Original Article#

Dietary Salt Intake and Hypertension in An Urban South Indian Population – [CURES - 53]

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Abstract

Objective : The aim of the study was to determine the mean dietary salt intake in urban south India and to look at its association with hypertension.

Methods : The Chennai Urban Rural Epidemiology Study (CURES) is an ongoing population based study on a representative population of Chennai city in southern India. Phase 1 of CURES recruited 26,001 individuals aged ≥ 20 years, of whom every tenth subject (n=2600) was invited to participate in Phase 3 for detailed dietary studies and 2220 subjects participated in the present study (response rate : 84.5%). Participants with self-reported history of hypertension, diabetes or heart disease were excluded from the study (n=318) and thus the final study numbers were 1902 subjects. Dietary salt, energy, macronutrients and micronutrients intake were measured using a validated semi-quantitative food frequency questionnaire. Diagnosis of hypertension was based on the National Cholesterol Education Programme (NCEP) Adult Treatment Panel III criteria. Logistic regression analysis was used to look at the association of dietary salt with hypertension.

Results : Mean dietary salt intake (8.5 g/d) in the population was higher than the recommended by the World Health Organization (<5g/d). Higher salt intake was associated with older age and higher income (p for trend<0.0001). Subjects in the highest quintile of salt intake had significantly higher prevalence of hypertension than did those in the lowest quintile (48.4 vs 16.6%, p<0.0001). Both systolic and diastolic blood pressure significantly increased with increase in quintiles of total dietary salt both among hypertensive and normotensive subjects (p for trend p<0.0001). Addition of salt >1 teaspoon/day at the dining table was associated with a higher prevalence for hypertension compared to zero added salt (38.5% vs 23.3%, Chi-square = 18.95; p<0.0001). Multiple logistic regression analysis revealed that even after adjusting for age, gender, body mass index, total energy intake and dietary fat, total dietary salt intake was positively associated with hypertension. [Odds ratio (OR): 1.161, 95% Confidence Interval (CI): 1.115-1.209, p<0.0001].

Conclusion: Intake of dietary salt in urban south India is higher than currently recommended. Increasing salt intake is associated with increased risk for hypertension even after adjusting for potential confounders. This calls for urgent steps to decrease salt consumption of the population at high risk. ©

Introduction

Hypertension (elevated blood pressure) has become a major cause of morbidity and mortality worldwide and it is now ranked third as a cause of disability-adjusted life-years.[1] The World Health Report[2] states that elevated blood pressure alone contributes to about 50% of cardiovascular disease (CVD) worldwide. Furthermore, the risk for CVD starts even at upper limits of the normal levels of blood pressure.[3] The prevalence of hypertension has remained stable or has decreased in economically developed countries during the past decade. However it has dramatically increased in developing countries like India, where marked changes have occurred in food consumption patterns changing from 'traditional' to 'western' due to rapid nutritional transition.[4]

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A greater understanding of the risk factors that account for the increase in hypertension could potentially contribute to its future prevention by addressing its root causes. Public health efforts to reduce the prevalence of hypertension have rightly focused on non-pharmacological approaches that lower blood pressure. The World Health Organization (WHO) report states that a 2 % reduction in diastolic blood pressure could prevent 3,00,000 deaths from CVD by 2020.[5] Current guidelines recommend lifestyle modifications, including salt reduction, as one of the most effective approaches to prevent hypertension[6] and indeed as first line treatment for mild hypertension.

Epidemiological[7], clinical[8], experimental[9] and randomised controlled trials[10] suggest that diets habitually high in salt intake play an important role in increasing blood pressure. A recent article also suggests that health intervention, including government policy and action to regulate reduction in the salt content of processed foods, are cost effective ways to limit cardiovascular diseases and could avert over 21 million disability-adjusted life years per year worldwide.[11]

Salt consumption in developing countries is increasing in parallel with increasing urbanization.[7] There are very few recent epidemiological studies in India looking at dietary salt intake in relation to prevalence of hypertension in urban India. Such studies are extremely important in view of the rapid urbansation with the consequent epidemiological and nutritional transition. In the present study, we report on the current dietary salt intake and its association with blood pressure and hypertension in a representative population of Chennai in southern India

Materials And Methods

Sampling

The study subjects were recruited from the Chennai Urban Rural Epidemiology Study (CURES), an ongoing epidemiological study conducted on a representative population (aged ≥ 20 years) of Chennai City (formerly Madras) in southern India with a population of about 5 million people. The methodology of the study has been published elsewhere.[12] Our website http://www.drmohansdiabetes.org (under the link "publications") provides details of the sampling frame. In brief, in Phase 1 of the urban component of CURES 26,001 individuals were recruited based on a systematic random sampling technique.

Phase 2 of CURES deals with studies on prevalence of microvascular and macrovascular complications of diabetes. Phase 1 and 2 are not discussed further in this article.

In Phase 3 of CURES, every tenth subject recruited in Phase 1 (n=2600) was invited to our centre for detailed anthropometric measurements and biochemical tests. Of these, 2220 participated in the dietary assessment study (2220/2600 samples: response rate: 85.3 %). For the present study, subjects with self-reported history of diabetes, cardiovascular disease and hypertension were excluded (n=318) because of therapeutic alteration in their diets. The remaining 1902 subjects were included in the present study.

All study subjects underwent an oral glucose tolerance test (OGTT) using 75gm glucose load, except self-reported diabetic subjects, for whom fasting venous plasma glucose was measured. The fasting blood sample was drawn, after ensuring 8 hours of overnight fasting, for estimation of plasma glucose and serum lipids using a Hitachi 912 Autoanalyser (Roche Diagnostics GmbH, Mannheim, Germany). Anthropometric measurements including weight, height, waist and hip measurements were obtained using standardized techniques.[12] Demographic, socioeconomic characteristics, medical history, medications, family history of diseases, smoking (current smokers: yes or no) and alcohol consumption (current drinker: yes or no) were also obtained.[12] The protocol for the study was approved by the institutional ethical committee and informed consent was obtained from all study subjects.

Blood pressure measurements

The blood pressure was recorded in the right upper limb in sitting position to the nearest 2mmHg using a mercury sphygmomanometer (Diamond Deluxe BP apparatus, Industrial Electronic and Allied products, Pune, India). Two readings were taken 5 minutes apart, and the mean of two was taken as the blood pressure. Hypertension was diagnosed if the blood pressure greater than or equal to 130/85 mmHg based on the National Cholesterol Education Programme (NCEP) Adult Treatment Panel III criteria.[13]

Dietary assessment

Dietary intakes were assessed using a validated semi quantitative food frequency questionnaire which contains 222 food items designed to estimate food intakes during the preceding year.[14] Subjects were asked to estimate the usual frequency (number of times per day, week, month or year / never) and the usual serving size of the portion size of the food item in the FFQ. Common household measures such as household cups, bowls, ladles, spoons (for the cooked foods like vegetables) wedges, circles of different diameter and visual atlas of different sizes of fruits (small, medium, large) were shown. Information on total energy intake, macronutrients and micronutrients were obtained using the same FFQ. Quantitative intake of dietary salt included amount of salt used during cooking and/or added at the table.

Detailed description of the reproducibility and validity of the FFQ have been published elsewhere.[14] Responses to the individual food items, macronutrients and selected micronutrients were converted to average daily intake for each participant using an in-house EpiNu India® database and software (Version 1.0, Chennai) developed by the Department of Nutrition and Dietetics Research of the Madras Diabetes Research Foundation.

Statistical analysis

All analyses were conducted using the statistical software package SPSS, (10.0 version; SPSS Inc., Chicago IL). Subjects were divided into quintiles of dietary salt intake. The mean of each was reported and compared for the descriptive characteristic. Values are expressed as the mean ± SD. One way ANOVA was used to compare continues variables, and the chi-square test was used to compare the proportions among groups. Multiple logistic regression analysis was carried out using hypertension as dependent variables and dietary salt as the independent variable with adjustment for potential confounders such as age, sex, body mass index, total energy and dietary fat. All tests of significance were two-tailed and a p value of <0.05 was considered significant.

Results

The clinical and dietary profile of the normotensive and hypertensive subjects are shown in Table 1. Hypertensive subjects were older (hypertensive vs normotensive: 44.9 ± 12.9 years vs 36.7 ± 11.2 years, p<0.0001) and had significantly higher body mass index (25.0 ± 4.8 kg/m^2 vs 23.4 ± 4.4 kg/m^2, p<0.001) and waist circumference (88.2 ± 11.2 cm vs 81.8 ± 11.6 cm, p<0.0001) compared to normotensive subjects. Mean daily salt (9.9 vs 8.0g, p<0.0001) and dietary sodium (4357 ± 1570 mg vs 3607 ± 1209 mg, p<0.0001) intake were significantly higher among hypertensive subjects.

The mean daily salt intake in the population was 8.5 g/d which was higher than the level recommended by the WHO for adults (5 gm or less). Characteristics of participants by quintiles of dietary salt intake are presented in Table 2. Intake of dietary salt ranged from 4.9 g/d in the lowest quintile to 13.8g/d in the highest quintile. Higher intake of dietary salt was associated with older age (p=0.037), higher body mass index (p<0.0001) and waist circumference (p<0.0001). Both systolic

Table 1 : Clinical and dietary profile of normotensive and hypertensive subjects

Variables	Normotensive subjects	Newly diagnosed hypertensive subjects	P value
n	1388	514	
Age, years	36.7 ± 11.2	44.9 ± 12.9	<0.0001
Male, n (%)	566 (40.8)	255 (49.6)	<0.0001
Body mass Index, kg/m^2	23.4 ± 4.4	25.0 ± 4.8	<0.0001
Waist circumference, cm	81.8 ± 11.6	88.2 ± 11.2	<0.0001
Smoking, n (%)	215 (15.5)	105 (20.4)	0.007
Alcohol, n (%)	500 (36.1)	201 (39.1)	0.125
Energy , kcal / day	2491 ± 605	2533 ± 636	0.184
Protein , % of energy	12.0 ± 1.7	11.8 ± 1.5	0.086
Fat, % of energy	23.8 ± 4.8	23.9 ± 5.2	0.940
Carbohydrates, % of energy	63.6 ± 7.9	63.7 ± 6.4	0.893
Potassium, mg / day	2312 ± 732	2276 ± 703	0.334
Calcium, mg /day	940 ± 356	926 ± 340	0.421
Dietary sodium, mg /day	3607 ± 1209	4357 ± 1570	<0.0001
Total dietary salt, g /day	8.0 ± 2.8	9.9 ± 3.9	<0.0001

Values are mean ± Standard deviation or n (%)

Table 2 : Descriptive characteristics of subjects by quintiles of total dietary salt intake [both added during cooking and at the table]

	Quintiles of dietary salt, gram / day					p for trend
Variables	Q1(n=385)	Q2(n=391)	Q3(n=384)	Q4(n=376)	Q5(n=366)	
Mean salt intake (grams /day)	4.9	6.6	7.9	9.6	13.8	
Age (years)	37.6 ± 12.9	37.7 ± 10.6	37.9 ± 11.6	39.7 ± 12.5	41.7 ± 13.4	0.037
Men, n (%)	128 (33.2)	152 (38.9)	173 (45.1)	174 (46.3)	194 (53.2)	<0.0001
BMI (kg/m^2)	22.1 ± 3.9	23.1 ± 4.5	24.2 ± 4.7	24.7 ± 4.87	24.8 ± 4.4	<0.0001
Waist circumference (cm)	79.3 ± 10.8	81.3 ± 11.9	84.5 ± 11.7	85.9 ± 11.9	87.0 ± 11.0	<0.0001
Systolic blood pressure (mm Hg)	113.0 ± 13.3	113.7 ± 13.7	115.4 ± 13.8	119.4 ± 18.7	129.2 ± 23.0	<0.0001
Diastolic blood pressure (mm Hg)	70.5 ± 10.1	70.6 ± 10.4	73.0 ± 10.2	74.5 ± 10.8	78.3 ± 12.6	<0.0001
Hypertension (%)	16.6	19.9	23.7	27.7	48.4	<0.0001†
Energy (kcal / day)	2077 ± 519	2351 ± 472	2553 ± 442	2712 ± 523	2842 ± 760	<0.0001
Protein (% of energy)	11.8 ± 1.72	11.8 ± 1.5	12.0 ± 1.7	12.1 ± 1.6	11.9 ± 1.7	0.205
Fat (% of energy)	21.9 ± 4.7	23.2 ± 4.3	24.1 ± 4.5	24.8 ± 4.3	25.1 ± 5.7	<0.0001
Carbohydrates (% of energy)	65.9 ± 6.0	64.2 ± 6.7	63.0 ± 7.2	62.4 ± 5.0	62.6 ± 10.9	<0.0001

Values are mean ± SD or n (%); † chi-square trend =95.4

(p<0.0001) and diastolic blood pressure (p<0.0001) were significantly higher in those in the highest quintile of salt intake. The prevalence of hypertension increased with increasing quintiles of salt intake (1st quintile: 16.6% vs. 5th quintile: 48.4%; chi square trend=95.4; p<0.0001). Total calories and percentage of calories from fat (p<0.0001) significantly increased across quintiles of salt intake. Mean salt intake at the age group of 20-29 years was 8.1g/d and 9.6g/d at ≥ 60 years (p=0.003) [data not shown].

Fig. 1 shows the mean salt intake by household income. Intake of dietary salt was significantly higher in those with household income > Rs 10,000 per month (9.4g, p=0.006) compared to those with < Rs 2000 per month (7.9g, p=0.006). However there was no association between dietary salt intake and the level of education (data not shown).

The prevalence of hypertension was higher among subjects who added >1 teaspoon / day of extra salt to their foods at the table compared to those who did not add any extra salt [38.5% vs 23.3%; chi-square=18.95, p<0.0001] (Fig. 2).

Dietary salt and blood pressure among normotensive

With increasing quintiles of dietary salt intake, there was a significant increase in both systolic and diastolic blood pressure among normotensive subjects. (Systolic blood pressure 1st quintile vs. 5th quintile: 108.8 vs.111.9 mmHg, p<0.0001 for trend; diastolic blood pressure: 67.7 vs.70.3 mmHg; p<0.0001 for trend) (Fig. 3). Bivariate correlation between systolic, diastolic blood and dietary factors are presented in Table 3. Both systolic

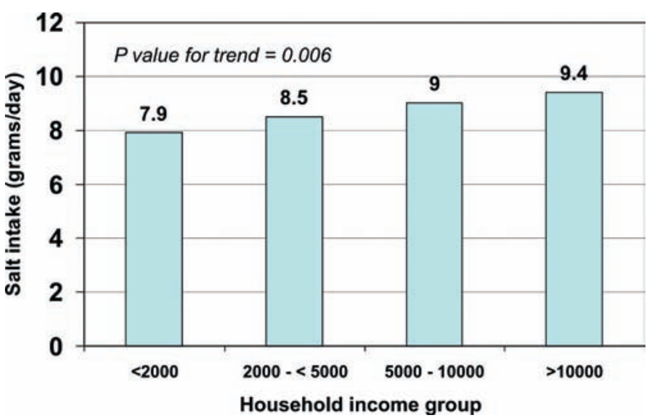

Fig. 1 : Mean dietary salt intake (g/day) by household income (n=1902).

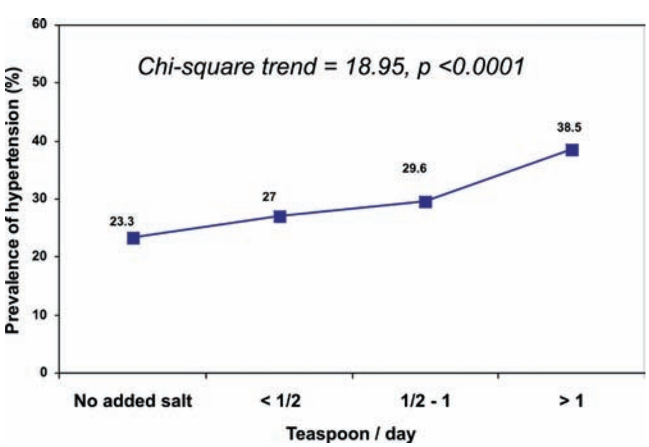

Fig. 2 : Prevalence of hypertension by salt added at the table (n=1902).

Table 3 : Bivariate correlation between dietary factors (g/d) and blood pressure

Dietary factors pressure (p value)	Systolic blood pressure (p value)	Diastolic blood
Energy , Kcal	0.056 (p=0.014)	0.089 (p<0.0001
Protein , g	0.039 (p=0.087)	0.094(p<0.0001)
Fat, g	0.039 (p=0.087)	0.094 (p<0.0001)
Carbohydrates, g	0.050 (p=0.030)	0.080 (p<0.0001)
Total dietary salt, g	0.349 (p<0.0001)	0.263 (p<0.0001)
Dietary sodium, mg	0.324 (p<0.0001)	0.251 (p<0.0001)
Visible fats and oils, g	0.048 (p=0.036)	0.105 (p<0.0001)
Cereals, g	0.051 (p=0.029)	0.053 (p=0.021)
Pulses and legumes, g	0.028 (p=0.224)	0.059 (p=0.010)
Fruits, g	-0.058 (p=0.012)	-0.010 (p=0.666)
Vegetables , g	-0.009 (p=0.683)	-0.013 (p=0.578)
Fishes and sea foods, g	-0.047 (p=0.059)	-0.012 (p=0.618)
Meat and poultry, g	0.047 (p=0.055)	0.089 (p<0.0001)

'r' coefficient

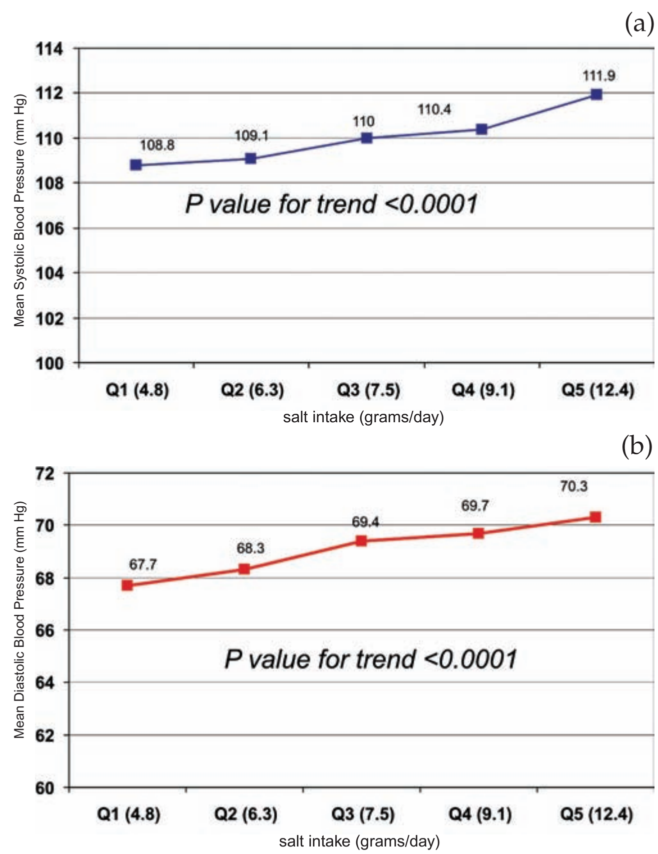

Fig. 3 : Mean systolic (a) and diastolic blood pressure (b) by total salt intake in normotensive subjects (n=1388).

Table 4 : Association of dietary salt with hypertension

Variable	Multivariate logistic regression				
	β	SE	OR	95% CI	p
Total dietary salt, grams/ day [added at the table & included in cooking]	Dependent variable : hypertension#				
Model 1	0.174	0.016	1.190	1.153-1.228	**<0.0001**
Model 2	0.151	0.017	1.162	1.124-1.202	**<0.0001**
Multivariate adjusted*	0.149	0.020	1.161	1.115-1.209	**<0.0001**
No. of teaspoon / day of extra salt added at the table					
Model 1					
No added salt [reference]					
< ½	0.193	0.123	1.213	0.954-1.542	0.166
½ - 1	0.323	0.159	1.382	1.012-1.888	**0.042**
> 1	0.722	0.166	2.059	1.488-2.849	**<0.0001**
Model 2					
< ½	0.278	0.132	1.321	1.020-1.710	**0.035**
½ - 1	0.398	0.172	1.488	1.062-2.085	**0.021**
> 1	0.565	0.178	1.759	1.240-2.495	**0.002**
Multivariate adjusted*					
< ½	0.236	0.140	1.266	0.962-1.666	**0.093**
½ - 1	0.405	0.181	1.500	1.052-2.137	**0.025**
> 1	0.530	0.187	1.698	1.176-2.452	**0.005**

Model 1: unadjusted; Model 2: Adjusted for age, gender and body mass index; *Multivariate adjusted: In addition to model 2, further adjusted for total energy (kcal/d) and dietary fat intake (g/d). #Hypertension: SBP ≥ 130 and/or DBP ≥ 85 mm Hg

and diastolic blood pressure showed strong correlation with dietary salt intake [SBP: r=0.349, p<0.0001; DBP r=0.263, p<0.0001]

Association of dietary salt with hypertension

Table 4 presents the results of multivariate logistic regression analysis using hypertension as the dependent variable. In unadjusted model, total dietary salt intake showed 1.190 [95% C.I: 1.153-1.228, p<0.0001] times higher risk for hypertension. After adjusting for confounding variables, dietary salt intake still associated with hypertension [Odds ratio (OR): 1.161, 95% C.I:1.115-1.209, p<0.0001].

In the unadjusted model, salt added at Table > 1 teaspoon/day showed two fold higher risk for hypertension [odds ratio [OR]: 2.059, 95% Confidence Interval [CI]: 1.488-2.849, p<0.0001] compared to zero added salt taken as reference. Even after adjusting for known risk factors (model 2) such as age, sex, and body mass index, the association between added salt intake (tsp/d) and hypertension remained significant [OR: 1.759, 95% C.I: 1.240-2.495, p=0.002]. Further adjustment for dietary variables such as total energy and dietary fat also did not substantially change this association [OR: 1.698, 95% C.I: 1.176-2.452, p=0.005].

Discussion

Studies in western populations have shown that dietary salt intake is a significant risk factor for hypertension[7] and cardiovascular disease.[15] Asian Indians are known to have very high prevalence rates of premature coronary artery disease compared to Europeans.[16] The prevalence of hypertension is also increasing rapidly in urban India.[17] However, there are few large well conducted epidemiological studies of dietary salt intake in Asian Indians in relation to hypertension and even fewer that have been controlled for potential confounding variables.

In this context, this study done in an urban south Indian population makes three important points: (i) consumption of dietary salt is higher than the currently recommended by WHO (ii) both systolic and diastolic blood pressure are influenced by higher intake of dietary salt among hypertensive and normotensive subjects (iii) increased salt intake is associated with increased prevalence of hypertension and this association is independent of age, sex, body mass index, total energy and dietary fat intake.

We observed that mean systolic blood pressure increases by 16.8 mmHg and diastolic blood pressure by 7.8 mmHg for those in the highest quintile (>13.8 g/d or equivalent to ≈ 2 tsp / d) compared to those in the lowest quintiles (< 4.9g/d or equivalent to 1tsp / d) of salt intake. An overview of observational data in populations[18] showed that a difference in dietary sodium intake of 100 mmol/day was associated with average difference in systolic blood pressure of 5 mmHg at age 15-19 years and 10mm Hg at age 60-69 years and about half of these values for diastolic blood pressure.

The INTERSALT[7] study showed a significant positive relationship between urinary sodium excretion and blood pressure across the 52 populations studied.

Results from the DASH trials[10] provide additional confirmation that dietary salt reduction significantly lowers blood pressure in both hypertensive and normotensive populations.

In a study conducted in urban North Indians, dietary fat, salt intake and lower physical activity were weakly, but significantly, associated with a higher prevalence of hypertension.[19] A significant relationship was also observed between habitual salt intake and blood pressure in the urban population of North Kashmir[20] while no such association was observed in a cross sectional study in Kerala in South India.[21] In some of these studies, adjustment for total energy intake was not done and this might explain some of the variation in the results. Our results are consistent with the published findings in the west[7] which have shown an association between salt intake and hypertension.

Developed nations and urban populations with higher salt consumption in developing countries appear to have the highest percentage of hypertension, while rural areas and less developed countries that use less salt have lower prevalence rates of hypertension.[7] Changes in dietary patterns, occupation and lifestyle are some of the possible contributors to the rapid rise in prevalence of hypertension in urban Indians. The urban Indian cooking involves high usage of salt partly in cooking and partly as salt added at the table. The mean salt intake of 8.5 grams /day, in this study is higher than the recommended by WHO.[5] This could partly explain the increasing prevalence of hypertension in urban southern India. Factors contributing to increase in salt intake include 'richer' foods associated with higher income levels and eating out particularly the fast-food culture which invariably increases intake of salty and fatty foods.

We found that on an average, 1.5-2 g increase in the salt intake among normotensive subjects was associated with an increase in both systolic and diastolic blood pressure by ~1mm Hg. The risk of cardiovascular disease rises with blood pressure throughout the normotensive blood pressure range and almost 60% of coronary heart disease events and 45-50% of strokes occur in those with high normal blood pressure.[3] Hence, persons with normal blood pressure may also benefit from lifestyle modification.

Reduction in salt intake at a population level to lower blood pressure would appear to be the most cost-effective method to reduce the burden of hypertension and thereby cardiovascular disease in the population. Current evidence suggests that a universal reduction in dietary intake of sodium by 50 mmol/d (equivalent to 1.2 g of salt/d) would not only lead to a 50% reduction in the number of people requiring anti-hypertensive therapy but also to 22% reduction in number of deaths due to stroke and a 16% reduction in number of deaths from coronary artery disease.[22]

One of the limitations of this study is that being a cross-sectional one, it is not the appropriate design to assess the cause and effect relationship between diets with disease. Future studies using longitudinal data or randomised clinical trials are needed on role of dietary salt in the development / prevention of hypertension and cardiovascular disease among Indians. The study however has several strengths. Firstly, the sample is representative of the population of Chennai adults which in turn is representative of urban India and hence the results can be extrapolated to urban India. Secondly, the sample size was quite large and the response rate was good. Thirdly, we were able to capture quantitative data on discretionary use of salt in the cooking or seasoning of food at the table using validated semi-quantitative food frequency questionnaire. Finally the use of logistic regression analysis in this study allowed for simultaneous adjustment of confounding variables in the association which, to the best of our knowledge, has not been done in earlier Indian studies.

In the Indian cuisine, salt intake depends on several sources: salt used in the cooking, salt added at the table directly and in the form of pickles, pappads etc. Therefore, public health strategies must be developed for educating patients i) to avoid excessive intake of salt in cooking, ii) to increase intake of foods low in salt (e.g. fruits and vegetables), iii) to avoid foods high in salt (e.g. pre-prepared / processed foods), iv) to refrain from adding salt at the table, v) to increase their awareness of the salt content of food choices in restaurants and vi) promote use of traditional foods rather than western or 'fast foods' and junk foods which are high not only in salt but also in calories, sugar and fat content. Such measures, if carried out across the whole population, could have substantial benefits in reducing the burden due to hypertension in India.

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Announcement

Dr. P.J. MEHTA YOUNG SCIENTIST AWARD

As you are aware for the past many years we have been giving the Young Scientist Award for the Best paper presentation at the National Conference of HSI.

Papers are invited from young research workers (below 35 years of age) who have done original research work in the field of hypertension and related subjects. These papers will be judged by a panel of referees. The finalists will be required to present their papers at the National Conference. From these will be selected the recipient of the **Dr. P.J. MEHTA YOUNG SCIENTIST AWARD.** The research worker who submits his paper must attach a certificate indicates his date of birth.

The finalists will be given 2nd Class A/c train fare to and from their hometown.

Please send 5 copies of the full manuscript of the paper along with the abstract typed in the abstract form enclosed along with to **Dr. B.R. Bansode, Secretary General, HSI, Dr. Babasaheb Ambedkar Memorial Hospital, Room No. 101, Central Railway, Byculla, Mumbai 400 027.**

Last Date to Receipt of Manuscript : **15th August, 2007.**

Dr. BR Bansode,
Secretary General,