Original Article

Iodine deficiency in children: A comparative study in two districts of south-interior Karnataka, India

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ABSTRACT

Introduction: Iodine is an essential component of the hormones produced by the thyroid gland that are essential for mammalian life. Although goiter is the most visible sequelae of iodine deficiency, the major impact of hypothyroidism as a result of iodine deficiency is impaired neurodevelopment, particularly early in life. According to the World Health Organization, it is the single most preventable cause of mental retardation and brain damage. The simplest, most effective and inexpensive preventive method is the consumption of iodized salt. **Objectives:** The objective of the following study is to estimate the prevalence of goiter in children in the rural areas of Mysore and Coorg districts in India and estimate iodine levels in salt samples. **Materials and Methods:** A cross-sectional study in the age group of 6-12 years, using population proportionate to size systematic sampling method. The total sample size was 10,082: out of which 5337 was from Mysore and the rest from Coorg district. Clinical examination of the thyroid gland was done and salt samples collected for the estimation of Iodine. **Results:** The total prevalence of goiter was 19.01% in children of 6-12 years in Coorg district and 8.77% in Mysore district and it was more in females than in males. **Conclusions:** It was observed that iodine deficiency disorders is endemic in both districts, with a prevalence of 19.01% in children aged 6-12 years in Coorg district and 8.77% in Mysore district. Analysis of salt samples suggested that most of the samples were inadequately iodised (73.92% in Coorg and 45.92% in Mysore).

Key words: Cross sectional study, dox plot, iodine deficiency, prevalence

INTRODUCTION

Iodine is an essential component of hormones produced by the thyroid gland. These are essential for mammalian life which therefore, makes iodine crucial. Although goiter is the most visible sequelae of iodine deficiency, the major impact of hypothyroidism due to iodine deficiency is impaired neurodevelopment, particularly early in life.[1] According to the World Health Organization, it is the single most preventable cause of mental retardation and brain damage.[2]

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Globally, 2 billion people are at risk of Iodine deficiency disorders (IDD) due to insufficient intake of iodine. Nearly 266 million school-aged children world-wide have insufficient iodine intake.[3] It has been estimated that in India 200 million people live in iodine deficient areas, 71 million persons suffer from goiter and other IDD.[4] Surveys conducted in various states showed that no state in the country is free from IDD. Sample surveys conducted in 25 states and five Union territories of the country revealed that out of 282 districts surveyed, IDD poses a major public health problem in 241 districts where the prevalence is more than 10%[5]

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.[6] School age children are an especially useful population group for the assessment of IDD, both because of their physiological vulnerability and their accessibility through schools.[7]

Though studies have been conducted to estimate the problem of IDD in different parts of India, very few studies have been conducted in this south interior part of Karnataka. Hence the need for this study. Such studies will be very useful for the development of intervention measures in iodine deficient areas. Mysore and Coorg are neighboring districts located in the south interior part of Karnataka state in India with different geographical terrains. Coorg is hilly while Mysore is a plain. It is well-known that goiter is more prevalent in hilly regions possibly owing to iodine deficiency in the soil and water compared with low lying areas. In view of this, it is meaningful to compare the goiter rates of school children in these neighboring districts.

MATERIALS AND METHODS

This cross-sectional study was conducted in Mysore and Coorg districts among school children aged 6-12 years, using the method of population proportionate to size (PPS) systematic sampling.[8] Mysore district has seven Taluks (administrative subdivisions) and Coorg district has three. The lists of villages and population of the respective villages were collected from the Registrar General Office, Mysore and Coorg. Informed consent was obtained from the block education officer of each Taluk and from the school heads before the start of the study.

With 5% level of significance, power 80%, the prevalence in India 19%,[9] effect size 0.019, permissible error 10%, "not equal to" alternative hypothesis and using hypothesis testing technique, The sample size was estimated to be 3347 in each district. However, due to the easy availability of school children in both the areas, a total of 5337 children from Mysore district and 4745 children from Coorg district were studied. A total of 30 schools were selected from the two districts.[10,11] Applying PPS systematic sampling and Neyman's allocation technique, the "taluk-wise" lists of schools and sample size of each school was derived.

Goitre was assessed clinically by physical examination of the thyroid gland and graded as follows:[5]

- Grade 1 - Thyroid swelling which is not seen but palpable
- Grade 2 - Thyroid swelling which is seen and palpable.

Salt samples were collected from the corresponding homes of every fifth child examined in the school. The iodine content of the salt samples was estimated using standardized iodine testing kits for spot testing, manufactured by MBI kits international, Chennai, India, which are used in the National Iodine Deficiency Disorders Control Program (NIDDCP) of India and expressed as iodine in parts per million (ppm).[5] Data were compiled and analyzed using appropriate statistical tests. Chi-Square test was used to compare the prevalence of goiter in age and sex groups. Wilk's lambda, Pillai trace and Hotelling-lowley trace tests were used to compare the hypotheses of two districts simultaneously with respect to the differences in number of goiter cases and grades of goiter.

RESULTS

From Table 1, it is observed that the overall prevalence of goiter in Mysore district was 8.77%, with the highest prevalence in H.D Kote taluk (17.27%) and the lowest in Hunsur taluk. (4.86%) The overall prevalence of goiter in Coorg district was 19.01%, with the highest prevalence in Somvarpet taluk (24.53%) and the lowest prevalence in Madikeri taluk (8.90%).

Table 2 shows that the pattern of sex distribution was similar in the two districts, with a higher prevalence among females than males, which was more evident in grade 2 goiter cases. However, between the two districts, the difference among the sexes was more prominent in Mysore district than in Coorg district.

Table 3 and and Figure 1 show an increasing trend in goiter rates from class 1 to class 7 in both districts, being more pronounced from class 5 onwards. Overall, females had a higher rate of goiter than males.

Tables 4 and 5 show the level of iodine in the salt samples collected in the two districts. In Mysore district, 54.08% of the salt samples were adequately iodized (>15 ppm) whereas in Coorg district, only 26.08% of the samples had adequate iodine levels.

Figure 2 represents the parallel coordinate display of Iodine level in salt samples across taluks. It is observed that there is a band created except the lines corresponding to Somvarpet and Mysore taluks. One can observe that zero iodine is more in Coorg with 178 samples in Somvarpet and 78 samples in Virajpet. Among the salt samples collected in Coorg, more than 64.8% have zero iodine level. Another taluk is Mysore which has 108 samples having 7 ppm of Iodine.

Table 6 shows the Chi-square values testing the independence between sex and disease for the two districts. In Mysore, it was very clear from the available data that females were more affected and the $P < 0.05$ indicates that there was a dependency between sex and disease. Whereas in Coorg, though the *P* value of 0.113 does not support the dependency between disease and sex, careful observation reveals that females were more prone to the disease. Thus goiter is more prevalent in females than in males.

Table 7 shows the results of analysis of variance. Wilks' lambda *P* value and Pillai trace and Hotelling-Lawley trace

Table 1: The distribution of children with goitre in Mysore and Coorg districts

District wise Taluks	Total number of children examined	Grade 1 (%)	Grade 2 (%)	Children with goitre (%)
Mysore district				
Mysore	1815	61 (3.36)	46 (2.48)	107 (5.84)
Nanjangud	485	34 (7.01)	23 (4.74)	57 (11.75)
K.R. Nagar	684	57 (8.33)	31 (4.39)	88 (12.72)
T. Narasipur	527	22 (4.17)	18 (3.42)	40 (7.59)
Hunsur	762	16 (2.10)	21 (2.76)	37 (4.86)
Periyapatna	647	40 (6.18)	26 (4.02)	66 (10.20)
H.D. Kote	417	27 (6.47)	46 (10.79)	73 (17.27)
Total	5337	257 (4.81)	211 (3.95)	468 (8.77)
Coorg district				
Madikeri	1101	38 (3.45)	60 (5.45)	98 (8.90)
Virajpet	2344	327 (13.95)	158 (6.74)	485 (20.69)
Somvarpet	1300	212 (16.3)	107 (8.23)	319 (24.53)
Total	4745	577 (12.16)	325 (6.85)	902 (19.01)

Table 2: Sex distribution of grade 1 and grade 2 goitre cases in Mysore and Coorg districts

District	Sex	Grade I (%)	Grade II (%)	Total (%)
Mysore	Male	105 (40.86)	52 (24.64)	157 (33.55)
	Female	152 (59.14)	159 (75.36)	311 (66.45)
	Total	257	211	468
Coorg	Male	255 (44.19)	126 (38.76)	381 (42.24)
	Female	322 (55.80)	199 (61.23)	521 (57.76)
	Total	577	325	902

Table 3: Sex and class distribution of goiter in Coorg and Mysore districts

Class	Mysore (%)		Coorg (%)	
	Male	Female	Male	Female
I	9 (5.73)	11 (3.54)	26 (6.82)	45 (8.63)
II	16 (10.19)	29 (9.32)	29 (7.61)	48 (9.21)
III	15 (9.55)	40 (12.86)	55 (14.43)	46 (8.82)
IV	27 (17.20)	40 (12.86)	62 (16.27)	88 (16.89)
V	20 (12.74)	38 (12.22)	57 (14.96)	82 (15.73)
VI	33 (21.10)	65 (20.9)	62 (16.27)	96 (18.42)
VII	37 (23.57)	88 (28.29)	90 (23.62)	116 (22.26)
Total	157	311	381	521

P values are all <0.05, which indicates that there is a significant difference between the two districts of Mysore and Coorg in terms of the overall cases of goiter and the two grades.

Figures 3a and b throw some light on the distribution pattern of Grade wise goitre cases and their variability nature. From Figure 3a, Coorg has a wider variability when compared to Mysore for Grade 1 cases. This is also true for Grade 2 cases, but the variability in Coorg is not as much as that of Grade1 in Figure 3a. Also there is no overlap

Table 4: Sex distribution of grade 1 and grade 2 goitre cases in Mysore and Coorg districts

Taluks	Iodine levels in salt samples (%) (ppm)		Total samples
	<15	>15(%)	
Mysore	140 (56.45)	108 (43.55)	248
Nanjangud	33 (33.33)	66 (66.67)	99
K.R. Nagar	46 (33.58)	91 (66.42)	137
T. Narsipur	57 (53.77)	49 (46.23)	106
Hunsur	24 (31.58)	52 (68.42)	76
Periyapatna	11 (29.73)	26 (70.27)	37
H.D. Kote	32 (72.72)	12 (27.28)	44
Total	343 (45.92)	404 (54.08)	747

Table 5: Salt sample analysis in Coorg district

Taluks	Iodine levels in salt samples (%) (ppm)		Total samples
	<15	>15	
Madikeri	1 (2.5)	39 (97.5)	40
Somwarpet	205 (76.78)	62 (23.22)	267
Virajpet	86 (97.73)	2 (2.27)	88
Total	292 (73.92)	103 (26.08)	395

Table 6: Goiter grade test statistics for Coorg and Mysore districts

Districts	Pearson Chi-square test statistic for goiter grades		
	Value	Degree of freedom	Probability
Coorg	2.508	1.000	0.113
Mysore	13.660	1.000	0.000

Table 7: Multivariate analysis of variance table

Test statistic	Value	F-statistic	Degree of freedom	Probability
Wilks' lambda	0.222	12.257	2, 7	0.005
Pillai trace	0.778	12.257	2, 7	0.005
Hotelling-lawley trace	3.502	12.257	2, 7	0.005

of points in Figure 3b which indicates the formation of two clear groups. Hence it is sensed out of both the figures that there is a significant vector difference in the number of Goiter cases among the districts. This is confirmed using the statistical test known as MANOVA.

DISCUSSION

The prevalence of goiter among school children was found to be 19.01% in Coorg district and 8.71% in Mysore district. According to the criteria for endemicity of IDD, both districts come under the category of mild endemicity.[5]

The prevalence of goiter found in Mysore district was similar to the findings in a recent study done in Kottayam,

Kerala (9.8%)[12] and a study in Malda, West Bengal (11.3%).[13] The prevalence in Coorg district was in accordance with the study by Hayat *et al.* in Lucknow (20.3%).[14] In a study in Saudi Arabia by Al Nuaim *et al.*, the prevalence of goiter in the studied areas ranged from 8% to 30%.[15] An overall prevalence of 16.8% was estimated in a survey in Yemen by Zein *et al.*[16]

A higher prevalence of goiter was noted in girls than boys in our study. Similar findings have been reported in many other studies. In a study in Belgaum district, Kamat *et al.* reported a higher prevalence of goiter among girls (21.1%) compared to boys (12.8%)[6] Sahu *et al.* reported a similar pattern in a study in Orissa: A prevalence of 23.1% in girls and 17.3% in boys.[17] A study carried out in Kottayam district of Kerala reported a higher prevalence among girls (21.1%) compared to boys (12.8%).[12] The sex differences in goiter rates may probably be due to the genetic predisposition of females to develop thyroid enlargement in response to iodine deficiency.

On analyzing the relationship of the prevalence of goiter with age, we observed an increasing trend of goiter rates in older children in both districts. A similar pattern was found in a study by Bhat *et al.*: 12.8% in 9 to 12-year-old children as against 10.6% in 6 to 8-year-olds.[18] In a study in Kottayam, a higher prevalence was noted in older children being 12.3% in 10-12-year-olds as compared to younger children.[12] A similar finding was noted in a study conducted in Bhubaneswar[19] 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.

Analysis of salt samples showed that in Mysore district, 54.08% of the salt samples had adequate iodine content (>15 ppm), whereas in Coorg district only 26.08% 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.[5] 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).[20] In a study by Kamat *et al.* in Belgaum, 50% of the households used adequately iodized salt[6] and in a study in Delhi,[21] it was noted that 41% of the households consumed adequately iodized salt.[21]

Among the taluks of Mysore, HD Kote taluk showed the highest prevalence of Goiter (17.27%) and correspondingly the lowest consumption of adequately iodized salt (27.3%). In Coorg district, both Somwarpet (24.53%) and Virajpet (20.69%) taluks had high rates of goiter and correspodingly low levels of consumption of adequately iodized salt (23.22% and 2.27% respectively).

The probable reasons for the higher goiter prevalence in Coorg district as compared to Mysore district, could be its hilly terrain with low levels of iodine in the soil and water. Also the inaccessibility of certain remote hilly regions makes

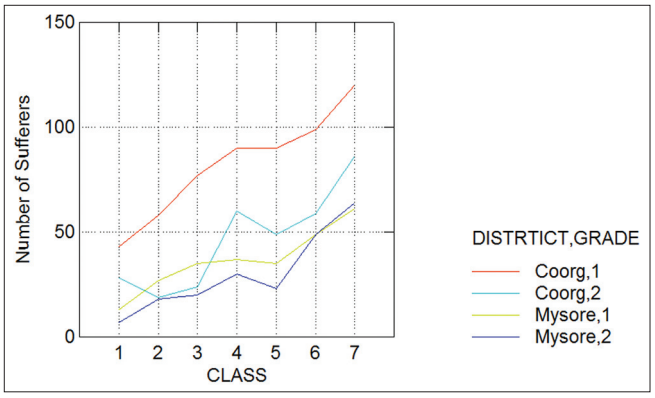

Figure 1: Line chart for class and district wise goiter cases

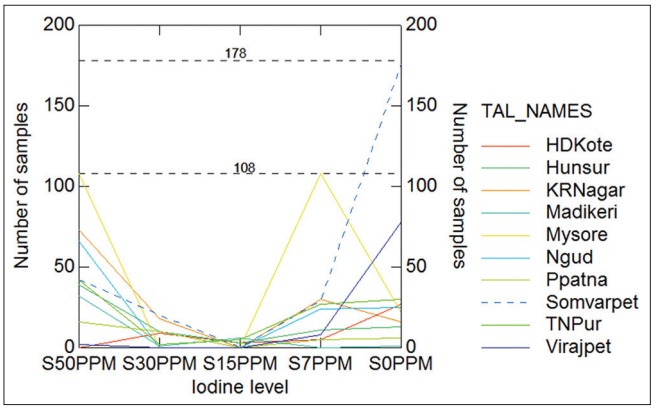

Figure 2: Parallel coordinate display of iodine level in salt samples

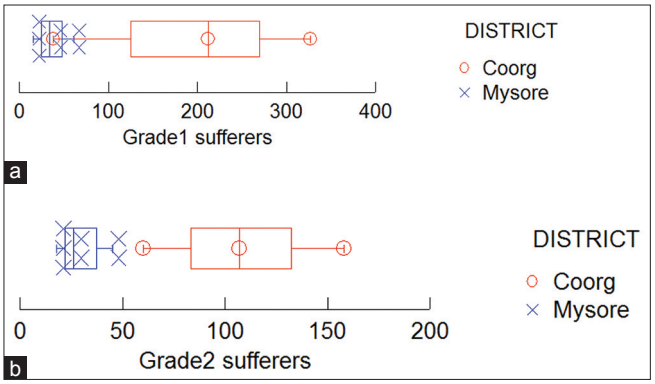

Figure 3: (a) Dox plot for Grade 1 goiter cases, (b) Dox plot for Grade 2 goiter cases

it difficult to obtain iodized salt. Another reason might be the role of goitrogens in the local diet of the population.

In Coorg the cases were much more varied than in Mysore. This was worse with respect to grade 1. It means that there was a fall in the rate of switch from grade 1 to grade 2. The low *P* value of Wilks' lambda test indicates that there is sufficient evidence against the null hypothesis of no significant difference among the vector sequences of the average number of different levels of goiter cases in both districts. This shows that there is a significant difference between the two districts of Mysore and Coorg in terms of the overall goiter cases and also the grades of goiter.

Universal salt iodization (USI) and iodine supplementation are highly effective strategies for preventing and controlling iodine deficiency. USI is now implemented in nearly all countries worldwide and two-thirds of the world's population is covered by iodized salt.[22]

The Government of India launched a centrally assisted National goiter control program in 1962. The program was renamed NIDDCP in 1992. The Government also took a policy decision to implement universal iodization of edible salt in the same year. The goal of NIDDCP was to reduce the prevalence of IDD to below 10% by 2010.[5] The present survey conducted 20 years after initial implementation of universal iodization of edible salt shows that it has not had much impact on the prevalence of goiter in Coorg district.

CONCLUSION

The present study shows a high prevalence in Coorg district (19.01%) indicating that it is an endemic area, where goiter remains a significant public health problem. Though the prevalence of goiter was lower in Mysore district (8.77%) it is still endemic there according to the criterion of goiter endemicity. More effort is, therefore, needed to bring down the prevalence to below 5% to make the district non endemic.

Because of the wide spectrum of adverse consequences of IDD, the very low proportion of the population using adequately iodized salt in Karnataka is a matter of serious concern. Furthermore, the emergence of districts with iodine insufficiency is a matter of concern in the post salt iodization era. There is a wide scope for research on IDD and its prevalence in terms of geographical susceptibility, dietary factors and the interaction of iodine with other micro-nutrients.

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