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Worldwide Consumption of Sodium and Its Impact on Human Health

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Abstract :- Sodium intake of different populations around the world varies markedly. In the vast majority of populations, salt intake is high and well above recommended daily intakes. There is strong and consistent evidence from animal studies, clinical trials and epidemiological data both within and across populations implicating high salt intake as an important risk factor for high blood pressure among both normotensive and hypertensive individuals. High salt is also associated with increased risk of future CHD and stroke. A search strategy was developed to identify studies that reported the data base about sodium intake around the world as well as its impact on human health. Data available around the world indicates that there is a strong need to initiate the sodium reduction programme as excessive sodium consumption found to be associated with many health problems especially hypertension which may further leads to cardiovascular disease and many more.

Keywords: *salt, sodium, hypertension, cardiovascular disease, sodium reduction.*

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I. INTRODUCTION

Sodium intake of different populations around the world were first brought to the attention of the research community after the publication of Louis Dahl's article in 1960, showing a positive linear relationship between prevalence of hypertension and mean sodium intake across five populations (Brown et al, 2009). Different National and International recommendations suggest that average population salt intake should be less than 5 gram/day. WHO (2007) also recommended that it should be < 5g/d. There is clear evidence that too much sodium, mainly in the form of salt (sodium chloride), has adverse implication for health. Sodium intake is associated with elevated blood pressure, which is a leading risk for cardiovascular disease, a major risk factor for premature deaths globally. It is currently the leading risk resulting in considerable death and disability worldwide and accounted for 9.4 million deaths and 7 percent of disability adjusted life years (DALYs) in 2010 (Lim et al, 2012). It has been predicted that by the year 2020, there will be an increase by almost 75 percent in the global cardiovascular disease burden (Gupta, 2004).

In addition to raising the blood pressure dietary salt is responsible for several other harmful effects. A high salt intake increases the mass of the left ventricle, thickens and narrows resistance arteries, including the coronary and renal arteries. It also increases the number of strokes, the severity of cardiac failure and tendency for platelets t aggregate. In renal disease, a high salt intake accelerates the rate of renal functional deterioration. Apart from its effect on the cardiovascular system dietary salt has an effect on calcium and bone metabolism, which underlies the finding that in post- menopausal women salt intake controls bone density of the upper femur and pelvis. Of all the factors that relate to cancer of the stomach, the second most common cancer in the world, the relationship to salt is the strongest. Carcinoma of the stomach is strongly related to dietary sodium intake. There is some evidence which suggests that salt is associated with the severity of the asthma in male asthmatic subjects (Wardener and MacGregor, 2002). Apart from health implications it has huge societal, developmental and economic costs. There is also noteworthy income loss to families affected by hypertension not only due to illness but also due to care giving and premature death (Mohan et al, 2013). That's why researchers and policy makers around the world stress on reducing salt intake to control hypertension because its key triggers – stress and faulty lifestyle- are difficult to control. The large and growing burden of diseases, despite improved medical therapies and increased awareness that dietary salt reduction can help prevent and treat hypertension reinforce the urgent need for dietary change.

II. METHODS AND MATERIALS

A search strategy was developed to identify studies that reported the data base about sodium intake around the world as well as its impact on human health. Additionally, reviewed reference lists of relevant original and review articles have also be done to search for more trials.

III. RESULTS

Sodium intake in different population

Sodium intakes of different population around the world were vividly brought to the attention of the research community by publication of Louis Dahl's famous graph in 1960, showing a positive linear relationship between prevalence of hypertension and mean salt intake across five population groups. It was noted that daily intakes of sodium (salt) varied considerably across population groups from 4g salt/d (1.56 g/d, 68 mmol/d sodium) among Alaskan Eskimon to 27 g salt/d (10.6 g/d, 460 mmol/d sodium) in Akita Prefecture, north- east Japan. American men had intakes averaging 10 g/d salt (3.91 g/d, 170 mmol/d sodium). It was also noted a strong north-south trend in death rates from stokes in Japan. This coincided with differences in sodium intakes ranging from 14 g salt/d (5.47 g/d, 238 mmol/d sodium) in south up to the 27 g/d (10.6 g/d, 459 mmol/d sodium) in the northeast region (Elliott and Brown, 2007). Most adult populations around the world have average daily salt intakes higher than 6 gram/day and for many in Eastern Europe and Asia higher than 12 grams. International recommendations suggest that average population salt intake should be less than 5-6 gram/day (He and MacGregor, 2009). INTERSALT (1988) provides by far the largest set of standardized data on 24 hour urinary sodium excretion patters around the world. Eight percent of the study sample collected to 24 hour urinary collections to estimates within individual variability of sodium intakes. Lowest values of sodium excretion were found among the Yanomamo Indians of Brazil, i.e. 0.8 mmol/d (18 mg/d) in men and 1.0 mmol/d (23 mg/d) in women. Three other remote population groups had 24 hour urinary sodium excretion at or below 60 mmol/d (1.38 g/d), i.e. Xingu Indians of Brazil, Papua New Guinea Highlanders and the Luo in rural Kenya. Highest value of urinary sodium excretion were recorded in Tianjin, China and were 259 mmol/d (5.95 g/d) in men and 233 mmol/d (5.35 g/d) in women. The highest mean urinary sodium excretion in Japan was found in Toyama and was estimated as 224 mmol/d (5.12 g/d) in men and 201 mmol/d (4.62 g/d) in women. Values over 200 mmol/d (4.6 g/d) in men were also found in Canada, Columbia, Hungary, Ladakh (India), Bassiano (Italy), Poland, Portugal and the Republic of Korea. A study was conducted by Molina et al (2003) in Vitoria, ES (Espireto Santo) found that the daily salt consumption estimated from the 12 hour excretion among the participants in the study was high (12.6 ± 5.8g). Reinivuo et al (2006) reported that salt intake in Finland has slowly decreased since the early 1980s. However, salt intake is still higher than the daily intake recommended by National and International Govt. organizations. They reported that in 2002, the mean daily sodium intake was 3.9 g (9.7 g salt) in men 2.7 g (6.7 g salt) in women. Excess dietary sodium is currently a public health concern in Canada. The estimated average sodium intake, not including sodium added at the table or during cooking, is 3092 mg/d, based on data from the 2004 Canadian Community Health Survey (CCHS) (Garriguet, 2007). Kim et al (2013) reported the median sodium excretion level in 24 hour urine of the study subjects ranged from 129 mmol to 216 mmol depending on age and gender of the group. Females and younger age group has lower excretion. A survey was conducted on 189 healthy adults with no history of hypertension. Malaysian Adult Nutrition Survey (MANS) conducted by Mirnalini et al (2008) revealed that sodium intake of Malaysians was 2575 mg/d. The MANS further revealed that although there was no significant difference in the rural –urban intake among Malaysians. Men consumed about 500 mg sodium more than women did, while consumption declined with age. Sodium was found to be highest in the group with highest educational level (2734 mg/d for college / university student), and among the ethnic Chinese (2916 mg/d). Ortega et al (2010) conducted a study on 196 men and 222 women aged 18-60 years selected as a representative sample of Spanish young and middle aged adult populations. They reported the 9.8 g/d (SD4.6 g/d) of the sodium consumed by whole populations and 11.5 (SD 4.8) and 8.4 (SD 3.9) g of salt /d in men and women. Data on the intake of sodium in the US was reported by Hoy et al (2011). The average sodium intake of the US population aged 2 years and older was 3330 mg/d. Yasutake et al (2013) reported mean salt excretion for all subjects over 4 weeks was 8.05± 1.61 g/d and the range (maximum minimum value) was 5.58± 2.15 g/d in Japan. Sodium excretion in Australian women was found to be 126 (SD 42) mmol/d i.e. approximately 7.6 (SD 2.5) g salt/d. A study was conducted on 70 healthy women living in metropolitan Adelaide, South Australia. Seventy percent of participants had sodium excretion ≥ 100 mmol/d (Keogh et al, 2012). In an another study conducted by Charlton et al (2010), mean sodium excretion of Australian women equated to salt intake of 6.41 (SD 2.61) g/d; 43 percent had values <6 g /d.

Salt intake in Indian population

In view of Indian scenario, an Indian council of medical research survey reported a daily salt intake of 13.8 gram in 13 states in 1986-88 (Kalra et al, 2013). Radhika et al (2007) conducted a study on a representative population of Chennai city in Southern India. The mean dietary salt intake in the population found to be 8.5 g/d which was higher than the value recommended by World Health Organization. i.e. 5 g/d. Intake of dietary salt ranged from 4.9 g /d in the lowest quartile to 13.8 g /d in highest quartile. Whereas a study was conducted by Jan et al (2006) in Kashmir depicted that the average 24 hour urinary sodium excretion in hypertensive group was higher as compared to controls which was statistically significant. The mean levels of sodium excretion were found to be ranging from 424±150.50 mg/d in hypertensives and 337±121.50 mmol/d in normotensives.

The HEART study was initiated in Tamil Nadu and an early report indicated a salt intake of 12 g/d (Chidambaram et al, 2012).

More recently, SCRIPT study conducted by Kumbla et al (2016) reported the mean total daily salt consumption of 10.9 grams in four different zones of the country. Region-wise, the mean daily salt consumption in North, East, West and South were 14.13, 9.81, 10.12 and 9.38 grams respectively that all were too high than the recommended values given by WHO (2007). Dhemla and Varma (2016) reported 14.8 g/day of salt intake in normotensive subjects residing in Jaipur city. Intake was measured by using 24 hours urinary sodium excretion as suggested by WHO (2007) as gold standard method to assess sodium intake in population. Weighted mean population 24-hour urine excretion of salt was 8.59 g/day (95% CI 7.68–9.51) in Delhi and Haryana and 9.46 g/day (95% CI 9.06– 9.85) in Andhra Pradesh (P=0.097) as reported by Johnson et al (2017).
Data available around the world indicates that there is a strong need to initiate the sodium reduction programme as excessive sodium consumption found to be associated with many health problems especially hypertension which may further leads to cardiovascular disease and many more. But before this we have to find out the data that will indicate the actual sodium consumption among population which will finally make people aware about this health concern and how much of salt they should cut off from their daily consumption. Therefore baseline studies which measure the dietary salt intake, sources and public knowledge by using standardized techniques are required.

Effect of excess sodium on health

The best available population-based data on the relationship between dietary sodium and blood pressure has been provided through the INTERSALT study (Elliott et al, 1996). Clinical trials, primarily the DASH-sodium study (Sacks et al, 2001) and the Trial of Hypertension Prevention (Cook et al, 1998), have confirmed conclusions of INTERSALT investigators demonstrating changes in blood pressure in response to dietary sodium reduction of the magnitude predicted by INTERSALT. Meneton et al (2005) stated the mechanisms by which dietary salt increases arterial pressure, seem related to the inability of the kidneys to excrete large amount of salt independent of the rise in blood pressure. Dietary salt also increases cardiac left ventricular mass, arterial thickness and stiffness, the incidence of strokes and the severity of cardiac failure.

There is clear evidence that too much sodium, mainly in the form of salt (sodium chloride), has adverse implication for health (He and MacGregor, 2009). Sodium intake is associated with elevated blood pressure, which is a leading risk for cardiovascular disease, a major risk factor for premature deaths globally. Kearney et al (2005) reported that worldwide, nearly one billion adults have hypertension, and 17% - 30% of hypertension can be attributed to excess dietary sodium. The results of meta-analysis, conducted by Strazzullo et al (2009), provide evidence of direct association between high dietary salt intake and risk of stroke as well as cardio vascular disease. About one-quarter of all cardiovascular disease deaths occurred in persons who were less than 70 years of age in the developed world, more than about half of these deaths occurred in those less than 70 years in the developing world (Rodgers et al, 2000). It has been predicted that by the year 2020, there will be an increase by almost 75 percent in the global cardiovascular disease burden (Gupta, 2004). A study conducted by Molina et al (2003) also determined a positive linear correlation between urinary sodium excretion and systolic (r = 0.15) and diastolic (r = 0.19) arterial pressure. Hypertensive individuals showed higher urinary sodium excretion than normotensive individuals. Meneton et al (2005) stated the mechanisms by which dietary salt increases arterial pressure, seem related to the inability of the kidneys to excrete large amount of salt independent of the rise in blood pressure. Dietary salt also increases cardiac left ventricular mass, arterial thickness and stiffness, the incidence of strokes and the severity of cardiac failure. Beyond the thinking, salt may increase the blood pressure and the risk of hypertension in workers working close to salt milling plants. They may inhale salt particle floating in air, leading to a rise in plasma sodium. Mean systolic blood pressure of workers, who worked with dry salts in the vicinity of salt milling plants, was significantly higher than that of worker working far away from milling plants (Haldiya et al, 2005). Association between dietary sodium and blood pressure was also established by Simmet et al (2012) in German population. Furthermore, in the sodium loading experiment, there was significant weight gain at each level of increased intake and at higher levels; peripheral edema and occasionally pulmonary congestion were observed (Logan, 2006). In this summary of evidence he also supported that even in healthy young people the kidneys ability to maintain sodium homeostasis begins to falter at very high levels of sodium intakes. Heaney (2006) added that sodium, in the form of sodium chloride, elevates urinary calcium excretion and at prevailing calcium intakes, evokes compensatory responses that may lead to increased bone remodeling and bone loss. The calciuria is partly due to salt-induced volume expansion, with an increase in GFR, and partly to competition between sodium and calcium ions in the renal tubule. On the basis of evidence, a causal relationship between salt intake and blood pressure reported by He et al (2011). Prospective study and outcome trials have demonstrated that a lower salt intake is associated with the decreased risk of cardiovascular disease. Increasing evidence also suggest that high salt intake is directly related to left ventricular hypertrophy (LVH) independent to blood pressure. Both raised blood pressure and LVH are important risk factors for heart failure. In patients who already have heart failure, a salt intake aggravates the retention of salt and water, thereby exacerbating heart failure symptoms and progression of the disease.

Indian scenario

The situation in India is more alarming. It was reported that of a total of 9.4 million deaths in India in1990, cardiovascular diseases caused 2.3 million deaths (25%). A total of 1.2 million deaths were due to coronary heart disease and 0.5 million due to stroke. It has been predicted that by 2020, there would be a 111% increase in cardiovascular deaths in India (Gupta, 2004). In India, hypertension is the leading NCD risk and estimated to be attributable for nearly 10 per cent of all deaths. Adult hypertension prevalence has risen dramatically over the past three decades from 5 per cent to between 20-40 per cent in urban areas and 12-17 per cent in rural areas The number of hypertensive individuals is anticipated to nearly double from 118 million in 2000 to 213 million by 2025. It is estimated that 16 per cent of ischaemic heart disease, 21 per cent of peripheral vascular disease, 24 per cent of acute myocardial infarctions and 29 per cent of strokes are attributable to hypertension underlining the huge impact effective hypertension prevention and control can have on reducing the rising burden of cardiovascular disease (CVD). The recent global burden of disease study reports excess salt intake to be the 7th leading cause of mortality in South East Asia Region which is much higher than in rest of the world (11th globally), highlighting the adverse impact of high intake in countries like India (Lim et al, 2012). Given the rising burden of hypertension and high salt consumption, the priority intervention of choice for hypertension prevention and control is population-wide salt reduction. However, its potential has yet to be tapped in India with efforts being initiated only recently (Mohan et al, 2013). Even though research on the association between excess salt consumption and various health issues is limited in Indian scenario, some existing studies indicates the association between effect of high salt intake and high blood pressure. Radhika et al (2007) in their study conducted in Chennai city on 1902 subjects reported the significantly higher prevalence of hyper tension in subjects with highest quintile of salt intake. Both systolic and diastolic blood pressure significantly increased with increase in total dietary salt among hypertensive and normotensive subjects. Apart from health implications it has huge societal, developmental and economic costs. There is also noteworthy income loss to families affected by hypertension not only due to illness but also due to care giving and premature death (Mohan et al, 2013). Several studies have been shown that a reduction in salt intake is one of the most cost-effective interventions to reduce cardiovascular disease in the population. For instance, a recent study in the USA showed that even a very modest reduction in salt intake of only 10% which could be easily achieved would prevent hundreds of thousands of strokes and heart attacks over the lifetimes of adults aged 40-80 years who are alive today, and could save >$32 billion in medical expenses in the USA alone. A larger decrease in salt intake would result in a larger health improvement and greater cost savings (He et al, 2011). If everyone consumes half a teaspoon less salt per day, there would be between54, 000 and 99,000 fewer heart attacks each year and between 44,000 and 92,000 fewer deaths. As examples a three-decade-long effort by Finland to reduce sodium levels by about 30% has resulted in 75% reduction in cardiovascular disease in those under 65 years and stroke rates have fallen by more than 70% in Japan (Indus health plus).

Population based intervention studies and randomized controlled clinical trials have been shown that it is possible to achieve significant reductions in blood pressure with reduced salt intake in people with and without hypertension (He and MacGregor, 2009). Sodium reduction is probably the most feasible lifestyle intervention, in part because it can be implemented without substantive change in societal structure or consumer behavior (Penz et al, 2008). Several Western countries including the UK and Finland have implemented regulations on salt content in food, experiencing associated declines in per capita salt intake and heart attacks, strokes and deaths (Cappuccio et al, 2011). Whether and how to reduce India’s high level of dietary salt intake is currently being debated.

IV. CONCLUSION

A different picture with regard to dietary sources of sodium is apparent in some developing countries, whereas sodium in the diet comes mainly from salt added during cooking and from sauces. These countries are amid an epidemiological transition with increasing rates of chronic diseases including hypertension and CVD. There is, therefore, the opportunity for timely community based, context-specific initiatives to limit the amount of salt added to food by individuals. The rising burden of hypertension, associated CVD and NCDs in India needs to be addressed as a public health priority employing an optimal context specific resource sensitive combination of the population and the clinical approach. There are numerous challenges ahead but also promising opportunities to galvanize efforts towards attaining the

WHO-UN goal of 25 percent reduction in NCD related mortality and associated reduction in hypertension and salt intake by 2025 (Mohan et al, 2013). Population based intervention studies and randomized controlled clinical trials have been shown that it is possible to achieve significant reductions in blood pressure with reduced salt intake in people with and without hypertension (He and MacGregor, 2009). Sodium reduction is probably the most feasible lifestyle intervention, in part because it can be implemented without substantive change in societal structure or consumer behavior (Penz et al, 2008). There is an urge need to initiate the sustained and concerted efforts to reduce salt consumption because >75 percent of consumed salt in India comes from home cooked food. Salt is ubiquitous in our curries, salads, biryanis etc reaching extremely high levels in papad & pickles and large quantity of salt consumed is hidden in processed foods. A meaningful strategy to reduce salt intake must involve public education to change consumption (Misra and Khurana, 2007). Modest reduction in dietary salt could substantially reduce cardiovascular events and medical costs and should be a public health target.

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