

4.4.2.2 Prevalence of Goiter as per age

The TGR as per the age of the adolescent girls in three districts of Uttarakhand is depicted in **Figure 48**. No association of TGR with age was observed.

Total goiter rate according to age groups in total population studied is depicted in **Table 71**. 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. There was no statistical significant difference in the age groups and TGR of adolescent girls in districts Udham Singh Nagar (p=0.615), Nainital (p=0.272) and Pauri Garhwal (p=0.594). It was found that out of 1823 adolescent girls surveyed in Udham Singh Nagar; 124 adolescent girls had goiter and 1699 adolescent girls had no goiter present. Similarly, in district Nainital, out of 1811 adolescent girls; 149 had goiter and 1622 had no goiter. In district Pauri Garhwal, out of 1796 adolescent girls; 101 had goiter and 1695 had no goiter present. Further when combining all the three districts no statistical significant difference was found in TGR and different age groups of adolescent girls studied (p=0.184).

Combining all the three districts it was found that the TGR of adolescent girls increases till the age of 14-15 years and then further decline in the age group of 16-18 years. There

was no statistical significant difference between the TGR and age groups of the adolescent girls studied **(Figure 49)**.

Table 71: Prevalence of goiter as per age groups of adolescent girls in all the three districts

Age groups (yrs)	**Goiter Grade**			**Total Goiter Rate (Goiter Grade I + II)**
	Udham Singh Nagar (N=1823)			
	Goiter Grade 0 (n=1699)	**Goiter Grade I(n=112)**	**Goiter Grade II(n=12)**	
12-13 (n=626)	585(93.5)	37(5.9)	4(0.6)	41(6.5)
14-15 (n=619)	572(92.4)	42(6.8)	5(0.8)	47(7.6)
16-18 (n=578)	542(93.8)	33(5.7)	3(0.5)	36(6.2)
p-value	**0.897^{NS}**			**0.615 ^{NS}**
	Nainital (N=1811)			
	Goiter Grade 0 (n=1662)	**Goiter Grade I(n=142)**	**Goiter Grade II(n=7)**	
12-13 (n=392)	357(91.1)	33(8.4)	2(0.5)	35(8.9)
14-15 (n=601)	545(90.7)	54(9.0)	2(0.3)	56(9.3)
16-18 (n=818)	760(92.9)	55(6.7)	3(0.4)	58(7.1)
p-value	**0.514 ^{NS}**			**0.272 ^{NS}**
	Pauri Garhwal (N=1796)			
	Goiter Grade 0 (n=1695)	**Goiter Grade I(n=96)**	**Goiter Grade II(n=5)**	
12-13(n=476)	446(93.7)	30(6.3)	0	30(6.3)
14-15(n=597)	562(94.1)	33(5.5)	2(0.4)	35(5.9)
16-18(n=723)	687(95.0)	33(4.6)	3(0.4)	36(5.0)
p-value	**0.476 ^{NS}**			**0.594 ^{NS}**
	Combined (all the three districts) (N=5430)			
	Goiter Grade 0 (n=5056)	**Goiter Grade I(n=350)**	**Goiter Grade II(n=24)**	
12-13(n=1494)	1388(92.9)	100(6.7)	6(0.4)	106(7.0)
14-15(n=1817)	1679(92.4)	129(7.1)	9(0.5)	138(7.6)
16-18(n=2119)	1989(93.9)	121(5.7)	9(0.4)	130(6.1)
p-value	**0.471 ^{NS}**			**0.184 ^{NS}**

Figure in the parentheses indicate percentages
WHO, 2007: TGR ≥5%: Iodine deficiency

Figure 48: Prevalence of goiter as per age of adolescent girls in all the districts

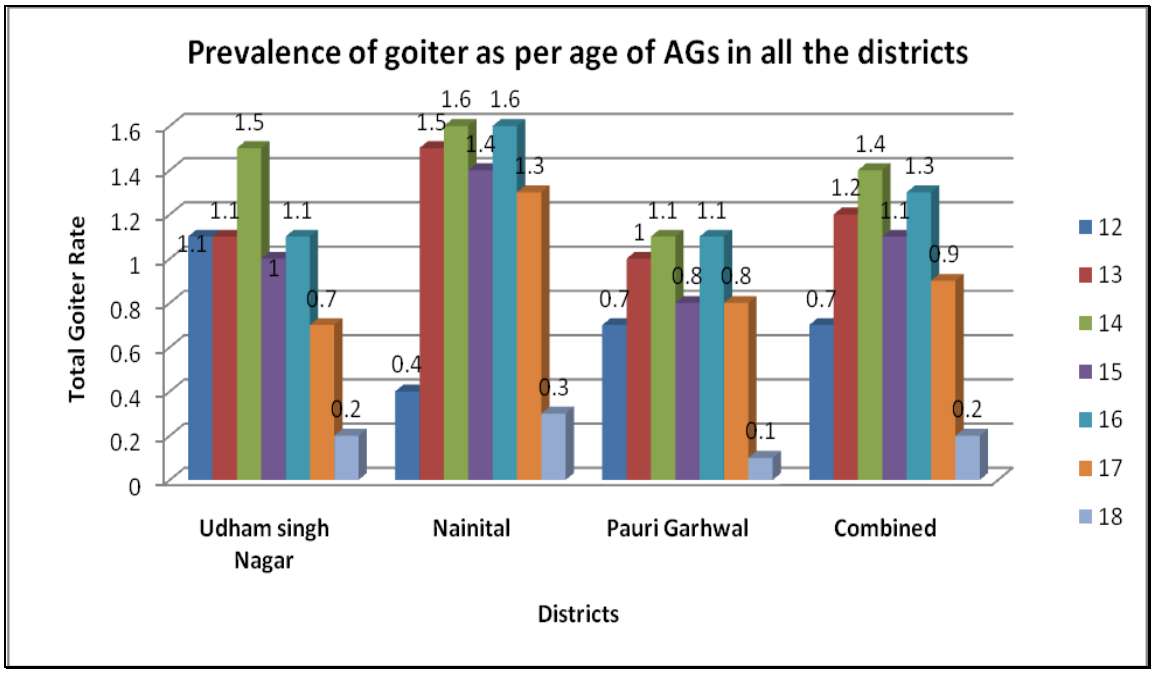
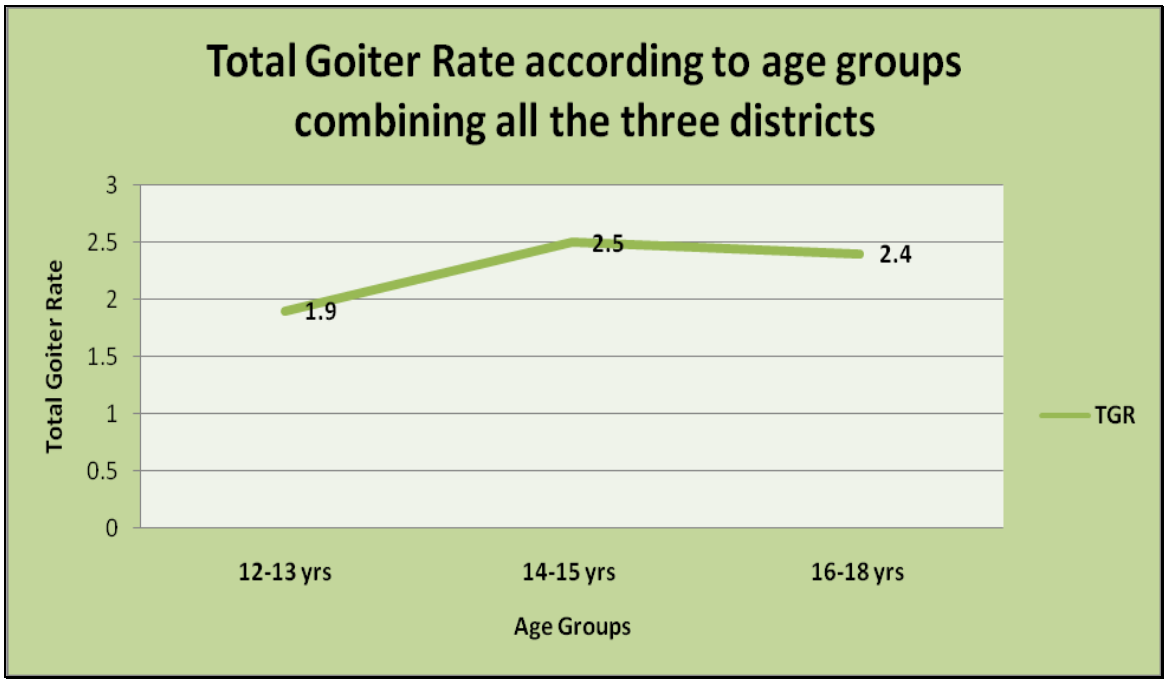


Figure 49: Total goiter rate according to age groups combining all the three districts



WHO, 2007: TGR ≥5%: Iodine deficiency

Major Findings:

- 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.

- Combining all the three districts the prevalence of TGR was found to be 6.8% indicating presence of mild iodine deficiency amongst adolescent girls in three districts of Uttarakhand state

- **Agewise prevalence of TGR:** 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. There was no statistical significant difference in the age groups and TGR of adolescent girls in districts Udham Singh Nagar ($p=0.615$), Nainital ($p=0.272$) and Pauri Garhwal ($p=0.594$).

- Combining all the three districts it was found that the TGR of adolescent girls increases till the age of 14-15 years and then further decline in the age group of 16-18 years. There was no statistical significant difference between the TGR and age groups of the adolescent girls studied.

4.4.3 Biochemical Estimation of adolescent girls enrolled in the study

4.4.3.1 Iodine deficiency status as per urinary iodine concentration level

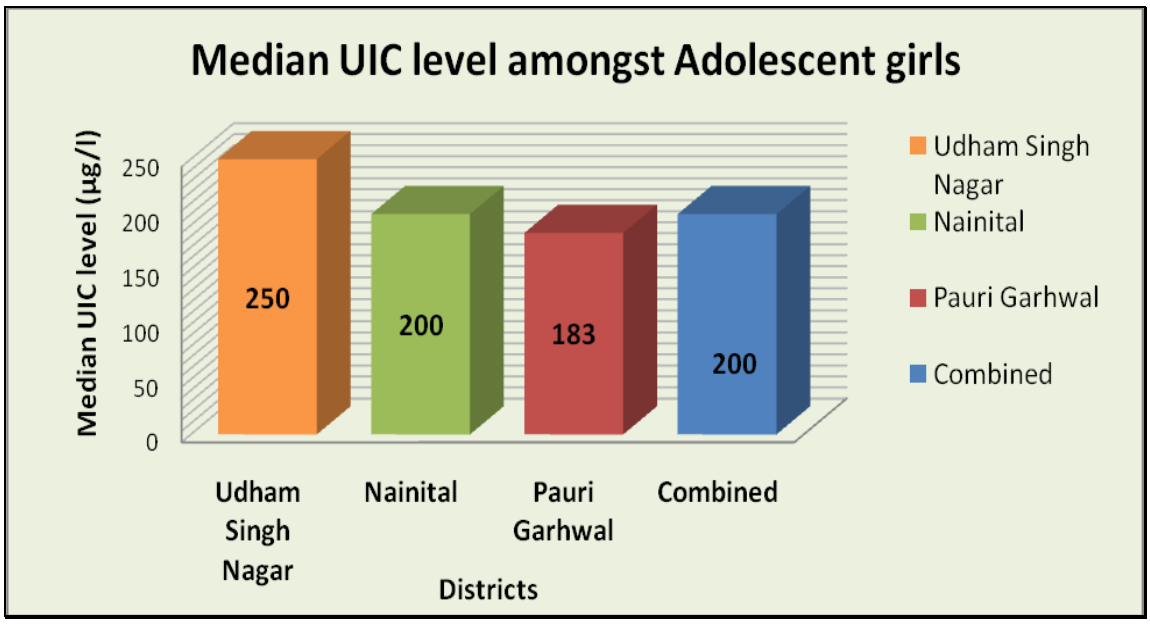
It was found that severe iodine deficiency was found in 0.2% (Udham Singh Nagar) and 1.5% (Pauri Garhwal) of adolescent girls. Moderate iodine deficiency was found in 1.4 (Udham Singh Nagar), 3.5 (Nainital) and 6.9 (Pauri Garhwal) percent of adolescent girls. Similarly, mild iodine deficiency was found in 7.2(Udham Singh Nagar), 8.8 (Nainital) and 10.8(Pauri Garhwal) percent of girls. The median UIC levels were found to be 250µg/l (Udham Singh Nagar), 200µg/l (Nainital) and 183µg/l (Pauri Garhwal), respectively indicating adequate iodine status amongst the adolescent girls in all the three districts **(Table 72)**. The median UIC level was found to be more in district Udham Singh Nagar followed by districts Nainital and Pauri Garhwal though adequate in all the three districts.

Table 72: Distribution of adolescent girls according to urinary iodine concentration levels in all the districts

UIC levels (µg/L)	Iodine status	Udham Singh Nagar (N=622)	Nainital (N=600)	Pauri Garhwal (N=594)	Combined (all the three districts) (N=1816)
		n (%)	n (%)	n (%)	n (%)
< 20	Severe iodine deficient	1(0.2)	0	9(1.5)	10(0.5)
20 – 49	Moderate iodine deficient	9(1.4)	21(3.5)	41(6.9)	71(3.9)
50 – 99	Mild iodine deficient	45(7.2)	53(8.8)	64(10.8)	162(8.9)
100-199	Adequate iodine nutrition	138(22.2)	204(34.0)	205(34.5)	547(30.1)
200-299	Likely to provide adequate intake for pregnant and lactating women	237(38.1)	216(36.0)	190(32.0)	643(35.4)
≥300	Iodine – induced hyperthyroidism	192(30.9)	106(17.7)	85(14.3)	383(21.0)
Median UIC (µg/l)		**250**	**200**	**183**	**200**

Figure in parentheses denotes percentage; WHO (2007): median UIC <100µg/L: ID

Figure 50: Median UIC of adolescent girls studied in all the three districts



WHO (2007): median UIC <100µg/L defines a population with ID

4.4.3.2 Iodine deficiency status as per urinary iodine concentration level in different age groups

The age wise distribution of UIC of amongst adolescent girls in districts Udham Singh Nagar, Nainital, and Pauri Garhwal is depicted in **Table 73**. It was found that in each district the trend was different. In district Udham Singh Nagar and Pauri Garhwal: Increasing trend of median UIC level with age was observed. In district Nainital: decreasing trend of median UIC level with age was found. There was no statistical significant difference in UIC levels with different age groups studied in districts Udham Singh Nagar (p=0.155), Nainital (p=0.643) and Pauri Garhwal (p=0.075).

The age wise distribution of UIC level of adolescent girls combining all the three districts found that in the age group of 12-13 years and 14-15 years the median UIC levels were same. Whereas, there was an increase in median UIC levels in the age group of 16-18 years. Further, there was no statistical significant difference in the UIC levels and different age groups studied (p=0.366).

Table 73: Urinary iodine concentration levels according to different age groups of adolescent girls in all the three districts

Age groups (yrs)	UIC levels (µg/l)				
	Udham Singh Nagar (N=622)				
	<20 (n=1)	20-49 (n=9)	50-99 (n=45)	≥100 (n=567)	Median UIC(µg/l)
12-13(n=207)	0	4(1.9)	18(8.7)	185(89.4)	226
14-15(n=210)	0	4(1.9)	16(7.6)	190(90.5)	250
16-18(n=205)	1(0.5)	1(0.5)	11(5.4)	192(93.6)	250
p-value	0.155				
	Nainital (N=600)				
	<20 (n=0)	20-49(n=21)	50-99 (n=53)	≥100 (n=526)	Median UIC(µg/l)
12-13(n=157)	0	7(4. 5)	13(8.3)	137(87.3)	200
14-15(n=198)	0	4(2.0)	16(8.1)	178(89.9)	200
16-18(n=245)	0	10(4.1)	24(9.8)	211(86.1)	200
p-value		0.643			
	Pauri Garhwal (N=594)				
	<20 (n=9)	20-49 (n=41)	50-99 (n=64)	≥100 (n=480)	Median UIC(µg/l)
12-13(n=181)	5(2.8)	6(3.3)	25(13.8)	145(80.1)	167
14-15(n=219)	1(0.5)	21(9.6)	21(9.6)	176(80.4)	175
16-18(n=194)	3(1.5)	14(7.2)	18(9.3)	159(82.0)	200
p-value		0.075			
	Combined (all the three districts) (N=1816)				
	<20 (n=10)	20-49 (n=71)	50-99 (n=162)	≥100 (n=1573)	Median UIC (µg/l)
12-13(n=545)	5(0.9)	17(3.1)	56(10.3)	467(85.7)	200
14-15(n=627)	1(0.2)	29(4.6)	53(8.4)	544(86.8)	200
16-18(n=644)	4(0.6)	25(3.9)	53(8.2)	562(87.3)	224.5
p-value		0.366			

Figure in parentheses denotes percentage

WHO (2007): median UIC <100µg/L defines a population with ID

Major Findings:

- 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. No trend of UIC level with age was observed.

4.4.4 Iodine content of salt amongst the household of adolescent girls enrolled in the study

4.4.4.1 Iodized salt intake

WHO/UNICEF/ICCIDD recommends that 90% of the household salts should get iodized at the recommended level of 15ppm (WHO, 2007). Iodine content of salt consumed by adolescent girls in districts Udham Singh Nagar, Nainital and Pauri Garhwal is depicted in **Table 74**. It was found that higher percentage of families in district Udham Singh Nagar (59.5%) were consuming salt with iodine content of <15ppm followed by district Pauri Garhwal (46.7%) and Nainital (44.0%).

Table 74: Iodized salt intake amongst adolescent girls in all the three districts

Iodine content of salt (ppm)	**Udham Singh Nagar (N=748)**	**Nainital (N=608)**	**Pauri Garhwal (N=600)**	**p-value**	**Combined (all the three districts) (N=1956)**
	n(%)	**n(%)**	**n(%)**		**n (%)**
<15	445(59.5)	268(44.0)	280(46.7)	0.002	993(50.8)
15 and more	303(40.5)	340(56.0)	320(53.3)		963(49.2)

Figure in parentheses denotes percentage

4.4.4.2 Iodized salt intake in different age groups

Age wise consumption of iodized salt in three districts of Uttarakhand is depicted in **Table 75**. Non significant difference was observed in the iodized salt intake by adolescent girls and different age groups in all the three districts.

Findings of our present study documented that iodine nutritional status amongst adolescent girls were adequate, this was probably due to consumption of salt with adequate iodine content.

Table 75: Consumption of iodized salt acording to different age groups adolescent girls in all the districts

Age groups (yrs)	Iodine content of salt		p=value
	Udham Singh Nagar (N=748)		
	<15ppm (n=445)	**≥15ppm (n=303)**	
12-13(n=253)	149(58.9)	104(41.1)	**0.418**^{NS}
14-15(n=251)	143(57.0)	108(43.0)	
16-18(n=244)	153(62.7)	91(37.3)	
	Nainital (N=608)		
	<15ppm (n=268)	**≥15ppm (n=340)**	
12-13(n=161)	74(46.0)	87(54.0)	**0.588** ^{NS}
14-15(n=197)	81(41.1)	116(58.9)	
16-18(n=250)	113(45.2)	137(54.8)	
	Pauri Garhwal (N=600)		
	<15ppm (n=280)	**≥15ppm (n=320)**	
12-13(n=173)	72(41.6)	101(58.4)	**0.278** ^{NS}
14-15(n=206)	99(48.1)	107(51.9)	
16-18(n=221)	109(49.3)	112(50.7)	
	Combined (all the three districts) (N=1956)		
	<15ppm (n=993)	**≥15ppm (n=963)**	
12-13(n=587)	295(50.3)	292(49.7)	**0.505** ^{NS}
14-15(n=654)	323(49.4)	331(50.6)	
16-18(n=715)	375(52.4)	340(47.5)	

Figure in parentheses denotes percentage

Major Findings:

- National goal of adequately 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..4.5 Comparison of prevalence of IDD based on TGR, UIC levels and iodized salt intake

4.4.5.1 Prevalence of iodine deficiency based on urinary iodine concentration and iodized salt intake in different age groups

The distribution of adolescent girls according to age groups with parameters studied is depicted in **Table 76.**

The median UIC levels were 250µg/l (Udham Singh Nagar), 200µg/l (Nainital) and 183µg/l (Pauri Garhwal), indicating adequate iodine status amongst the studied population. It was found that 59.5 (Udham Singh Nagar), 44.0 (Nainital) and 46.7 (Pauri Garhwal) percent of salt samples had iodine content of less than 15ppm. In India, there is lack of data available on iodine nutritional status amongst adolescent girls. Majority of the studies have been conducted on either school age children or on pregnant mothers for establishing the presence of ID in a region.

According to WHO, the median UIC level of <100µg/L amongst adolescent girls indicates ID in the community. In the present study, median UIC level were adequate i.e. >100µg/l in all the three districts of Uttarakhand indicating adequate iodine status.

A weak correlation was found between salt intake and UIC levels in districts Udham Singh Nagar ($r=0.125$; $p=0.003$), Nainital ($r=0.129$; $p=0.005$) and Pauri Garhwal ($r=0.134$; $p=0.003$).

When combining all the three districts studied a weak correlation was found between salt intake and UIC levels ($r=0.104$, $p=<0.001$).

Table 76: Distribution of adolescent girls according to age group and iodine intake and urinary iodine concentration levels in districts Udham Singh Nagar, Nainital and Pauri Garhwal

	Parameters	Age Group			p-value	Post hoc comparison		
		12-13 Median (min-max)	14-15 Median (min-max)	16-18 Median (min-max)		1vs 2	2 vs 3	1 vs 3
Udham Singh Nagar	**Salt Intake (n=748)**	13.8 (1.1-45.5)	13.8 (1.1-46.6)	13.8 (1.1-33.9)	0.431 NS	0.366 NS	0.203 NS	0.760 NS
	UIC (n=622)	226 (30-301)	250 (30-301)	250 (17.6-301)	0.125 NS	0.070 NS	0.912 NS	0.086 NS
Nainital	**Salt Intake (n=608)**	15.9 (3.2-29.6)	15.9 (2.1-34.9)	16.9 (1.1-42.3)	0.753 NS	0.627 NS	0.707 NS	0.483 NS
	UIC (n=600)	200 (30-301)	200 (20-301)	200 (20-301)	0.806 NS	0.801 NS	0.532 NS	0.689 NS
Pauri Garhwal	**Salt Intake (n=600)**	16.9 (1.1-42.3)	15.9 (3.2-38.1)	15.9 (2.1-116)	0.317 NS	0.298 NS	0.631 NS	0.133 NS
	UIC (n=594)	167 (10-301)	175 (10-301)	200 (10-301)	0.001 *	0.189 NS	0.020*	<0.001*

Age wise distribution of total goiter rate, urinary iodine concentration level and iodized salt intake in all the three districts

Table 77 depicts the age wise distribution of total goiter rate, urinary iodine concentration level and salt intake in districts Udham Singh Nagar, Nainital and Pauri Garhwal. It was found that all the age groups studied had adequate iodine status as depicted by median UIC level of >100µg/l. and moreover no specific trend were observed with any of the parameters.

Table 77: Age wise distribution of total goiter rate, urinary iodine concentration level and salt intake in all the three districts

Age wise	Population of adolescent girls	TGR (goiter grade 1 and 2)n(%)	No. of Urine samples (n)	UIC <100 n(%)	Median UIC level (µg/l)	No. of salt samples (n)	Salt intake (≥15ppm) n(%)
Udham Singh Nagar							
12-13	626	41(33.1)	207	22 (10.6)	226	253	104(41.1)
14-15	619	47 (37.9)	210	20 (9.5)	250	251	108(43.0)
16-18	578	36 (29.0)	205	11(5.4)	250	244	91 (37.3)
Nainital							
12-13	392	35 (23.5)	157	20 (12.7)	200	161	87 (54.0)
14-15	601	56 (37.6)	198	20 (10.1)	200	197	116 (58.9)
16-18	818	58 (38.9)	245	34 (13.9)	200	250	137 (54.8)
Pauri Garhwal							
12-13	476	30 (29.7)	181	36 (19.9)	167	173	101 (58.4)
14-15	597	35 (34.6)	219	43 (19.6)	175	206	107 (51.9)
16-18	723	36 (35.7)	194	35 (18.0)	200	221	112 (50.7)
Combined (all the three districts)							
12-13	1494	106(7.0)	545	78(14.3)	200	587	292(49.7)
14-15	1817	138(7.6)	627	83(13.2)	200	654	331(50.6)
16-18	2119	130(6.1)	644	82(12.7)	224.5	715	340(47.5)

Figure in parentheses denotes percentage; WHO (2007): TGR ≥5%; median UIC <100µg/L defines a population with ID

Major Findings:

- **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 withiodine intake ≥15ppm and <15ppm had median UIC level of 200µg/l and 180µg/l, respectively.

4.4.6 Relationship between goiter grade and urinary iodine concentration levels of adolescent girls

Table 78 depicts the relationship between goiter grade and UIC levels of adolescent girls in all the three districts of Uttarakhand. It was found that TGR was higher in the adolescent girls of median UIC level of <100µg/l in districts Nainital and Pauri Garhwal. However, when combining all the three districts similar trend was observed. However the difference between the TGR and UIC level was not statistically significant.

Table 78: Goiter grade and urinary iodine concentration levels of adolescent girls in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Goiter Grade	Urinary Iodine Concentration levels (µg/l)		p-value
	Udham Singh Nagar (N=622)		
	<100 (n=53)	**≥100 (n=569)**	
Grade 0 (n=568)	49(8.6)	519(91.4)	**0.652**^{NS}
Grade I + II (n=54)	4(7.4)	50(92.6)	
	Nainital (N=600)		
	<100 (n=511)	**≥100 (n=89)**	
Grade 0(n=536)	458(85.4)	78(14.5)	**0.575** ^{NS}
Grade I + II(n=64)	53(82.8)	11(17.2)	
	Pauri Garhwal (N=594)		
	<100 (n=463)	**≥100 (n=131)**	
Grade 0 (n=555)	431(77.7)	124(22.3)	**0.522** ^{NS}
Grade I + II (n=39)	32(82.1)	7(17.9)	
	All the three districts (N=1816)		
	<100 (n=1030)	**≥100 (n=748)**	
Grade 0 (n=1367)	1384(83.4)	275(16.6)	**0.108** ^{NS}
Grade I + II (n=411)	134(85.3)	23(14.6)	

Figure in parentheses denotes percentage

4.4.7 Relationship between Iodized salt intake and UIC levels adolescent girls

Relationship of iodized salt intake and urinary iodine concentration levels of adolescent girls in districts Udham Singh Nagar, Nainital and Pauri Garhwal is depicted in **Table 79**. It was found that the higher percentage of adolescent girls consuming inadequately iodized salt (<15ppm) had low urinary iodine concentration level compared to adolescent girls who were consuming adequately iodized salt. A non statistical significant difference between the salt intake and UIC levels was observed in all the three districts.

Moreover, when combining all the three districts there was a non statistical significant difference between the iodized salt intake levels and UIC levels of the adolescent girls studied.

Table 79: Iodized salt intake and urinary iodine concentration levels of adolescent girls in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Urinary Iodine Concentration levels (µg/l)	**Salt Intake (ppm)**		**p=value**
	Udham Singh Nagar (N=555)		
	<15ppm (n=326)	**≥15ppm (n=229)**	
<100 (n=45)	29(64.4)	16(35.6)	**0.417^{NS}**
≥100 (n=510)	297(58.2)	213(41.8)	
	Nainital (N=464)		
	<15ppm (n=206)	**≥15ppm (n=258)**	
<100 (n=55)	28(50.9)	27(49.1)	**0.300 ^{NS}**
≥100 (n=409)	178(43.5)	231(56.5)	
	Pauri Garhwal (N=463)		
	<15ppm (n=219)	**≥15ppm (n=244)**	
<100 (n=82)	44(53.7)	38(46.3)	**0.204 ^{NS}**
≥100 (n=381)	175(45.9)	206(54.1)	
	Combined (all the three districts) (N=1482)		
	<15ppm (n=751)	**≥15ppm (n=731)**	
<100 (n=184)	103(56.0)	81(44.0)	**0.124 ^{NS}**
≥100 (n=1298)	648(49.9)	650(50.1)	

Figure in parentheses denotes percentage

4.4.8 Block wise prevalence of Iodine deficiency based on Total Goiter Rate, Urinary Iodine Concentration levels and iodized salt intake

Udham Singh Nagar: The blockwise distribution of adolescent girls studied with different parameters in district Udham Singh Nagar is depicted in **Table 80**. It was found that all the blocks studied had adequate iodine status as depicted by median UIC level of >100µg/l indicating no biochemical deficiency of iodine in the blocks studied. 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. Thus it could be said that adolescent girls who were consuming salt with adequate iodine content (>15ppm) had higher median UIC level as compared to adolescent girls who were consuming salt with inadequate iodine content.

Nainital: The blockwise distribution of adolescent girls studied with different parameters in district Nainital is depicted in **Table 81**. It was found that all the blocks studied had adequate iodine intake as indicated by median UIC level of >100µg/l in all the blocks studied. 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.

Pauri Garhwal: The blockwise distribution of adolescent girls studied with different parameters in district Pauri Garhwal is depicted in **Table 82**. It also found the similar results. But the lowest median UIC level was found in block Rikhnikhal.

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. Thus it could be said that adolescent girls who were consuming salt with adequate iodine content (>15ppm) had higher median UIC level as compared to adolescent girls who were consuming salt with inadequate iodine content.

Table 80: Blockwise distribution of total goiter rate urinary iodine concentration levels and iodized salt intake in district Udham Singh Nagar

	Goiter (N=1823)		UIC level (N=622)			Salt Intake (N=748)	
Block	**Population of adolescent girls**	**TGR (goiter grade 1 and 2) n(%)**	**No. of Urine samples (n)**	**UIC <100 (n=622) n(%)**	**Median UIC level**	**No. of salt samples (n)**	**Salt intake (≥15ppm) n(%)**
Rudrapur	241	8(6.4)	88	0	300	84	42(50.0)
Kichha	60	6(4.8)	29	0	250	26	8(30.8)
Gadarpur	305	17(13.7)	110	8(7.2)	250	126	50(39.7)
Kashipur	307	29(23.4)	99	9(10.0)	224.5	136	50(36.8)
Sitarganj	306	15(12.1)	99	16(16.2)	200	127	39(30.7)
Khatima	301	22(17.7)	100	8(8.0)	225	133	71(53.4)
Bazpur	303	27(21.7)	97	12(12.8)	210	116	43(37.1)
Total	**1823**	**124**	**622**	**53**		**748**	**303**

Figure in parentheses denotes percentage;
WHO (2007): TGR ≥5%; median UIC <100µg/L defines a population with ID.

Table 81: Blockwise distribution of total goiter rate, urinary iodine concentration levels and iodized salt intake in district Nainital

	Goiter (N=1811)		UIC level (N=600)			Salt Intake (N=608)	
Blocks	**Population of adolescent girls**	**TGR (goiter grade 1 and 2) n(%)**	**No. of Urine samples (n)**	**UIC <100 n(%)**	**Median UIC level**	**No. of salt samples (n)**	**Salt intake (≥15ppm) n(%)**
Bhimtal	543	37(24.8)	180	35(19.4)	200	201	115(57.2)
Kotabagh	181	16(10.7)	61	9(14.7)	175	60	35(58.1)
Ramnagar	545	46(30.9)	179	8(4.5)	216	174	82(47.1)
Haldwani	542	50(33.5)	180	22(12.2)	200	173	108(62.4)
Total	**1811**	**149**	**600**	**74**		**608**	**340**

Figure in parentheses denotes percentage
WHO (2007): TGR ≥5%; median UIC <100µg/L defines a population with ID

Table 82: Block wise distribution of total goiter rate, urinary iodine concentration levels and iodized salt intake in district Pauri Garhwal

	Goiter (N=1796)		UIC level (N=594)			Salt Intake (N=600)	
Block Pauri	**Population of adolescent girls**	**TGR (goiter grade 1 and 2) n(%)**	**No. of Urine samples (n)**	**UIC <100 n(%)**	**Median UIC level**	**No. of salt samples (n)**	**Salt intake (>15ppm) n(%)**
Pauri	362	16(15.8)	120	14(11.7)	184	120	67(55.8)
Khirsu	182	10(9.9)	60	6(10.0)	180	60	31(51.7)
Pabau	184	7(6.9)	60	26(43.3)	109	60	40(66.7)
Kot	180	11(10.9)	60	13(21.7)	184	60	30(50.0)
Dwarikhal	120	9(8.9)	40	7(17.5)	184	40	22(55.0)
Eakeshwar	182	14(13.9)	60	16(26.7)	167	60	31(51.7)
Riknikhal	46	4(4.0)	20	10(50.0)	100	20	4(20.0)
Dugadda	540	30(29.7)	174	22(12.6)	223	180	95(52.8)
	1796	**101**	**594**	**114**		**600**	**320**

Figure in parentheses denotes percentage
WHO (2007): TGR ≥5%; median UIC <100µg/L defines a population with ID

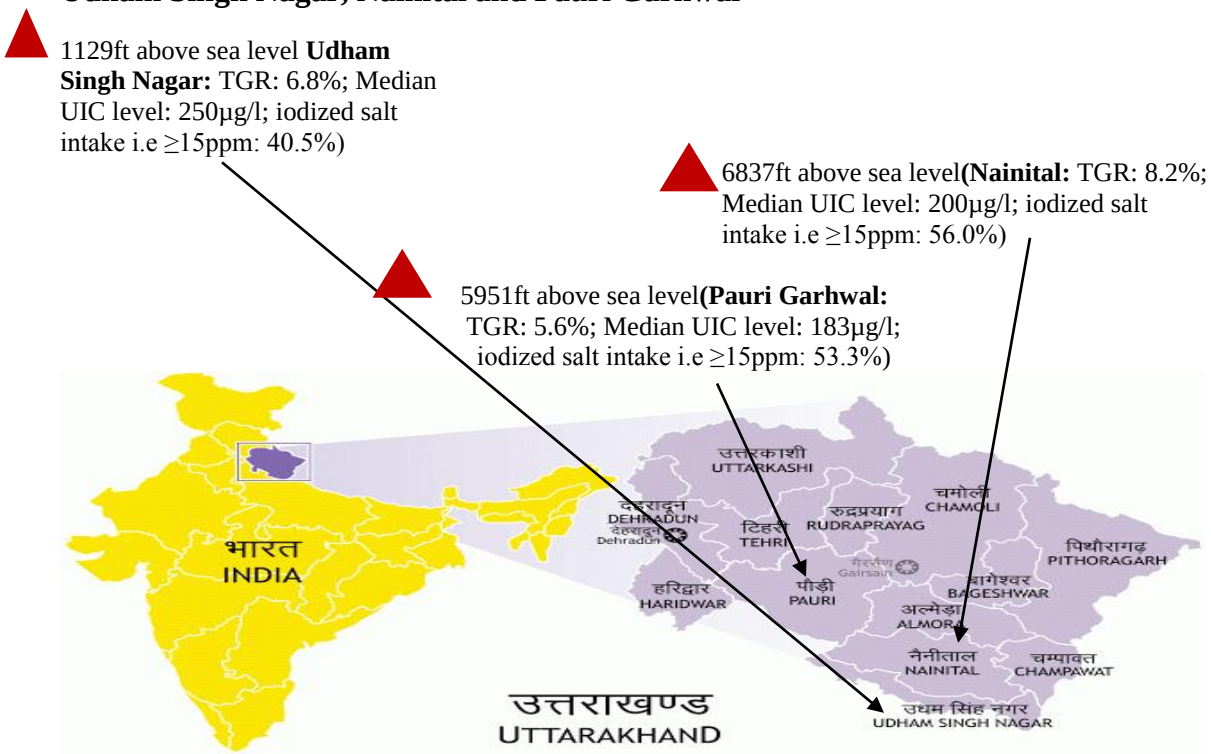
4.4.9 Summary

Table 83: Summary of iodine nutritional status amongst adolescent girls in districts Udham Singh Nagar, Nainital and Pauri Garhwal

Parameters	Udham Singh Nagar	Nainital	Pauri Garhwal	Combined (all the three districts)
TGR	**6.8(1823)**	**8.2(1811)**	**5.6(1796)**	**6.8(5430)**
Median UIC (µg/l)	250(622)	200(600)	183(594)	200(1816)
Percentage consuming adequately iodized salt (≥15ppm)	40.5(748)	56.0(608)	53.3(600)	49.2(1956)

***Figures in parenthesis denotes total samples analyzed*
WHO (2007): TGR ≥5%; median UIC <100µg/L defines a population with ID

Figure 51: Summary of iodine nutritional status amongst adolescent girls in districts Udham Singh Nagar, Nainital and Pauri Garhwal



DISCUSSION OF RESULTS OF THE PRESENT STUDY WITH OTHER STUDIES

Total nutrient needs are higher during adolescence than any other time in the life cycle. Nutrition and physical growth are integrally related; optimal nutrition is a requisite for achieving full growth potential. Failure to consume an adequate diet at this time can result in delayed sexual maturation and can arrest and slow liner growth (Story, 1992).

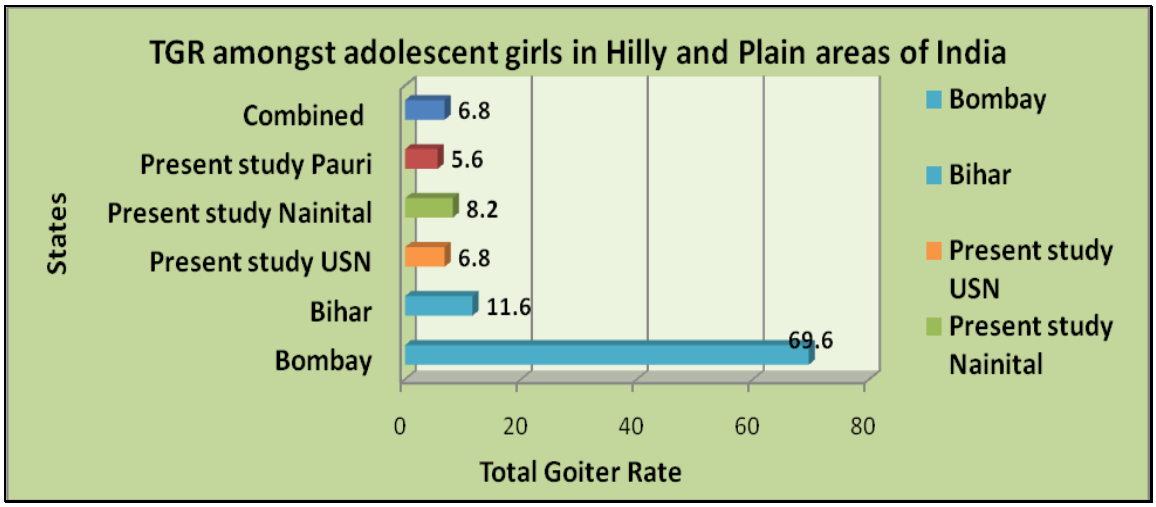
Iodine is important during adolescence for two reasons. These are the high growth velocity of adolescents, and increased iodine requirement during pregnancy. As a large percentage of adolescent girls get married early and bear children during adolescence, their requirements for iodine increase to provide for their own growth as well as for the needs of the fetus. Severe iodine deficiency in children results in learning disability and lowered achievements (Tiwari et al, 1996). In fact, even moderate iodine deficiency can lead to loss of 10-13 IQ points. Iodine deficiency during pregnancy has been associated with increased incidence of miscarriages, still births, birth defects and mental retardation, and of severe, may result in cretinism in the offspring (Levander and Whanger 1996).

Adolescent girls are future mothers. The deficiency during pregnancy leads to adverse health consequences amongst the newborns. A recent study published in lancet amongst 14-15 years girls reported the presence of mild iodine deficiency (51.0%), moderate deficiency (16.0%) and severe deficiency (1.0%) in the subjects studied (Vanderpump et al, 2011).

In India, there is limited data available on iodine nutritional status amongst adolescent girls. Majority of the studies have been conducted on school age children and pregnant mothers for establishing the presence of ID in a region (Kapil et al, 2014; Sareen and Pradhan, 2015).

Comparison of prevalence of TGR in the present study with other studies

Figure 52: Comparison of total goiter rate in adolescent girls in the present study with other studies conducted in India



WHO (2007): TGR ≥5% defines a population with ID
Source: *Bihar: Rao and Vijay et al, 2003; Bombay: Dodd et al, 1993

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.

A study conducted amongst adolescent girls in Rawalpindi reported the TGR as 53%, which was quite high may be because of the fact that Rawalpindi is surrounded by hills of Himalayans range and soil may have reduced the iodine content (Shahid et al, 2009). In India, limited data is available on iodine deficiency amongst adolescent girls (Shahid et al, 2009).

A study conducted amongst adolescent boys and girls in Bombay reported the high prevalence of goitre as 56% in both boys and girls. Another similar study conducted reported the total goiter rate of 65.2% among boys and 69.6% among girls (Dodd et al, 1993; Dodd et al, 1992). Another study conducted amongst adolescents 10-12 years in Bihar reported the total goiter prevalence of 11.6% (Rao et al, 2003).

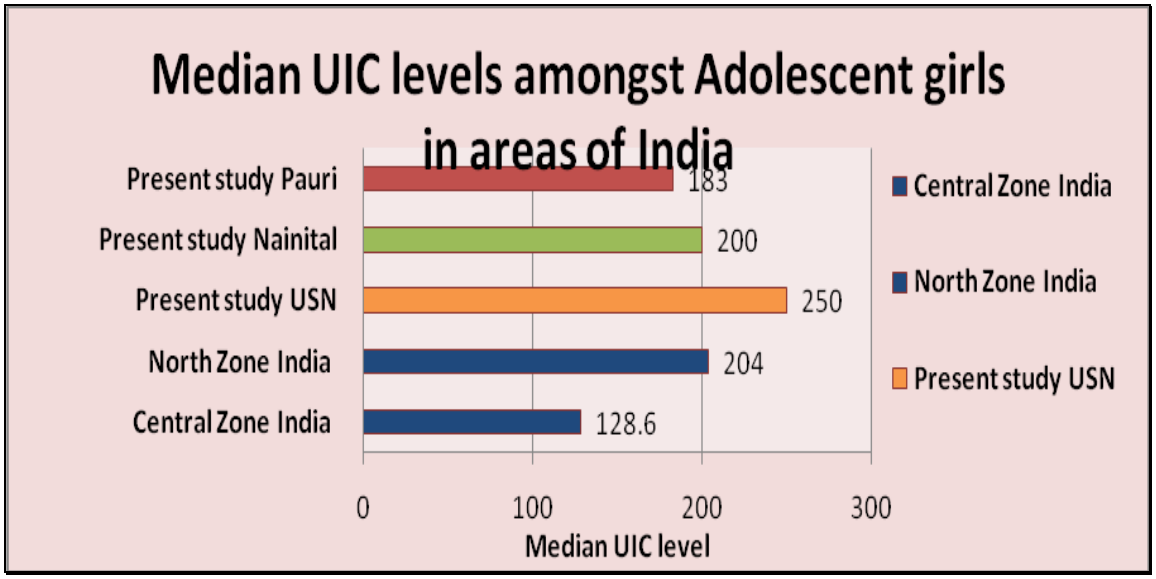
Most iodine absorbed in the body eventually appears in the urine. Therefore, urinary iodine concentration is a good marker of very recent dietary iodine intake. In individuals, urinary iodine concentration can vary somewhat from day to day and even within a given day. However, this variation tends to even out among populations (WHO, 2007).WHO/UNICEF/ICCIDD have also recommended that no iodine deficiency be indicated in a population when median urinary concentration level is 100µg/L or more i.e. more than 50% of the urine samples have UIC level of ≥100µg/L and not more than 20% of the samples have UIC level of less than 50µg/L (WHO, 2007).

Comparison of iodine deficiency according to median UIC level of the present study with other studies

In 1990, iodine deficiency affected almost one-third of the world population and was the greatest single cause of preventable brain damage and mental retardation (Delange & Lecomte, 2000).

Our present study also reported adequate median UIC level amongst adolescent girls of three districts of Uttarkhand. Similar results were reported by National iodine and salt intake survey (NISI) in which they reported the adequate median UIC level from North and Central zone of India (ICCIDD; IDD Newsletter, 2015). According to WHO, the median UIC level of <100µg/L amongst adolescent girls indicates ID in the community. In the present study median UIC levels were adequate (>100µg/l) in all the three districts of Uttarakhand indicating adequate iodine status in the studied population. Comparison of median urinary iodine concentration levels amongst adolescent girls in the present study with other studies is depicted in **Figure 53.**

Figure 53: Comparison of median urinary iodine concentration levels amongst adolescent girls in the present study with other studies



Median Urinary iodine concentration (UIC) level of <100µg/L indicates iodine deficiency in the population studied (North and South Zone India: ICCIDD, 2015)

A study National iodine and salt intake survey (NISI) reported that the median urinary iodine concentration (MUIC) at the national level was 158µg/L among women of reproductive age (non pregnant), reflecting optimal iodine nutrition in India. The median varied significantly between the rural (148.5µg/L) and urban (167.9µg/L) areas. Sub-nationally, iodine intake was found to be adequate across all zones and in both urban and rural areas. The Central zone reported the lowest median (128.6 µg/L) and the North zone reported the highest (204.0µg/L), both well within the adequate range. The UICs showed a positive correlation with the iodine content of household salt: the median UIC was 112.4µg/L in the households with non-iodized salt, 123.4µg/L in the households with poorly iodized salt, and 168.4µg/L in those with adequately iodized salt. Access to adequately iodized salt has been increasing steadily, and by as much as 7% since 2009 (ICCIDD, 2015).

Similar results were reported by a study conducted by Rashid et al, 2009 in Bangladesh among 13-19 year adolescent girls. It was found that prevalence of iodine deficiency was 38.4% in adolescent girls. The median UIC level was 186.3µg/l. Another study by Ara et

al, 2010 in Bangladesh reported median UIC level as 135µg/l and UIC level of less than 100µg/l was found in 37% of the subjects. A study conducted by Pawloski et al, 2004 in Mali, South Africa reported iodine concentration level as 93µg /L.

Limited studies have been conducted in India on iodine nutritional status amongst adolescent population or women of reproductive age groups. A study conducted by Dodd et al, 1992 amongst adolescent girls in Bombay reported that according to UIC level mild iodine deficiency was present in 38% and moderate iodine deficiency as 12.4% in the subjects studied.

Our present study found that the median urinary iodine concentrations of adolescent girls in the three districts of Uttarakhand (Udham Singh Nagar, Nainital and Pauri Garhwal) were 240, 200 and 183µg/l, respectively. These concentrations were >100 µg/l defined as minimum by WHO. A zone is declared endemic for iodine deficiency when up to 20% of a study population is iodine deficient (Dunn et al. 1998) in our study, the percentage of subjects with urinary iodine concentration lower than 100µg/L was 8.8% (Udham Singh Nagar), 12.3% (Nainital) and 19.2% (Pauri Garhwal), respectively. Thus, the three districts of Uttarakhand is a non endemic zone for iodine deficiency amongst adolescent girls according to the studied population.

There is an effect of iodine shortage on thyroid iodine physiology, thereby increasing the risk of low thyroid hormone production and supply especially in females. Low production of the thyroid hormone may result to reproductive failure in pregnant females or poor mental development and low intellectual ability of the child. This may be responsible for the number of antenatal abortions in the health centre in this province (Taga et al, 2009).

A study by Jimal (ISP 2011 Poster) conducted amongst 16-18 years adolescent girls of Bangladesh reported that median urinary iodine (MUI) level was 269 mcg/L, and distribution analysis showed that 15.3% of the students had biochemical iodine deficiency (urinary iodine <100 mcg/L). The highest percentage (16.2%) of deficiency was observed among girls aged 16 years. The average level of iodine was found 3 times

higher than it should be which is reflected in the MUI. Thus it was concluded that a large percentage of the study population was not consuming the standard level of iodine from their household salt intake.

A recent study conducted by Watutantrige Fernando et al, 2015 in Italy amongst childhood to adulthood females reported that median UIC decreased from childhood to adulthood (median UIC 107, 77 and 55µg/l in the young girls, females at puberty and fertile women, respectively). Though using iodized salt improved iodine status in all groups, a significantly higher UIC was only noted in females at puberty. The study concluded that, dietary iodine status declines from childhood to adulthood in females due to different eating habits. A mild iodine deficiency emerged in women of child-bearing age that could have consequences during pregnancy and lactation.

Iodine deficiency also appears to have adverse effects on growth and development in the postnatal period. Adolescents in regions of ID are at risk for some degree of intellectual disability. A meta-analysis of studies relating iodine deficiency to cognitive development suggested that iodine deficiency alone caused an average loss of 13.5 intelligence quotient (IQ) points in affected subjects (Bleichrodt, 1994). Developmental studies in iodine-deficient regions have many limitations, including an inability to distinguish between the persistent effects of fetal iodine deficiency and the ongoing effects of iodine deficiency in adolescence.

Intellectual disability resulting from the effects of iodine deficiency on the central nervous system during fetal development is not reversible. In contrast, the additional impairment caused by continuing postnatal hypothyroidism and/or iodine deficiency may improve with appropriate thyroid hormone replacement and/or iodine supplementation (Van den Briel et al, 2000).

There is no data available to compare the findings of age wise distribution of UIC level with adolescent girls with present study.

Comparison of Iodized salt intake amongst adolescent girls in the present study with other studies

WHO/UNICEF/ICCIDD recommends that 90% of the household salts should get iodized at the recommended level of 15ppm (WHO, 2007). In the present study it was found that higher percentage of families in district Udham Singh Nagar (59.5%) were consuming salt with iodine content of <15ppm followed by district Pauri Garhwal (46.7%) and Nainital (44.0%).

A study by Jimal (ISP 2011 Poster) conducted amongst 16-18 years adolescent girls of Bangladesh reported that the highest percentage (16.2%) of deficiency was observed among girls aged 16 years. The mean iodine value of salts consumed in the household level was 49 ppm (as per law, 15 ppm iodine should be present at household level). However, some salt samples contained no iodine. Only 8.1% of the salt samples contained iodine in the range of 10 to 20 ppm. More than 34% of the salt samples contained iodine greater than the standard factory level (45 to 50 ppm). Iodine in salt was reflected by a urinary iodine concentration. The average level of iodine was found 3 times higher than it should be which is reflected in the median urinary iodine concentration. Thus it was concluded that a large percentage of the study population was not consuming the standard level of iodine from their household salt intake. Salt factories should thus be more careful and sincere about mixing iodine properly in household salts. Higher salt iodine corresponds to higher urinary iodine.

Adolescent girls are the future mothers and when pregnancy takes place in conditions with iodine restrictions or deficiency, the more severe the iodine deficiency, the more obvious frequent, and profound the potential maternal and fetal impact. The main changes in the thyroid function associated with pregnancy are related to increased hormone requirements, which begin in the first trimester of pregnancy. Increased hormone requirements can only be met by proportional increased hormone production, directly depending upon availability of iodine in the diet (Glinoer et al, 2001). The most critical period for the fetus is from the second trimester of pregnancy to the third year after birth. The fetal thyroid begins functioning around the 12^{th} week of pregnancy.

Before this the adequate maternal thyroid hormone is essential for normal human development (Dunn et al, 2003). If iodine insufficiency leads to inadequate production of thyroid hormones and hypothyroidism during pregnancy, irreversible fetal brain damage can result (American Academy of Pediatrics, 2006).

Iodine deficiency in pregnancy has been associated with increased incidence of spontaneous abortion, still birth and congenital abnormalities (WHO, 1996). In the U.S overt hypothyroidism has been seen in about 0.3%-0.7% of women of reproductive age and sub clinical hypothyroidism in approximately 2.5% (Robert et al, 2005). Als et al (2000b) did a survey in Switzerland on subjects aged 0-90 years and the result showed that women of child bearing age (13-35yrs) had mild iodine deficiency.

A 1944 Medical Research Council survey reported visible goitre in 50% of adult women and 26–43% of schoolgirl (Medical Research Council Goitre Subcommittee, 1944). Recently, concern has again been expressed about United Kingdom iodine status because up to 50% of United Kingdom women of childbearing age screened in smaller studies at single centres were iodine deficient (Kibiridge et al, 2004; Bath et al, 2008; Pearce et al, 2010). A similar pattern of iodine deficiency has been seen in Ireland, with iodine intake being especially low in the summer months (Nawoor et al, 2006).

The study conducted by Vanderpump et al, 2011 focused on young female participants aged 14–15 years who were in pre pregnancy found that Median urinary iodine concentration was 80·1μg/L (IQR 56·9–109·0). Urinary iodine measurements indicative of mild iodine deficiency were present in 51% (n=379) of participants, moderate deficiency in 16% (n=120), and severe deficiency in 1% (n=8). Prevalence of iodine deficiency was highest in Belfast (85%, n=135).

Epidemiological studies have also shown that reduced iodine intake during pregnancy leads to development of goitre, decreased free thyroxine concentrations, and increased serum thyroid-stimulating hormone (TSH) in pregnant women. Because maternal thyroxine is crucial for maturation of the fetal nervous system, especially before development of the fetal thyroid before 13 weeks of pregnancy, even mild iodine

deficiency could be harmful. Data from the USA and Netherlands suggest that the children of women with hypo- thyroxinaemia can have psychoneurological deficits and delayed mental and motor function compared with controls (Henrichs et al, 2010; Pop et al, 2003). This finding is in accord with those in classic areas of iodine deficiency, for which a range of psychological and neurological deficits in children are described and in which maternal hypothyroxinaemia rather than high serum TSH is the biochemical abnormality (Zimmermann, 2009). Little is known of the consequences of mild-to-moderate iodine deficiency in older children (Gordon et al, 2009). A recent randomised, placebo-controlled, double-blind trial in 184 children aged 10–13 years in New Zealand (median urinary iodine 63μg/L) showed that iodine supplementation (150μg/L daily) for 28 weeks improved perceptual reasoning, suggesting that mild iodine deficiency might prevent children attaining their full intellectual potential. Similar positive findings have been reported in European children who were moderately iodine deficient (Zimmermann et al, 2006). A study by Rashid et al, 2009, in Bangladesh reported that 71.8% of the families consumed salt with iodine content of >15ppm. Whereas, another study by Shahid et al, 2009 in Rawalpindi reported that 50.3% of the subjects consumed salt with iodine content of >15ppm.

Table 84: Comparison of results of the present study (adolescent girls) with other studies conducted in India

Author/ year	Place	Age group	Result
Present study	**Three districts (Udham Singh Nagar, Nainital and Pauri Garhwal) Uttarakhand**	**12-18**	**TGR: 6.8% (Udham Singh Nagar), 8.2% (Nainital), 5.6% (Pauri Garhwal) Median UIC: 250 (Udham Singh Nagar), 200 (Nainital), 183 (Pauri Garhwal) Iodized salt intake (≥15ppm):40.5(Udham Singh Nagar), 56.0(Nainital), 53.3(Pauri Garhwal)**
Dodd et al, 1993	Bombay	-	Prevalence of goiter: 56% in both boys and girls Visible goiter in girls: 10.6%
Dodd et al, 1992	Bombay	-	TGR in girls: 69.6% According to UIC: Mild deficiency in : 38% Moderate deficiency:12.4%
Goyle and, Prakash , 2011	Jaipur	10-16	21.6% of the subjects had mild iodine deficiency
Ray et al, 2009	West Bengal		76.32% are suffering from iodine deficiency.
Rao andVijay, 2003	Bihar	10-12	Total goiter prevalence of 11.67%
ICCIDD, 2015	North and South Zone India	-	Median UIC North zone: 204µg/l South Zone: 128.6 µg/l

Picture 4: Presence of Goiter amongst Pregnant Mothers

Picture 5: Presence of Goiter amongst School Age Children

Picture 6: Presence of Goiter amongst Adolescent Girls

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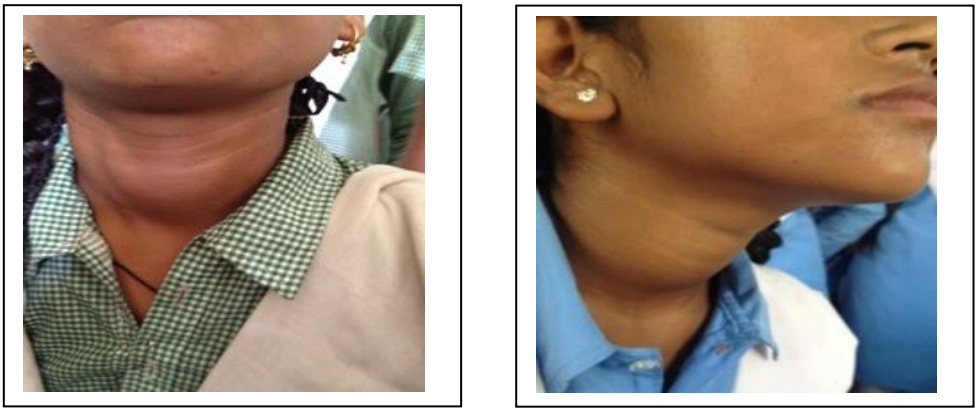


4.5 PART 5: ENVIRONMENTAL INFLUENCES (FOOD AND WATER SAMPLES)

The result of this part is further divided into following sections:

4.5.1 Iodine content of Water

4.5.2 Iodine content of Food

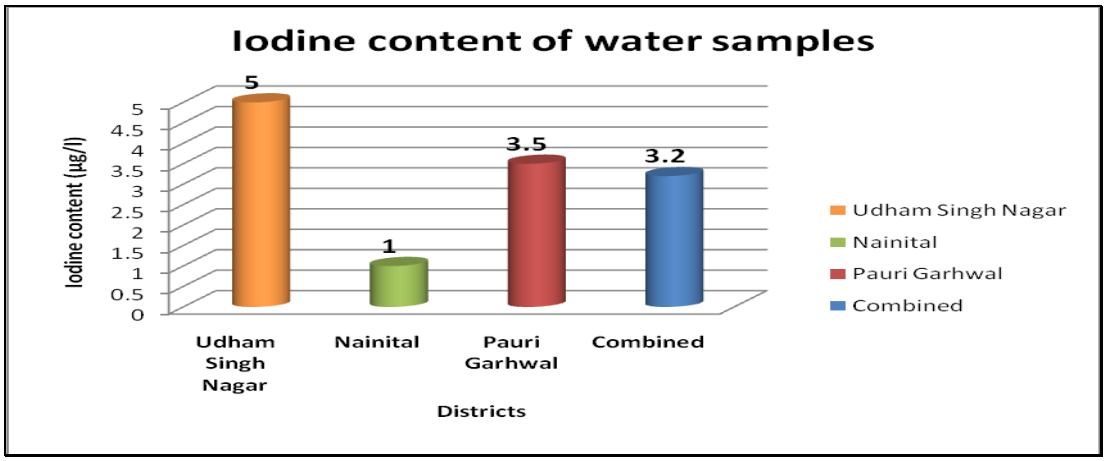
Food and water are considered the major sources of iodine to meet the daily metabolic requirement. The iodine content of the diet is considered critical to compensate for the metabolic losses (Koutras et al, 1970). Goitre surveys so far are limited to clinical symptoms, urinary iodine output and, to some extent, plasma thyroid hormone levels. Thus, less priority is given to quantitative factors, such as absorption and the balance of iodine resulting from important sources like water and food.

Data on the iodine contents of foods and water from the goitre-endemic northeast region of India are scanty (Tulpule, 1969; Sharma et al, 1994). Despite the widespread occurrence of IDD, very few studies provide comprehensive information on the iodine content of water and food samples.

4.5.1 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/dl (Pauri Garhwal), respectively.

Figure 54: Iodine content of water samples from all the three districts



WHO reported that the mean concentration of total iodine in drinking-water in the USA is 4µg/litre, and the maximum concentration is 18µg/litre (WHO, 2005). This is presumably predominantly iodide.

A recent study conducted by Longvah et al, 2012 in 22 states of India reported that the mean iodine content of drinking water was found to be 9.0±7.78 µg/l. It was further reported that the mean iodine content in water samples from the goitre-endemic states of northeast India ranged from 6.65±1.8 µg/l in Sikkim to 8.89±4.98µg/l in Assam. The water iodine content from northeast India varied from 3.0 to 31.5µg/l. However, values below 3µg/l in Gelecky PHC, Assam, have been reported (RMRC Dibrugarh; Annual Report 1991±1992).

In Arunachal Pradesh, water iodine content ranged from 3.5 to 14.5µg/l, whereas Tulpule (1969) reported a higher iodine content of 13± 26µg/l in water samples from erstwhile NEFA, now Arunachal Pradesh. This could be due to seasonal fluctuations (Broadhead et al., 1965) and differences in the method of estimation. Such a conclusion was also drawn in other studies by Koutras et al. (1970) and Fischer and Carr (1974).

A study conducted by Ramalingaswamy in 1973 reported that iodine contents of water samples to be less than 3.0µg/l in the goitre-endemic areas of India, Nepal and Sri Lanka. However, Krishnamachari (1974) reported 9±36µg/l from the goitre belt of the Aurangabad district, Maharashtra. High water iodine contents have been reported by Mahesh et al. (1989) from other nonendemic areas such as Hyderabad.

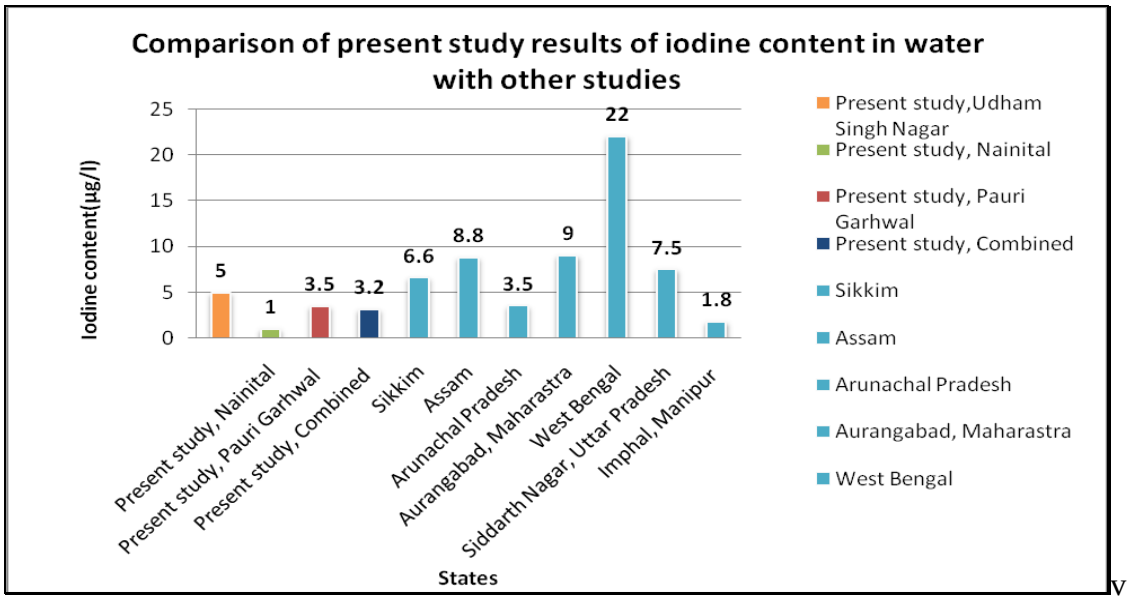
A study by Caughey and Follis (1965) reported a high incidence of goitre in areas where iodine concentration in drinking water was from 3 to 7µg/l as compared with non-endemic regions with water iodine contents of 20µg/l or more. The lowest range of iodine content in water 3±12.6µg/l) was encountered in Sikkim, where the incidence of goitre was reported to be 54% (Pulger et al., 1992).

According to various studies, the goitre rates in northeast India ranged from 25 to 54% (Health Information of India, 1993; ICMR task force study, 1989; Pulger et al., 1992). In the Gilghit district of Pakistan, the iodine content of water ranges from 1.2 to 13.0µg/l with goitre rates of 25.2±76.5% (Siraj-ul-Haq Mahmud, 1986). The low iodine content of water and high incidence of goitre, prevalent in the sub-Himalayan belt, can be observed in the Gilghit district of Pakistan as well as in northeast India. Weak but significant negative correlations have been reported between drinking water iodine concentration and goitre prevalence (Das et al, 1989). The distribution of environmental iodine deficiency in northeast India is more or less similar. The water iodine content of all the states varied within a narrow range with 82% of the samples from 5.0 to 10µg/l and a pooled mean of 7.38±2.7µg/l. Several studies conducted by Chandra et al reported that the iodine content of water ranges from 22-119µg/l in West Bengal (Chandra et al, 2005), 7.5-10.7 µg/L in Siddharth Nagar, Uttar Pradesh (Chandra et al, 2008), 21 to 119µg/L in Sunderban, West Bengal (Chandra et al, 2007), 1.8-2.6microg/l in Imphal, Manipur (Chandra et al, 2006), 48.9 ± 30.7microg/l in West Bengal (Chandra et al, 2006), 82µg/l in Howrah (Chandra et al, 2004) and 2.92 +/- 1.75µg/l in Manipur (Chandra et al, 2008).

A study conducted by Bulliyya et al, 2008 in Orrisa reported the iodine content in water as 1.22-3.6 pmicro. Whereas a study conducted by Shengmin et al, 2001 in China in five

wells, five households reported The iodine content ranged from 47.7mg/l to 945.0mg/l, with the median iodine content being 166.0mg/l. Among the thirty villages, the median iodine content in drinking water was 150mg/l in twenty villages and 150mg/l in ten villages. A study conducted by Sharma et al, 1999 in Assam on iodine content of water reported that the iodine content in water samples were reported to be Ponds: 1.53±0.44 Dug Wells: 1.53±0.58, Tubewells: 1.36±0.1, River: 1.87±0.77, Watersupply: 1.43±0.52, Total: 1.52±0.48 and Range: 0.76 to 3.01µg/l. Comparison of present study results on iodine content of water with other studies is depicted in **Figure 55.**

Figure 55: Comparison of present study results on iodine content of water with other studies



(Source: Sikkim, Asaam: Longvah et al, 2012; Arunachal Pradesh: Tulpule, 1969; Arungabad: Krishnamachari, 1974; West Bengal: Chandra et al, 2005; Uttar Pradesh: Chandra et al, 2008; Manipur: Chandra et al, 2006)

Comparison of present study results on iodine content in water samples with other studies from different regions of the world are depicted in **Table 85.**

Table 85: Comparison of present study results on iodine content in water samples with other studies from different regions of the world

Author/year	Place	Source of Water samples	Iodine content in water samples
Present study	**3 districts of Uttarakhand**	**Shallow tube wells**	**5.0µg/l (Udham Singh Nagar), 1.0µg/l (Nainital) 3.5µg/dl (Pauri Garhwal)**
International studies			
Yin et al, 2014	China	Tap water	0.611 to 1.473 µg/L
Shengmin et al, 2001	China	five wells, five households	47.7mg/l to 945.0mg/l,
Rasmussen et al., 2000	Denmark	TAP water	2.1 to 30.2 µg/l
WHO, 2003	U.S.A	Drinking water	Mean Conc: 4 µg/l Max Conc: 18 µg/l
Fordyce , et al, 2000	Sri Lanka	Drinking Water :shallow drinking wells	up to 84microg/l
Koutras et al, 1970.	Athens, Greece	Drinking water: from wells	Athens: 0.47µg/100ml Endemic areas: 0.24 µg/100ml
National studies			
Longvah et al, 2012	22 states 1. AP 2. Assam 3. Bihar 4. Chattisgarh 5. Gujarat 6. Haryana 7. HP 8. J&K 9. Jharkhand 10. Karnataka, 11. Kerala, 12. MP, 13. Maharashtra 14. Meghalaya 15. Orrisa 16. Punjab 17. Rajasthan 18. Sikkim 19. TN 20. UP 21. Uttarakhand	Household Drinking water	22 states results Mean of all samples: 9.0±7.78 µg/l 1. AP (4): 19.7µg/l 2. Assam (2); 11.7µg/l 3. Bihar (4): 11.3µg/l 4. Chattisgarh (8): 2.7µg/l 5. Gujarat (5): 17.0µg/l 6. Haryana (4): 9.7µg/l 7. HP (4): 8.3 µg/l 8. J&K (2): 6.2 µg/l 9. Jharkhand(1):11.9 µg/l 10. Karnataka(2):15.8µg/l 11. Kerala(2); 13.9µg/l 12. MP(8): 2.4µg/l 13. Maharashtra(2):4.0µg/l 14. Meghalaya(1): 1.3µg/l 15. Orrisa (4): 7.3µg/l 16. Punjab (4): 9.9µg/l 17. Rajasthan (8): 3.6µg/l 18. Sikkim (1): 3.2µg/l 19. TN (3): 23.2 µg/l 20. UP (4): 8.0µg/l

	22. WB		21. Uttarakhand (4):7.2 µg/l 22. WB (5): 13.8µg/l
Chandra et al, 2008	Manipur	Drinking water	2.92 +/- 1.75µg/l
Chandra et al, 2008	Siddharth Nagar, UttarPradesh	shallow tube wells,	7.5-10.7 µg/L
Bulliyya et al, 2008	Orissa		1.22-3.6 pmicro
Chandra et al, 2007	Sunderban, West Bengal	Drinking Water	21 to 119µg/L
Chandra et al, 2006	Imphal, Manipur	Drinking Water	1.8-2.6microg/l
Chandra et al, 2006	West Bengal	Drinking water	48.9 ± 30.7microg/l
Chandra et al, 2005	West Bengal	Drinking water	22-119microg/l
Chandra et al, 2004	Howrah, West Bengal	Drinking water	82µg/l
Sharma et al, 1999	Assam	Drinking Water: 1. Ponds 2. Dug wells 3. Tube wells 4. River 5. Rural water supply	1. Ponds:1.53±0.44 2. Dug Wells: 1.53±0.58 3. Tubewells: 1.36±0.11 4. River: 1.87±0.77 5. Watersupply:1.43±0.52 Total: 1.52±0.48 Range: 0.76 to 3.01µg/l

4.5.2 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 µg per 100g (Rice) to 7.2 µg per 100g (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.

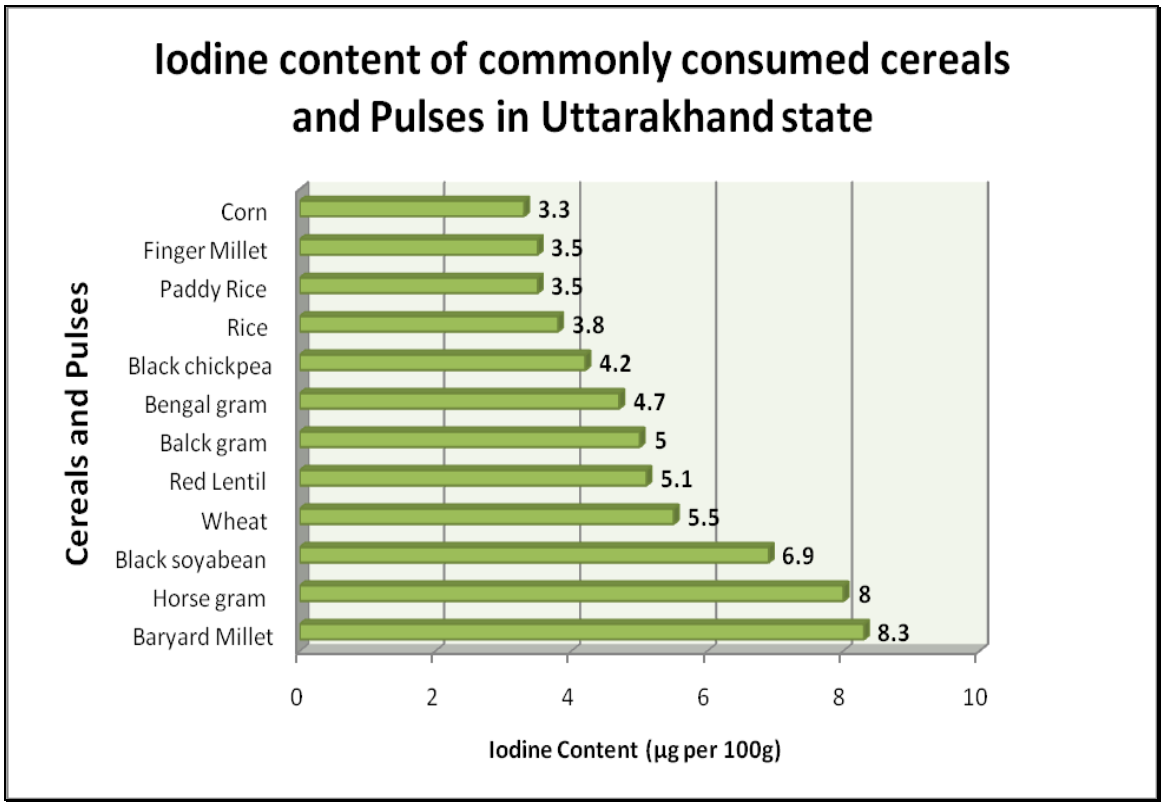
Combining all the three districts the pooled iodine content of various cereals and pulses were: Wheat (n=12): 5.5± 0.4µg per 100g, Rice (n=10): 3.8± 0.3µg per 100g , paddy rice (n=5): 3.5± 0.3µg per 100g, Finger Millet (n=5): 3.5± 0.2µg per 100g, Black gram (n=4): 5.0± 0.4µg per 100g, Black soyabean (n=2): 6.9± 0.3µg per 100g, Bengal gram (n=1):

4.7µg per 100g, Corn (n=1):3.3µg per 100g, Red Lentil (n=1):5.1µg per 100g, Black chickpea (n=1): 4.2µg per 100g, Horse gram (n=1):8.0µg per 100g, Barley (n=1):1.1 µg per 100g, Baryard Millet (n=1):8.3µg per 100g, respectively.

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

Iodine content of commonly consumed cereals and pulses in Uttarakhand state is depicted in **Figure 56.**

Figure 56: Iodine content of commonly consumed cereals and pulses in Uttarakhand state



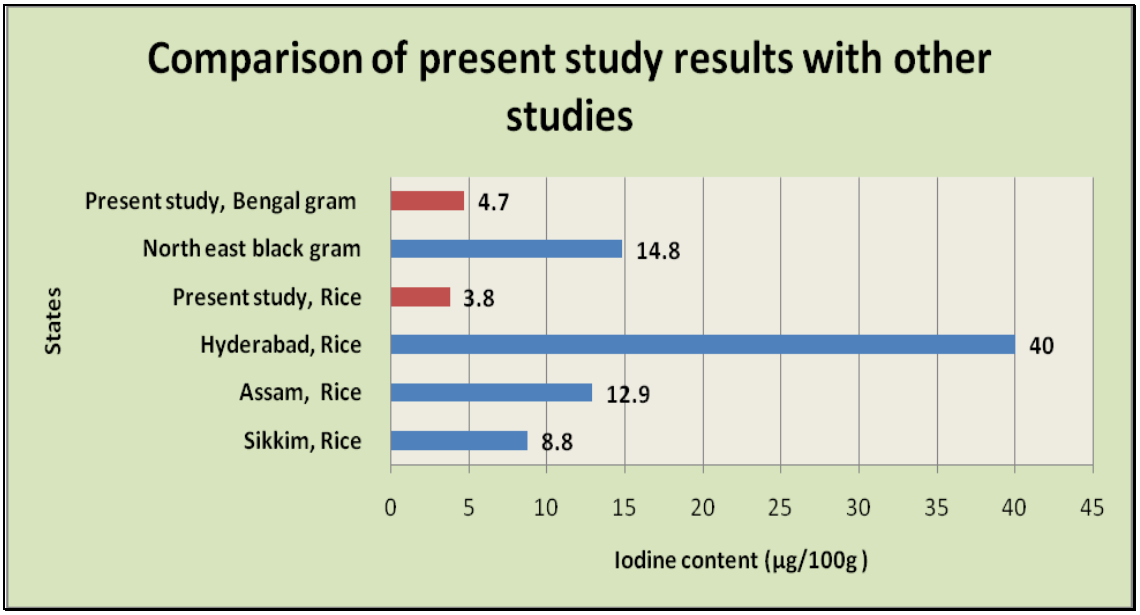
National Institute of Nutrition (NIN) conducted studies on iodine content of various food stuffs**.** It was found that the foods of animal origin had more iodine as compared to plant. Amongst vegetarian foods, nuts and oilseeds had highest amount of iodine (35.0 to 54.0 µg/100g) followed by spices (6.0 to 96.0 µg/100g) and condiments, while fruits and vegetables had the lowest level of iodine content (2.7 to 20.0 µg/100g). All types of

foodstuffs in endemic districts had lower iodine content as compared to non-endemic districts (NIN, 1987).

A recent study conducted by Longvah et al, 2012 in 22 states of India reported that in cereals the mean iodine content of rice from the goitre-endemic states of northeast India was lowest in Sikkim (8.8±3.0 µg/100g) and highest in Assam (12.9±2.6 µg/100g). The iodine content of rice in northeast India varied within a narrow range with a pooled mean of 10.4±2.9 µg/100g in contrast to samples from non-endemic areas such as Hyderabad (40.0±3.36 µg/100g). Similarly, pooled mean iodine contents of other cereals such as maize (8.0±2.9 µg/100g), millet (7.3±2.6 µg/100g) and Job's tears (8.25±1.3µg/100g) from the goitre-endemic states of northeast India were around 25% of the values reported from non-endemic areas such as Hyderabad. A low iodine content of cereals was also reported from other goitre-endemic areas such as Baiga Chak, Madhya Pradesh by Mahesh (1993).

It was also found that among the legumes analyzed red gram contained relatively high iodine (18.0±21.7 µg/100g). However, these values were still lower by 23±36% compared with non-endemic areas such as Hyderabad. More than 80% of the legume samples from the goitre-endemic states of northeast India exhibited mean iodine content below 20 µg/100g in contrast to non-endemic areas such as Hyderabad, where the iodine content was reported to be in the range of 25±50µg/100g. The pooled mean iodine content of individual legumes from the states of northeast India such as soyabeans (17.6±5.0 µg/100g), rice beans (9.1±2.9 µg/100g), field beans (20.1±5.6 µg/100g), Green gram (11.8±3.9 µg/100g), cowpea (16.3±4.1µg/100g), Black gram (14.8±5.5 µg/100g), and Red gram (19.6±2.9 µg/100g) were 30±80% less than the values encountered from non-endemic areas such as Hyderabad. It was concluded that all the foods analyzed from northeast India showed that the area is highly deficient in iodine with 45% of the foods falling below 10µg/100g sample and 100% below 30µg/100g sample. It is clear that the foods from endemic areas such as northeast India have much lower iodine contents compared with non-endemic areas, thus reflecting the genuine differences in the iodine content of the environment.

Figure 57: Comparison of present study results (iodine content in food samples) with other similar studies



Source: Hyderabad, Assam, Sikkim Rice: Longvah et al, 2012

Major Findings:

- 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.
- 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