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RESEARCH ARTICLE

ETIOLOGY OF IODINE DEFICIENCY DISORDERS IN SELECTED VILLAGES OF DISTRICT CHAMOLI IN GARHWAL HIMALAYA.

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Abstract

Introduction:-

Iodine deficiency is an ecological phenomenon which occurs naturally. This arises from the distant past through glaciations, compounded by the leaching effects of snow, water and heavy rainfall, which remove iodine from the soil resulting in Environmental Iodine Deficiency (EID). The mountainous regions of the Indian Subcontinent, China, Europe, Andean region in South America and lesser ranges of Africa are all iodine deficient. But in addition the soil of flooded river valleys is also deprived of iodine as in the Ganga Valley in India, Irawady Valley in Burma & Songkala valley in Northern China. The deficiency in the soil leads to iodine deficiency in all forms of plant life and cereal grown in the soil. Hence populations living in systems of subsistence agriculture are considered at risk of iodine deficiency.

In the Indian subcontinent iodine deficient Himalayan goitre belt has been described passing through North Western Himalaya to Eastern Himalaya. Garhwal Himalaya constitutes a part of this iodine deficient Himalayan Goitre belt. However, our results in (Farswan 2007) indicated that despite being considered an endemic zone incidence of goitre in this area is very low. Physical observation revealed only 2.3% palpable non visible goitre grade Ia and non existent visible goitre. According to WHO criteria on the basis of goitre grading this zone would be categorized as iodine sufficient zone. Other physiological parameters are also in concord with this observation e.g near normal thyroid hormone profiles are in harmony with the data indicating overall low incidence of iodine deficiency disorders in the area. Results of urinary iodine excretion of the general population also indicated only mild iodine deficiency in the area. These findings call for a systematic survey of actual iodine consumption statu**s.**

In this present work we report the results of intensive surveys on the iodine prophylaxis, salt procurement/ storage & usage pattern, cultivated crops & vegetables, feeding habits, staple diet and source of drinking water and socioeconomic status of inhabitants of 11 villages of district Chamoli.

Our results indicated most of the population is using uniodized salt. Despite almost nil iodine prophylaxis the low incidence of goitre and other IDD in the area is indeed intriguing. This section, therefore also includes the pedigree analysis of IDDs associated with goitre in different families of surveyed population.

Material & methods:-

Dietary Salt:-

Household salt samples to measure the iodine content, were collected from 184 families in district Chamoli. WHO/UNICEF/ICCIDD recommended questionnaire based informations were obtained from the chief or a member of each family. The questionnaire includes information regarding usage pattern of dietary salt, type of salt Crystal *gara* uniodized or iodised packed, source of salt purchase, annual frequency of salt purchase, storage condition and household salt storage duration. The shopkeepers were also interviewed for details about salt purchase, storage condition storage period & consumption of salt in respective villages.

Each family was provided small zipped polythene bags with a tag for household identification. People were requested to bring four tea spoons of salt (about 20 gram) from their family kitchen. Collected samples were transferred to the laboratory for measurement of iodine. Iodine content in salt samples were measured by commonly used iodometeric method ((WHO 2001) & results expressed in parts per million ppm. Iodine is volatile in nature. Precautions were, therefore, taken to avoid contamination during measurements. Firstly used fresh, repeatedly washed and fully autoclaved separate glassware were used for different samples.

Iodine content was estimated by iodometric titration. Free iodine reacts with sodium thiosulfate solution; sulphuric acid is added to a solution of iodized salt liberating iodine, which is titrated with sodium thiosulfate. Starch is used as an external indicator. Potassium iodide solution is added to keep the iodine in dissolved state

Socio-economic status:-

Questionnaire based information were collected on the socio-economic status of inhabitants of the area. The questionnaire includes the information on size of family, education of family members, family income, source of income, awareness towards health and environmental hygiene, drinking water quality, source of water etc. The details regarding location, climate and population etc of survey area / villages have been discussed in earlier section.

Feeding Habits in different villages:-

Questionnaire based information were collected on food and feeding habits of inhabitants of the area. The questionnaire includes the information on size of family, availability of cultivated land, seasonal cultivation, major and minor crops of the area, annual / seasonal production, daily, monthly and annual consumption of major food / staple diet in the family and other sources of food gain except self cultivation etc.

Pedigree analysis of the families:-

The surveys were conducted in 184 families of 11 villages in district Chamoli. Individuals of the family were examined personally by trained person for different traits viz strabismus, speech defect, hearing defect etc. At least two individuals of the family preferably the senior most including chief of family were interviewed for family history of different traits.

Results:-

Dietary Salt analysis:-

Results summarized in table 1, 2, 3 indicated that

- Only 7.06% families were using iodised packed salt and rest 92.93% families consumed open uniodised crystal *gara* salt
- Open uniodised crystal *gara* salt occasionally contained traces of iodine (overall average 3.4 ± 0.4 ppm)
- The iodine content in iodised packed salt (overall average 10.4±3.6 ppm) was far below the WHO prescribed amount (15 - 30 ppm).
- 15.59 ± 4.9 % families were consuming salt with nil (0 ppm) iodine content.
- 56.25 ± 7.2 % families were consuming salt with iodine content less than 5 ppm.
- 27±5.2 % families were consuming salt with iodine less than 15 ppm.
- Only 1.13 % families were consuming iodine sufficient salt, with 15 ppm or more iodine content.

Feeding Habits:-

Results are summarized in table 4, 5, 6, 7

- Most of the families grow corn for personal use, depend upon self cultivation. But self cultivated grains and other dietary component were not sufficient to last the entire year. Inhabitants thus depend for supply partly on

local markets. The local suppliers obtained goods from *Mandis* (big wholesale markets) situated in the lower *terai* region (sub-Himalayan region) namely Najeemabad and Sahranpur.

- It is significant that the least affected villages (Salla, Awani, Ratoli & Nargoli) happen to belong to category of villages (A) which consumed protein rich pulses soyabean, urad, gahat throughout the year as against those that consume these only over to six months. Peas & bean are also cultivated here (not in the category B villages).
- The size of family in the surveyed villages ranged from 2 to 11 members. And there was normal distribution of families in the villages according to size. The daily consumption of staple food increases with the increment in family size (as expected).

Socio-economic status:-

Results are summarized in table 8

- In this study the inhabitants of surveyed area were categorized into labour/ farmer and service class. The majority of inhabitants (60 -100 % population of a villages) were labour / farmer in majority of villages (about 73 % villages) and in three villages (out of 11) i.e Salla, Ratoli & Awani 90 – 95% inhabitant were from service class. The literacy rate was very high (about 95 %) in all the villages.
- Inhabitants were found highly aware toward personal and environmental hygiene.
- Inhabitants were also well aware towards routine health checkup and national health program but health care facility are lacking in entire region.

Pedigree analysis of the families:

- Results indicated occurrence of strabismus in 68 families out of 184.
- Results of pedigree analysis indicated that the different traits including strabismus, hearing defects etc are running in different generations of families.
- Out of 184 families Strabismus was found running in three generations in 10 families and two generations in 12 families.
- Speech defects were found in two generations in 2 families and in three generations in a single family
- Hearing defects were found in two generations in a single family.
- These results are in the process of being subjected to detailed genetic analysis. Which will constitute a deeper investigation.

Discussion:-

Sources of iodine uptake in surveyed area:-

Our results indicated that 92.93% families in 11 villages used exclusively open gara (uniodized) crystal salt whereas 7.06% families were using both *gara* (uniodized) & iodized pack salt in their meals. In 73 %, 37 % of villages iodized & uniodized salt was used respectively (Table 1. People purchased uniodised *gara* salt, beause of cheaper price at the local market. Our results also exhibited that open uniodised crystal *gara* salt contained traces of iodine (overall average 3.4 ± 0.4 ppm). Iodine being higly volatile this may be due to contamination (table 1).

In India, salt is produced mainly in three states – Gujarat, Rajasthan and Tamilnadu. Iodisation plants are also established in the proximity. Railways play an important role in transporting salt from production centers. The nearest railway stations for our study area are Rishikesh and Kotdwara from where it is supplied onwards by road. The road transportation takes approx 2-3 weeks. The iodised salt has its shelf life of iodisation of six months only (Subramanian 1987). It is not clear to what extent and in what state the iodisation reaches the consumers in India as studies are not available. According to WHO - ICCIDD iodized salt should contain a minimum of 30ppm of iodine at the manufacture and 15 ppm of iodine at the consumer's level

In our study whatever little iodised salt was used assayes revealed 10.6 ± 3.6 ppm it was below the WHO prescribed level. Around 15.59% of open *gara* salt samples contain nil iodine content, 56.25% of salt samples contain iodine content less than 5 ppm, 27% salt samples showed iodine content less than 15 ppm whereas 1.13% salt samples showed iodine content 15 & more ppm.

It is clear from these analyses that almost all villages in surveyed area are using iodine deficient salt and iodine content in salt ppm were far below the WHO recommendations. Govt of India & state Govt passed a law in 1966 & banned the supply of uniodized salt to mountainous areas considering them iodine deficient (Uttar Pradesh salt control order 1966). But no studies had ever been conducted to assess the actual status of iodine deficiency. For the

first time we carried out studies on actual measurements of dietary iodine content as well as use pattern of iodized and uniodized salts in Uttarakhand. Himalaya.

In the face of iodine deficiency as observed by the current analysis. It is remarkable that without any iodine prophylaxis the incidence of visible goitre was zero in district Chamoli**.** Either iodine deficiency actually does not produce drastic effects or some amount of iodine is reaching the diet (other than iodised salt). The latter possibility appears more likely. Till about 40 years ago villagers in Garhwal were totally dependent on the indigenous agricultural products and they continue to practice the age-old annual system bartering the local produce *Amaranthus f*or cheaper open uniodised crystal *gara* salt which is stored for the entire year. In recent years people, to fulfill their need,s buy grains from general suppliers and from government grain supply agencies also which derive from larger stockists or from government godowns in the plains. The supplies to the godowns may come from fertile areas of the country e. g plains of U P, Punjab etc. which are not so called iodine deficient. This may be one possibility of iodine reaching the diet.

Obviously the present study raises questions on the success of iodization program of Govt in these areas. During the survey, it was found that Govt representatives rarely or never visited these villages to ensure availability of iodized salt. This may be due to remoteness, rough terrain & lack of transport facilities to reach these villages.

Socioeconomic status of this area has become better since last 4-5 decades. Low incidence of thyroid hormone disorders in the present intensive study comparing with previous results and other endemics may be related to bettering socio-economic status. There are reports from other endemics also indicating that prevalence of goitre increases with decrease in low socio-economic status (Knudsen N 2003). Prevalence of goitre and cretinism was found to decrease with increasing socio-economic status (Stott et. al 1931, Najjar and Woodruff 1963, Correa 1980, Jiangun and Xin 1987). In our study it is significant that three villages Slla, Ratoli, Awani, villages i.e group A with almost negligible IDD also happened to be socially more aware, economically better with 79% families in service class. However this issue requires greater sample size to be resolved.

Feeding Habits in different villages in Garhwal Himalaya:-
Daily requirement of iodine is met through food, fruits, salt and water. Drinking water is limited source of dietary iodine. The iodine content in food and water depends on the content of the soil either the soil is iodine deficient or iodine sufficient (Hercus et. al 1925, CIEB 1958, Kelly and Snedden 1960). These Substances in diet also have been known to interfere with iodine trapping mechanism resulting in suppressed thyroid function. Many plants which are included in the main staple diet of the area have been documented to have goitrogenic effect.

In Garhwal Himalaya the main indigenous grains, pulses, vegetables used by the inhabitants of this area are given in Table 4 5, 6 and 7. In this area millets, rice, and wheat are the main staple diet. Mustard, *Brassica napus sp*. are chiefly grown for oil which is used for cooking as well as multipurpose use during the whole year. Millets that constitute part of the staple diet of the villagers in these areas have been shown to contain flavoniods which are known to have goitrogenic effect (Gaitan 1989). It is well established that genus *Brassica* (Crucifer family) which are another highly consumed food have thiocynates and isothiocyanates which are demonstrated as goitrogenic principles (Green 1962, Bachelar et. al 1963, Langer and Stolc 1965, Sarkar et. al 1989). Most of the common vegetables consumed in the area belong to cruciferae family, plants which have been shown rich in flavonoids and therefore may be involved in the etiology of goitre (see review Delang F. 1988). The incidence of thyroid hormone disorders in Garhwal Himalaya should not be attributed to deficiency of iodine alone. Present studies indicated that these thyroid hormone disorders in district Chamoli of Garhwal Himalaya may have multifactorial origin. Studies also showed the consumption of vegetables, millet, cereals rich in goitrogens. However their contribution to development of IDD in this area needs to be further examined separately before drawing unequivocal conclusion.

Is there a genetic basis of IDD?
The spectrum of iodine deficiency disorders includes goitre, cretinism, mental retardation, spastic diplegia, deaf/mutism and strabismus. Deficient thyroid synthesis due to inadequate iodine supplementation to the body is the major known cause for the goitre and associated IDDs. The results of our study (discussed in earlier section), however, indicated incidence of different IDDs in the absence of visible goitre. Results of the hormonal profiles are also in harmony with the observed low incidence of goitre. Considering the above finding we explored the possibility of factors other than iodine deficiency & goitre being involved in the genesis of associated neuromotor developmental & neuromotor disorders e.g. Cretinism, spastic diplegia, deaf mute, strabismus, hearing defects,

speech defects,. Families with two or more generation of these disoders were data mined from the results. Results indicated strabismus running over three generation in 10 families and in two generations in 12 families. Speech and hearing defects were also found running in different generations (speech defects over two generation in two generations of one family). Surveys on social marital pattern indicated narrow – marriage system (marriages in geographically not very distant villages). The studies strongly indicated that these thyroid hormone disorders in this area of Garhwal Himalaya may have a genetic origin also. Pedigree analyses using special software are in progress and shall constitute a deeper study.

Present results explain the incidence of IDD in the absence of goitre as observed in Farswan 2007 & support the presumption that iodine deficiency disorders need not necessarily be due to iodine deficiency.

Table 1:- Consumption of dietary salt type in different villages of district Chamoli

Village	**Total population**	**No. of families surveyed**	**Surveyed population**	**No of families consuming open uniodised crystal *gara* salt**	**% families consuming open uniodised crystal *gara* salt**	**No of families consuming iodised packed salt**	**% families consuming iodised packed salt**
Nijmulla	1200	18	136	18	100	0	0
Gonna	2000	23	162	23	100	0	0
Bayara	1200	10	64	10	100	0	0
Kamyar	1200	20	100	20	100	0	0
Bamaru	1000	24	130	24	100	0	0
Syun	600	33	185	33	100	0	0
Ludho	400	13	77	13	100	0	0
Salla	300	8	30	8	100	0	0
Ratoli	800	14	100	10	71.42	4	28.6
Nargoli	600	10	62	8	80	2	20
Awani	1000	11	60	4	36.3	7	63.6

Table 2:- Iodine content in salt samples obtained from families in villages of district Chamoli

Village	Total population	No. of families Surveyed	Surveyed population	No of families from which salt samples obtained	Iodine content in open uniodised *gara* salt (ppm) mean ±se	Iodine content in iodised packed salt (ppm) mean ±se
Kamyar	1200	20	100	14	1.97±0.60	*
Bamaru	1000	24	130	11	6.24±0.92	*
Syun	600	33	185	19	3.68±0.77	*
Ludho	400	13	77	9	3.08±0.56	*
Salla	300	8	30	8	3.1±0.72	*
Ratoli	800	14	100	14	2.87±1.02	14.98±2.61
Nargoli	600	10	62	6	3.38±1.03	3.2
Awani	1000	11	60	11	3.28±0.79	13.22±3.08
Overall average					3.4±0.4	**10.4±3.6**
*In habitants do not use iodised packet salt at all.						

Table 3:- Iodine content in salt samples consumed in different villages of district **Chamoliin (% families per villages)**

Name of villages	Nil	<5 ppm	5<15 ppm	15& more ppm
Kamyar	35.71%	50%	14.28%	0
Bamaru	9.09%	45.45%	45.45%	0
Syun	31.57%	31.57%	36.84%	0
Ludho	0	88.88%	11.11%	0
Salla	25%	62.5%	12.5%	0
Ratoli	14.28%	42.85%	42.85%	0
Nargoli	0	83.33%	16.66%	0
Awani	9.09%	45.45%	36.36%	9.09%
Overall families	**15.59±4.9**	**56.25±7.2**	**27±5.2**	**1.13**

Iodine content

Table 4:- The main grain used by the inhabitants in different villages of district Chamoli

Grain	Botanical Name	Cultivation Season approx)	Sufficient For six month	Source of Other six month	Supply from	Source of Water
Wheat	*Triticum aestivum L*	May, June	,,	Local market	Rishikesh, Kotdwar	Natural
Rice(Dhan)	*Dryza sativa*	September, October	,,	Local market	Rishikesh, Kotdwar	
Mandua (coda)	*Eleusine corcana gaertn*	September, October	,,	Local market	Local area	
Jangora	*Echinochloa frumentacea*	September, October	,,	Local market	Local area	
Cheena	*Panicum milliaceum*	September, October	,,	Local market	Local area	
Chauli (marsa)	*Amaranthus cruentus L.*	September, October	,,	Local market	Local area	
Jau	*Hordeum vulgare L.*	May, June	,,	Local market	Local area	
Kauni	*Setaria italica Beauv*	September, October	,,	Local market	Local area	

Table 5:- The main pulses used by the inhabitants in different villages (grouped according to common pulses consumed).

Pulses	**Botanical name**	**Cultivation Season (approx)**	***Source of supply**	**Consumption**	
				Villages A	**Villages B**
Rajma	*Phaseolus vulgaris*	October to November	Own cultivation	six month	six month
Soyabean	*Glycine max*	October to November	,,	Throughout the year	six month
Sunta	*Vigna unguiculata*	October to November	,,	Throughout the year	Three month
Bhatt	*Glycine max*	October to November	,,	Throughout the year	six month
Urad	*Vigna mungo*	October to November	,,	Throughout the year	six month
Gahat	*Macrotyloma uniflorum*	October to November	,,	six month	Three month
Masur	*Lens culinaris*	October to November	,,	six month	Three month
Tor	*Cajanus cajan*	October to November	,,	six month	six month
Mung	*Vigna radiata*	October to November	,,	six month	Three month

*Occasionally when local supply is not sufficient produce obtained from lower tarai region (e.g Najeemabad) through local market.
Villages A: Sall, Ratoli, Awani, Nargoli
Villages B : Syun, Bamaru, Ludho, Gonna, bayara, Kamyar,Nijmulla

Table 6:- The main Vegetables used by the inhabitants in different villages

Vegetables	Botanical name	Cultivation Season (approx)	*Source of supply	Consumption Villages A	Villages B
Pyaz	*Allium cepa*	May, June	Own cultivation	Throughout the year	Throughout the year
Sarson	*Brassica campestris*	April to May	,,	April to May(leaf) Seed(Oil)	April to May(leaf) Seed(Oil)
Rai	*Brassica Juncea*	Over the year	,,	Throughout the year	Throughout the year
Palak	*Spinacea olaracea*	Over the year	,,	Throughout the year	Throughout the year
Baigan	*Solanum melongina*	July to September	,,	Three month	Three month
Arvi	*Colocasia esculenta*	Over the year	,,	Throughout the year	Throughout the year
Bhindi	*Abelmuschus esculentus*	July to September	,,	Three month	Three month
Kaddu	*Cucuebita maxima*	July to September	,,	Throughout the year	Throughout the year
Aaloo	*Solanum tuberosum*	Over the year	,,	Throughout the year	Throughout the year
Mooli	*Raphanus sativus*	Over the year	,,	Throughout the year	Throughout the year
Band Gobhi	*Brassica olesacea var. capitata*	December to February	,,	Throughout the year	Occasionally
Lahsun	*Allium sativum*	May to June	,,	Throughout the year	Throughout the year
Lauki	*Lagenaris sicevaria*	July to September	,,	Three month	Three month
Kakri	*Cucunis sativum*	July to September	,,	Three month	Three month
Phool Gobhi	*B. oleracea var botryis*	_	,,	Depend on availability	not cultivated
Matar(Pea)	*Pisum sativum*	January to March	,,	Three month	not cultivated
Bean	*Lablab purpurreus*	July to September	,,	Three month	not cultivated

*Occasionally when local supply is not sufficient produce obtained from lower tarrie region (e.g Najeemabad) through local market.
Villages A : Sall, Ratoli, Awani, Nargoli **Villages B** : Syun, Bamaru, Ludho, Gonna, bayara, Kamyar,Nijmulla

Table 7:- Daily consumption of staple food (kg) in different villages of districts Chamoli according to family size.

Distribution of cereals consumption (Kg) according to number of members in families studied at Chamoli district																			
2		3		4		5		6		7		8		9		10			11
R	M+W	R	M+W	R	M+W	R	M+W	R	M+W	R	M+W	R	M+W	R	M+W	R	M+W	R	M+W
1	1	1	1	1	1.5	1.5	2	1.5	2	2	2	1	1	2	2.5	2	2.5	2	2.5
0.5	0.5	1.5	1	1	1.5	1.5	2	2	2	1	2	1.5	2.5	2	3	1	2.5	3	2
0.5	1	1	1	1.5	1	0.5	1	1	2	2	2.5	1.5	2			2	2.5	3	2
0.5	0.5	1	1	1	1	1.5	1	1	2	1.5	1	1.5	2			2.5	3	3	3
0.62	0.75	1	2	1	0.5	1.5	1	1.5	2	3	3	2	2.5			3	2.5	2	3
		0.5	1	0.5	0.5	1.5	1	2	1.5	2	1.5	2	2.5			2	3		
		1	1	1	1	1	1	1.5	1	1.5	2	2	2.5			2.5	2		
		1	1	1	1.5	1.5	1	1.5	1	2	2.5	2	2.5			2	3		
				1	1.5	1	1	1	1.5	1.5	2	2	4			2	3		
				1	1.5	1.5	1	1	1	1.5	2	2	2			2	2.5		
				1	1.5	1.5	1	1	1.5	1	1.5	2	2.5						
				0.5	2	1	1	1.5	2.5	1.5	1	2	2.						
				1	1	1	1	1	1	2	2.5	3	4						
				1	1	1	1.5	1	1.5	2	2.5	1	1.5						
				1	2	1	1.5	1	1.5	1	1.5	2	3						
						1.5	1	1	2	2	2.5	3	2						
						1.5	1.5	1	1	1	2	3	2						
						1	1.5	1	2	1.5	2	2	2						
						1	1.5	1	2	1	1.5	3	3						
						1	1.5	1.5	2	1	1.5	2	3						
						1.5	1	1	2	2	3								
						1.5	1	1	1.5	2	1								
						1	1.5	1	1.5	2	2								
						1	1.5	2	1.5										
						1	2	2	2.5										
						1	2	1	2.5										
						2	2.5	1	1.5										
						1	1.5	1.5	1										
						2	1.5	1.5	2										
						1.5	2	1	2										
	M=mandua, R= rice, W= wheat																		

Table 8:- Distribution of sources of income generation in different villages of district Chamoli.

Villages	**Source of income in families**	
	Labour / agriculture	**Service class**
Nijmulla	90%	10%
Gonna	95%	5%
Bayara	90%	10%
Kamyar	95%	5%
Bamaru	60%	40%
Syun	100%	-
Ludho	100%	-
Salla	5%	95%
Ratoli	5%	95%
Nargoli	97%	3%
Awani	10%	90%

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