is dismally low. This is usually consumed during the second half of pregnancy. Also, the prevalence of asthma in Indian children has been reported to be 7.2%.[8] Though the incidence of asthma in India is among the lowest in the world, an increase in the prevalence of asthma has been reported.[9,10]

The implications of this study may be difficult to ascertain. Although asthma is a serious and long-term condition, it is treatable. Moreover, the benefits of taking folic acid supplements during the periconceptional period or in early pregnancy, particularly with regard to prevention of birth defects such as spina bifida and pregnancy-associated anaemia in developing countries possibly outweigh the risk of developing asthma. More studies, preferably randomized controlled trials, would be needed to ascertain the relationship between maternal folic acid intake and childhood asthma.

## REFERENCES


1 Centers for Disease Control. Recommendations for the use of folic acid to reduce the number of cases of spina bifida and other neural tube defects. *MMWR* 1992;**41** (RR–14):1–7.
2 Ministry of Health and Family Welfare (MOHFW). *Annual report 2004–2005.* New Delhi:MOHFW; 2005.
3 University of Ottawa. Large study links folic acid supplementation with reduced risk of preeclampsia during pregnancy. *Science Daily* 24 Jan 2008. Available at *http://www.sciencedaily.com/releases/2008/01/080123113752.htm* (accessed on 1 June 2010).
4 Food Standards Australia New Zealand. *Proposal P295—Consideration of mandatory fortification with folic acid. Final assessment report—4 October 2006.* Canberra, Australia:Food Standards Australia New Zealand; 2006 (available at *http://www.foodstandards.gov.au/foodstandards/proposals/proposalp295considerationofmandatoryfortificationwithfolicacid/p295finalassessmentr3568.cfm* (accessed on 2 December 2009).
5 *Australia New Zealand Food Authority.* Evaluating the folate–neural tube defect health claim pilot. Process evaluation of the management framework. Outcome evaluation. *Canberra, Australia:Australia New Zealand Food Authority; 2000.*
6 *Food Standards Australia New Zealand.* NUTTAB 2006—Australian food composition tables. Canberra, Australia:Food Standards Australia New Zealand; 2007.
7 International Institute of Population Sciences (IIPS) and Macro International. *National Family Health Survey (NFHS III), 2005–6, Vol. I.* Mumbai:IIPS; 2007.
8 Pal R, Dahal S, Pal S. Prevalence of bronchial asthma in Indian children. *Indian J Community Med* 2009;**34:**310–16.
9 Pearce N, Aït-Khaled N, Beasley R, Mallol J, Keil U, Mitchell E, Robertson C; and the ISAAC Phase Three Study Group. Worldwide trends in the prevalence of asthma symptoms: Phase III of the International Study of Asthma and Allergies in Childhood (ISAAC). *Thorax* 2007;**62:**758–66.
10 Worldwide variations in the prevalence of asthma symptoms: The International Study of Asthma and Allergies in Childhood (ISAAC). *Eur Respir J* 1998;**12:**315–35.



RUCHI JAIN
ANITA S. ACHARYA
*Department of Community Medicine*
*Lady Hardinge Medical College*
*New Delhi*
*ruchiafmc@yahoo.com*


# Dietary salt reduction and cardiovascular disease

Bibbins-Domingo K, Chertow GM, Coxson PG, Moran A, Lightwood JM, Pletcher MJ, Goldman L. (Departments of Medicine, Epidemiology and Biostatistics, and Clinical Pharmacy, School of Pharmacy, University of California, San Francisco [UCSF]; Division of General Internal Medicine and the Center for Vulnerable Populations at San Francisco General Hospital, UCSF, San Francisco; Department of Medicine, Stanford University, Palo Alto, California; Department of Medicine, College of Physicians and Surgeons, Columbia University, New York, USA.) Projected effect of dietary salt reductions on future cardiovascular disease. *N Engl J Med* 2010;**362:**590–9.

## SUMMARY

The benefits of a low salt diet in reducing blood pressure (BP) and other risk factors for cardiovascular diseases (CVD) are well established. In this study, the authors project the population health impact of dietary salt reduction by 3 g/day (1200 mg of sodium) and its relative cost-effectiveness compared with primary and secondary prevention for CVD. Three computer simulations were done using the Coronary Heart Disease (CHD) Policy Model, a state-transition (Markov cohort) model. The study population of American adults $\geq$35 years of age was divided into three groups: blacks, non-blacks and the entire American population. Each group was further stratified according to age (<65 and >65 years), sex and presence or absence of hypertension.

The intervention used in the model was reduction in dietary salt intake by 3 g/day. The primary projections were annual reductions in (i) the incidence of CHD, (ii) new and recurrent myocardial infarctions (MIs), (iii) incidence of stroke, and (iv) all-cause mortality. The secondary projection was cost-effectiveness of the intervention compared with that of treating patients with hypertension and calculated as cost per quality-adjusted life year (QALY) gained. The beta-coefficients for CVD risk factors were derived from the national datasets, and the Framingham Heart Study and Framingham Off-Spring Study were used for estimating the primary projections. Data from a large meta-analysis and clinical trials were used for the lower and higher estimates of systolic BP, respectively. The simulations were run assuming a linear effect of salt reduction on BP and greater responses in the higher risk groups: blacks, those with hypertension and the elderly (>65 years of age). Sensitivity analysis was done using Monte Carlo simulations. The effects of the intervention were compared with specific public health and clinical strategies for reducing CVD risk by modelling 50% reduction in smoking and environmental exposure to tobacco, 5% decrease in body–mass index of obese adults and standard prescribed treatment with statins and antihypertensive drugs.

The model projected that a populationwide reduction in dietary salt by 3 g/day would reduce the incidence of CHD by 60 000–120 000; myocardial infarction by 54 000–99 000; stroke by 32 000–66 000 and all-cause mortality by 44 000–92 000. Such a decline was found in all age, sex and race groups; however, the anticipated relative benefits were higher for the middle-aged and elderly population, and for blacks. The projected relative reduction in stroke was higher for women, especially black women (9%–15% reduction) and all-cause mortality was relatively low in young and middle-aged adults. Sensitivity analysis showed that if the high risk groups were not comparatively more salt-sensitive, the overall effects would be decreased, but CVD events would still be lower in the black population, which has a higher prevalence of hypertension. These positive impacts were either equivalent to or greater than those projected for the specific public health and clinical interventions. Such a dietary intervention will be cost-effective at the population level resulting in an estimated annual gain of 194 000–392 000 QALYs and healthcare cost savings of US$ 10–24 billion. The authors projected that the gains in QALY per dollar spent will be higher than those in treating all patients with hypertension, and the Federal Government would save costs in Medicare and other healthcare programmes even if it were to bear the entire cost of a regulatory programme. Further, even a more modest reduction of 1 g of salt per day was projected to cause a large difference in the incidence of CVD events at the population level and its cumulative benefits over a decade would be equivalent to that achieved through a reduction of 3 g/day.

## COMMENT

This study has major implications for India as the prevalence of CVD is high, affecting mainly the young adult population.[1] It is estimated that 118.2 million people in India were hypertensive in the year 2000 and the prevalence is projected to increase to 213.5 million by 2025.[2] A large case–control study (INTERHEART) showed that hypertension is an important risk factor for CVD.[3] Previously, another multicentre case–control study (INTERSALT), conducted in different population groups in 32 countries across the world, showed a significant positive association of high salt consumption and hypertension, even after controlling for other known risk factors.[4,5] Further, an epidemiological study done in a southern Indian population demonstrated a significant association of dietary salt and CVD.[6] The mean dietary salt intake among Asian Indians has been estimated to be 8.5 g/day, but consumption varies in the range of 4.9–13.5 g/day across diverse population groups primarily due to different traditional methods of cooking and eating habits.[6] Therefore, there is a case for reducing dietary salt intake at the population level in India.

Though a randomized controlled trial (RCT) to measure the benefits of reduced salt intake by 3 g/day would have provided unquestionable evidence, the Markov cohort model used in this study is a well-established model to address epidemiological questions using hypothetical cohorts based on existing data within a short period of time. However, it is important to understand the two limitations of this model:

1. It is like a laboratory experiment through simplification of real world conditions and because of this the study cannot address the uncertainty of generalizing differential effects of salt reduction on age and race.
2. Markov's model lacks memory termed as the 'Markovian assumption'. While moving participants of the hypothetical cohort from one state to another during the modelling cycles, it does not take into account the history of the participants. All chronic diseases have a protracted course and multiple determinants; thereby, as acknowledged by the authors, the assumption of a linear relationship between the intervention and effects could have accentuated the results on cost-effectiveness and diluted the effects on CVD incidence.

While this modelled projection highlights the ethnic differences on impact of dietary salt reduction of 3 g/day, the INTERSALT study did not find a huge difference across its study population. The relationship between sodium excretion and blood pressure varied within a very small range; 100 mEq of sodium or 6 g of salt per day was associated with an average difference of 3–6 mmHg in systolic blood pressure across the population.[4]

Therefore, a population level approach through a common intervention can infer equivalent benefits to the diverse population of India. Further, this projection study successfully demonstrates that measures at the population level for reducing risk factors can result in greater gains in life-years and higher reduction in disabilities.

Finally, though there is robust evidence of the impact of dietary salt intake on blood pressure,[4,7,8] policy changes in India will have to transcend three major challenges. First, it will be hard to change the entrenched traditional cooking and eating habits and, therefore, policy changes should be accompanied by sustained health promotion through community participation. Second, salt is used as a vehicle for iodine supplementation, which has resulted in a substantial reduction in the prevalence of iodine deficiency disorders.[9] Therefore, there will be a need for consultation among experts in identifying methods to reduce salt intake without having an impact on iodine consumption. Lastly, salt is an emotive issue for Indians from the historical perspective of the 'Salt Satyagraha' (the salt movement led by Mahatma Gandhi) and hence will pose some political challenge. However, the overwhelming evidence provided by this and other studies necessitates the need to re-visit the existing salt policies and modify them appropriately to reduce salt intake. Consideration should be given to contextual issues in Indians and allaying the concerns of special interest groups such as paediatricians and endocrinologists.

## REFERENCES


1 Joshi P, Islam S, Pais P, Reddy S, Dorairaj P, Kazmi K, *et al.* Risk factors for early myocardial infarction in South Asians compared with individuals in other countries. *JAMA* 2007;**297:**286–94.
2 Perkovic V, Huxley R, Wu Y, Prabhakaran D, MacMahon S. The burden of blood pressure-related disease: A neglected priority for global health. *Hypertension* 2007; **50:**991–7.
3 Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, *et al.* Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): Case–control study. *Lancet* 2004;**364:**937–52.
4 Intersalt Cooperative Research Group. Intersalt: An international study of electrolyte excretion and blood pressure: Results for 24 hour urinary sodium and potassium excretion. *BMJ* 1988;**297:**319–28.
5 Stamler J, Rose G, Elliott P, Dyer A, Marmot M, Kesteloot H, *et al.* Findings of the International Cooperative INTERSALT Study. *Hypertension* 1991;**17** (1 Suppl): I9–I15.
6 Radhika G, Sathya RM, Sudha V, Ganesan A, Mohan V. Dietary salt intake and hypertension in an urban south Indian population—[CURES-53]. *J Assoc Physicians India*. 2007;**55:**405–11.
7 Yamori Y, Nara Y, Mizushima S, Mano M, Sawamura M, Kihara M, *et al.* International Cooperative Study on the Relationship Between Dietary Factors and Blood Pressure: A report from the Cardiovascular Diseases and Alimentary Comparison (CARDIAC) Study. *J Cardiovas Pharmacol* 1990;**16:**543–7.
8 Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, *et al.* A clinical trial of the effects of dietary patterns on blood pressure: DASH Collaborative Research Group. *N Engl J Med* 1997;**336:**1117–24.
9 Pandav CS, Anand K. Towards the elimination of iodine deficiency disorders in India. *Indian J Pediatr* 1995;**62:**545–55.



MANISHA NAIR
*Fogarty International Centre (FIC)–New Delhi and*
*Centre of Excellence–Centre for cArdiometabolic*
*Risk Reduction in South Asia (CoE-CARRS)*

DORAIRAJ PRABHAKARAN
*FIC-New Delhi and CoE-CARRS*
*Public Health Foundation of India*
and *Centre for Chronic Disease Control*
*C1/52 Safdarjung Development Area, New Delhi*
*dprabhakaran@ccdcindia.org*