

Reducing dietary sodium and decreases in cardiovascular disease in Canada

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BACKGROUND: Increases in dietary sodium increase blood pressure, whereas emerging evidence confirms that the reduction in dietary sodium results in reduced cardiovascular events.

OBJECTIVES: To estimate the effect that reducing dietary sodium can have on cardiovascular events in Canada.

METHODS: Based on published meta-analyses of randomized controlled trials, blood pressure reductions associated with different levels of reduction in dietary sodium were used in the model. The RR for cardiovascular events associated with the blood pressure reduction was modelled based on a meta-analysis of diuretic trials. Assumptions were made that controlled hypertensive patients would or would not have similar reduction in blood pressure as the normotensive population. Cardiovascular events in Canada for 2002 were used to estimate the decrease in cardiovascular events.

RESULTS: A reduction in daily sodium intake of 1840 mg/day was estimated to prevent 11,550 cardiovascular disease events per year. This varied from about 7300 to 10,700 events per year when hypertension control rates were varied from 13% to 66%. Reduction in cardiovascular events ranged from 8300 to 16,800 per year for a reduction in dietary sodium from 1200 mg/day to 2400 mg/day.

CONCLUSIONS: Reducing dietary sodium can substantially reduce cardiovascular disease events in Canada. This information can aid policy makers in assessing the importance of public health policy and to monitor the health impact of changes in dietary sodium in Canada.

Key Words: Blood pressure; Cardiovascular disease; Dietary sodium

Cardiovascular disease is a major burden on society, accounting for more deaths, disability and health care costs than any other disease. In 2002, cardiovascular disease accounted for 74,530 Canadian deaths (1). Hypertension is the leading risk factor for cardiovascular disease (2). Reducing blood pressure in hypertensive patients by a diverse variety of pharmacological mechanisms decreases stroke, myocardial infarction, congestive heart failure and death rates (3). Recent reports of improved blood pressure management in Canada are encouraging (a 66% treatment and control rate in Ontario was reported by Dr F Leenen at the Canadian Cardiovascular Congress in 2007 [unpublished data]). However, aging of the population, coupled with poor dietary habits, sedentary behaviour and increasing obesity rates, suggest that rates of hypertension may increase substantially unless preventive measures are taken (4).

High dietary sodium increases blood pressure in a dose-dependent fashion (5-7). The World Health Organization and many public health agencies have called for a reduction in dietary sodium intake, predicting that this would have major impact on blood pressure and cardiovascular disease (8,9). The average Canadian adult consumes approximately 3500 mg sodium/day, while the Institute of Medicine recommendations (9) are that 2300 mg/day sodium is the upper

La réduction du sel d'origine alimentaire et la diminution des maladies cardiovasculaires au Canada

HISTORIQUE : L'augmentation du sel d'origine alimentaire accroît la tension artérielle, tandis que des données émergentes confirment que la réduction du sel d'origine alimentaire diminue le nombre d'événements cardiovasculaires.

OBJECTIFS : Estimer les effets possibles de la diminution du sel d'origine alimentaire sur les événements cardiovasculaires au Canada.

MÉTHODOLOGIE : D'après des méta-analyses publiées d'essais aléatoires et contrôlés, les auteurs ont utilisé dans leur modèle des réductions de la tension artérielle associées à divers taux de diminution du sel d'origine alimentaire. Ils se sont fondés sur une méta-analyse d'essais sur les diurétiques pour déterminer le modèle de RR d'événements cardiovasculaires reliés à la réduction de la tension artérielle. Ils ont ensuite établi un modèle de RR d'événements cardiovasculaires associés à une réduction de la tension artérielle d'après une méta-analyse d'essais sur les diurétiques. Ils ont postulé que les patients à l'hypertension contrôlée présenteraient ou non une diminution de la tension artérielle similaire à celle de la population normotensive. Ils ont utilisé les événements cardiovasculaires de 2002 au Canada pour estimer la diminution des événements cardiovasculaires.

RÉSULTATS : Les auteurs ont estimé une diminution de la consommation quotidienne de sodium de 1 840 mg/jour pour prévenir 11 550 événements reliés aux maladies cardiovasculaires par année. Le nombre d'événements variait de 7 300 à 10 700 par année selon des taux de maîtrise de l'hypertension de 13 % à 66 %. La réduction des événements cardiovasculaires oscillait de 8 300 à 16 800 par année, pour une réduction du sel d'origine alimentaire de 1 200 mg/jour à 2 400 mg/jour.

CONCLUSIONS : La diminution du sel d'origine alimentaire peut réduire considérablement les événements reliés aux maladies cardiovasculaires au Canada. Cette information peut aider les décideurs à évaluer l'importance des politiques de santé publique et à surveiller les répercussions des variations du sel d'origine alimentaire sur la santé au Canada.

tolerable limit for health for adults, and that an adequate intake is 1200 mg/day to 1500 mg/day, depending on age. A recent study (10) estimated that reducing dietary sodium by 1840 mg/day in Canada would reduce the number of hypertensive Canadians by one million and save \$430 to \$540 million per year in reduced costs of managing hypertension. In the present study, we have estimated the reduction in cardiovascular events (acute myocardial infarction, heart failure and stroke) that can occur by reducing dietary sodium intake.

METHODS

Reduction in blood pressure with reduced dietary sodium

The blood pressure reductions used in the model of the present study were taken from a meta-analysis of randomized controlled trials designed to measure the effect on blood pressure of a reduction in dietary sodium. The primary analysis was based on a meta-analysis of 20 randomized clinical trials assessing the effects of salt reduction on blood pressure. Overall, a median reduction in urinary sodium of 1840 mg/day sodium (4.6 g salt/day) was associated with a mean reduction in blood pressure of 5.06/2.7 mmHg in hypertensive subjects and 2.03/0.99 mmHg in normotensive individuals (11). The present study also examined the effects of a 1200 mg/day and a 2400 mg/day

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TABLE 1
Estimated reduction in cardiovascular events in Canada based on a reduction in dietary sodium of 1840 mg/day

a) Based on all hypertensive patients having a similar response to sodium restriction

Event	Number of events in 2002	Occurrence	Total preventable events (n)	Events prevented (n)
AMI	76,878	70% in hypertensives	53,891	3185
		30% in normotensives	22,987	521
Stroke	47,373	84% in hypertensives	39,793	5790
		16% in normotensives	7580	423
Heart failure	9488	91% in hypertensives	8634	1571
		9% in normotensives	854	60
Total	133,739		133,739	11,550

b) Based on a treatment and control rate of 13% and controlled hypertensive patients having a blood pressure lowering effect similar to that of normotensive individuals

Event	Number of events in 2002	Occurrence	Total preventable events (n)	Events prevented (n)
AMI	76,878	61% in hypertensives	46,885	2771
		9% in controlled	7006	159
		30% in normotensives	22,987	521
Stroke	47,373	73% in hypertensives	34,620	5037
		11% in controlled	5173	289
		16% in normotensives	7580	423
Heart failure	9488	79% in hypertensives	7512	1366
		12% in controlled	1122	78
		9% in normotensives	854	60
Total	133,739		133,739	10,704

c) Based on a treatment and control rate of 66% and controlled hypertensive patients having a blood pressure lowering effect similar to that of normotensive individuals

Events	Number of events in 2002	Occurrence	Total preventable events (n)	Events prevented (n)
AMI	76,878	24% in hypertensives	18,320	1083
		46% in controlled	35,571	806
		30% in normotensives	22,987	521
Stroke	47,373	29% in hypertensives	13,530	1969
		55% in controlled	26,263	1465
		16% in normotensives	7580	423
Heart failure	9488	31% in hypertensives	2936	534
		60% in controlled	5698	397
		9% in normotensives	854	60
Total	133,739		133,739	7258

AMI Acute myocardial infarction

reduction in dietary sodium from a meta-analysis (7) that examined the dose-dependent relationship of different levels of reduction in dietary sodium. Reduction in sodium intake of 1200 mg/day (3 g salt) was associated with a reduction in blood pressure of 3.6/1.9 mmHg in hypertensive subjects and 1.8/0.8 mmHg in normotensive subjects. A reduction in sodium intake of 2400 mg (6 g salt) was associated with a reduction in blood pressure of 7.1/3.9 mmHg in hypertensive and 3.6/1.7 mmHg in normotensive subjects.

To estimate the effects of reducing blood pressure on cardiovascular events, RR for myocardial infarction, cerebrovascular and heart failure events associated with a specific reduction in blood pressure were used from a meta-analysis of trials of diuretic therapy (3). In the meta-analysis by Psaty et al (3), the blood pressure reduction achieved with diuretic therapy was 13.2/4.9 mmHg and was associated with RR of 0.87, 0.68 and 0.60 for myocardial infarction, stroke and heart failure, respectively, compared with placebo therapy. To establish the RR associated with lower reductions in blood pressure achieved with sodium reduction, a linear regression model was calculated that assumed that zero change in blood pressure was associated with an RR equal to 1.0 for each cardiovascular event, and that a blood pressure reduction of 13.2/4.9 mmHg was associated with RR for acute myocardial infarction, stroke and heart failure of 0.87, 0.68 and 0.60, respectively. The number of myocardial infarctions, cerebrovascular events and heart failure events in Canada in 2002 were obtained from the Canadian Mortality Database at Statistics Canada, and hospitalization data were obtained from the Canadian Institute for Health Information. Based on Framingham data, it was assumed in the present model that 70% of myocardial infarctions, 84% of strokes and 91% of heart failure events occur in hypertensive patients (12-14). The remaining events were assumed to occur in normotensive individuals.

In the primary analysis, it was assumed that the reduction of blood pressure with reduced dietary sodium in hypertensive patients with controlled blood pressure was similar to that of uncontrolled patients. In a sensitivity analysis, it was also assumed that the reduction of blood pressure in controlled hypertensive patients was similar to that of normotensive patients. Because the current rate of control of blood pressure in Canada is not known, the rate of hypertension control was varied from that reported in a survey conducted from 1985 to 1992 (13%) to that recently reported in Ontario (66%, oral report by Dr F Leenen at the Canadian Cardiovascular Congress in 2007 [unpublished data]).

Estimates of the current costs of cardiovascular disease events are not available in Canada; therefore, cost estimates of the reduced cardiovascular events were not performed.

RESULTS

RR reduction in cardiovascular events and mortality associated with changes in blood pressure

Based on a sodium consumption reduction of 1840 mg/day and a blood pressure change of 5.06/2.7 mmHg in the hypertensive individual, the RR was 0.94 for acute myocardial infarction, 0.85 for stroke and 0.82 for heart failure. In the normotensive individual, the same reduction in sodium would result in a smaller blood pressure change (2.03/0.99 mmHg), with estimated RR for acute myocardial infarction, stroke and heart failure of 0.98, 0.94 and 0.93, respectively. With a 2400 mg/day reduction in sodium intake, it was estimated that the respective RR for hypertensive and normotensive Canadians were 0.92 and 0.96 for acute myocardial infarction, 0.79 and 0.90 for stroke, and 0.72 and 0.88 for heart failure. If a 1200 mg/day sodium reduction was achieved, it was estimated that the respective RR for hypertensive and normotensive Canadians were 0.96 and 0.98 for acute myocardial infarction, 0.90 and 0.95 for stroke, and 0.87 and 0.94 for heart failure.

Cardiovascular disease event reductions

Based on achieving a dietary sodium reduction of 1840 mg/day and a corresponding reduction in blood pressure of 5.06/2.7 mmHg, a total of 11,550 cardiovascular disease events/year would be prevented (Table 1). Assuming that 13% of the hypertensive population is treated and controlled, and assuming a similar reduction in blood pressure to that of normotensive subjects, the reduction in cardiovascular events and deaths would be 10,704. Using similar assumptions, if 66% of hypertensive subjects are treated and controlled, the reduction in cardiovascular events per year would be 7258.

TABLE 2
Estimated reduction in cardiovascular events in Canada associated with a reduction in dietary sodium intake of 2400 mg/day

Event	Number of events in 2002	Events prevented*	Events prevented with 13% control (n) [†]	Events prevented with 66% control (n)
AMI	76,878	4538 in hypertensives	3948	1543
		909 in normotensives	277	1407
		NA in controlled	909	909
Stroke	47,373	8249 in hypertensives	7177	2805
		738 in normotensives	504	2558
		NA in controlled	738	738
Heart failure	9488	2237 in hypertensives	1946	761
		104 in normotensives	137	694
		NA in controlled	104	104
Total	133,739	16,775	15,740	11,519

*All hypertensive patients having a similar response to sodium restriction;
[†]Reduction in blood pressure in controlled hypertensive patients was assumed to be similar to that of normotensive patients, assuming either a 13% control rate or a 66% control rate. AMI Acute myocardial infarction; NA Not applicable

The potential effects of the reductions in dietary sodium of 2400 mg/day and 1200 mg/day (Tables 2 and 3) were also examined. The reductions of 2400 mg/day and 1200 mg/day were estimated to result in reductions of cardiovascular disease events of 16,776/year and 8313/year, respectively. Similar assumptions of a reduced blood pressure-lowering effect of reducing dietary sodium in controlled hypertensive patients were made (Tables 2 and 3). Using the assumption that 13% of the hypertensive population is treated and controlled, the number of cardiovascular events and deaths would be reduced by 15,740 with a 2400 mg/day sodium reduction and by 7790 with a 1200 mg/day sodium consumption reduction. Assuming that a higher number of hypertensive subjects are treated and controlled (66%), 11,519 and 5652 cardiovascular events per year would be prevented with 2400 mg/day and 1200 mg/day sodium reductions, respectively.

With respect to the proportion of cardiovascular events that would be prevented with the model, there would be an approximate 3% to 5% reduction in acute myocardial infarction, 8% to 13% reduction in strokes and 10% to 17% reduction in heart failure events with a reduction in dietary sodium of 1840 mg/day. Table 4 highlights the number and proportion of all events in the model with different sodium reduction targets.

DISCUSSION

Reduction of dietary sodium has been broadly advocated by national and international health organizations as a mechanism to reduce blood pressure and cardiovascular disease (8,9). Previously, we have estimated (10) that a reduction in dietary sodium of 1840 mg/day can prevent hypertension in one million Canadians and save \$430 to \$540 million per year just in reduced costs required to manage hypertension. In the present study, we have estimated that a similar reduction in sodium consumption can also prevent up to 11,550 cardiovascular events per year, or 8.6% of total cardiovascular events. If dietary sodium was reduced by 2400 mg/day, the reduction in cardiovascular events is estimated to be up to 16,775, and if the reduction in dietary sodium was 1200 mg/day, the reduction in cardiovascular events is estimated to be up to 8314/year. The reduced health care costs associated with reduced cardiovascular events could not be estimated because there are no recent data on the costs of cardiovascular diseases

TABLE 3
Estimated reduction in cardiovascular events in Canada associated with a reduction in dietary sodium intake of 1200 mg/day

Event	Number of events in 2002	Events prevented*	Events prevented with 13% control (n) [†]	Events prevented with 66% control (n)
AMI	76,878	2253 in hypertensives	1960	766
		442 in normotensives	135	684
		NA in controlled	442	442
Stroke	47,373	4099 in hypertensives	3566	1394
		359 in normotensives	245	1242
		NA in controlled	359	359
Heart failure	9488	1111 in hypertensives	967	378
		50 in normotensives	66	337
		NA in controlled	50	50
Total	133,739	8314	7790	5652

*All hypertensive patients having a similar response to sodium restriction;
[†]Reduction in blood pressure in controlled hypertensive patients was assumed to be similar to that of normotensive patients, assuming either a 13% control rate or a 66% control rate. AMI Acute myocardial infarction; NA Not applicable

TABLE 4
Estimated proportion of all cardiovascular events in Canada prevented by various reductions in dietary sodium intake

	Hypertension control rate	2400 mg/day sodium reduction	1840 mg/day sodium reduction	1200 mg/day sodium reduction
AMI	Similar response*	7	5	4
	13% control [†]	7	4	3
	66% control	5	3	2
Stroke	Similar response	19	13	9
	13% control	18	12	9
	66% control	13	8	6
Heart failure	Similar response	25	17	12
	13% control	23	16	11
	66% control	16	10	8

*All hypertensive patients having a similar response to sodium restriction;
[†]Reduction in blood pressure in controlled hypertensive patients was assumed to be similar to that of normotensive patients, assuming either a 13% control rate or a 66% control rate. AMI Acute myocardial infarction

in Canada. Nevertheless, even in 1998, the total costs of cardiovascular disease were estimated to be over \$18 billion/year (15); therefore, the cost savings associated with up to an 8.6% reduction in cardiovascular events would have been considerable, even in 1998. These data support the action to reduce dietary sodium in Canada with the degree of benefit relating largely on the extent of reduced dietary sodium.

Approximately 80% of sodium in the diets of individuals living in developed countries is from salt added to food during its processing before purchase (16). Many consumers may not be aware they are eating excessive sodium. However, Statistics Canada recently confirmed that the vast majority of Canadians, regardless of age or sex, were eating more sodium than the upper tolerable limit recommended for health (17). Statistics Canada has estimated the intake of sodium of Canadian adults from processed food at 3100 mg/day, with approximately another 10% to 20% being added by the consumer (16,17). Therefore, the average sodium intake of adults is approximately

3500 mg/day. Currently, the upper tolerable limit for sodium in adults is listed as being 2300 mg/day, and 1200 mg/day to 1500 mg/day is indicated to be adequate (depending on age) (9). The reduction in dietary sodium used in our primary analysis (1840 mg/day) would result in the average adult Canadian eating approximately 1700 mg/day. Our secondary analyses, based on reductions in dietary sodium of 1200 mg/day, would result in an average intake of approximately 2300 mg/day. Therefore, a reduction of 1200 mg/day would result in many adult Canadians remaining above the level of consumption considered to be healthy. A reduction of 2400 mg/day for the average adult would result in an average consumption of 1100 mg/day or below that recommended as adequate (1200 mg/day to 1500 mg/day, depending on age).

Canada has an emerging initiative to reduce dietary sodium. In 2007, 16 major Canadian health care organizations endorsed a Blood Pressure Canada health policy to reduce dietary sodium to less than 2300 mg/day or the upper tolerable limit (the health policy statement is available at <www.hypertension.ca>). Food & Consumer Products of Canada, a major umbrella organization for food manufacturers in Canada, agreed in 2007 to collaborate in the reduction of sodium additives to food. Campbell's (Canada) was awarded a certificate of excellence in 2007 for producing a line of soups low in sodium and for having gradually reduced sodium additives in their other products. More recently, the Government of Canada announced that Health Canada would form and lead a work group of government, food industry and health and public sector members to oversee the reduction in dietary sodium. Although there are clear challenges to reducing dietary sodium, it is expected that the Canadian initiative will result in most Canadians eating below the upper tolerable limit by 2020. The relatively long time course to reduce dietary sodium will therefore delay the health benefits we have estimated, as well as cost savings.

Limitations

There are some limitations to our analysis. A small number of scientists hypothesize that lowering dietary sodium may cause harm (ie, that it is a health benefit that a large proportion of the population has hypertension as a result of high dietary sodium) (18,19). This vocal group is often used as consultants by the food sector to raise concerns about lowering dietary sodium (see <www.saltinstitute.org>). However, major national and international health organizations that have carefully and thoroughly considered the evidence concluded that high levels of dietary sodium are unhealthy, and cause hypertension and hypertension-related complications, and likely blood pressure-independent disease (8,9,20). Specifically, the Trials Of Hypertension (TOHP) (21), which looked at people with prehypertension assigned to a sodium reduction intervention, reported a 25% to 30% lower risk of cardiovascular outcomes in a long-term post-trial follow-up. A randomized controlled trial in a veterans' home in Taiwan (22) assigned 1981 veterans to either a 50% reduction in sodium using an enriched potassium diet or a regular sodium diet. A significant reduction in cardiovascular mortality was observed in the experimental group (age-adjusted hazard ratio of 0.59). In addition, there were significant differences in the incidence of mortality from cerebrovascular diseases and heart failure between the two groups. In Finland, a comprehensive program resulted in reductions in dietary sodium of 33% over 30 years with observed decreases in population systolic and diastolic blood pressure of more than 10 mmHg, despite an increase in factors causing hypertension (increased obesity and alcohol consumption) (23). The comprehensive cardiovascular risk reduction program in Finland had a 75% to 80% decrease in both stroke and coronary artery disease mortality during this time frame (23). Recently, Asaria et al (24) estimated that reducing dietary sodium in low- and middle-income countries would prevent 8.5 million deaths/year, and 75% of these deaths would be from cardiovascular diseases. The costs of the program were modest (up to \$1.10/person/year) and the programs to reduce sodium were estimated to have a similar or greater cost-effectiveness as programs to reduce smoking.

There are other limitations to our study. We estimated the cardiovascular disease risk associated with blood pressure reduction based on findings from diuretic-based trials. In part, this was because of a lack of reliable data on which to model a reduction in cardiovascular disease due to the direct effects of reduction in dietary sodium, and because the blood pressure-lowering action of diuretics is believed to be based on sodium excretion (25). Similar degrees of blood pressure lowering by other antihypertensive drugs produce similar benefits; however, we cannot be certain that the benefit associated with sodium reduction is the same as that derived from antihypertensive drugs. Another potential limitation in our model is that we estimated the RR of cardiovascular events in normotensive individuals, even though there are insufficient data in normotensive individuals to be certain that benefits will accrue in this population. Nevertheless, the definition of hypertension is arbitrary with increases in cardiovascular risk throughout the normotensive and hypertensive range (26). In clinical trials, even individuals with lower stages of hypertension and low cardiovascular risk-derived benefits (27). More recently, benefits of antihypertensive therapy have been found in normotensive individuals who are at high cardiovascular risk (28,29). Therefore, it is reasonable to expect that lowering blood pressure by reducing sodium in normotensives would reduce cardiovascular risk.

Another potential limitation in our model is that we did not exclude people who might have already been on low sodium diets and, thus, would not have necessarily fully benefited from further sodium reduction. The impact of this on our calculations is likely to be small, given that we based our analysis on average sodium intake in Canada. Furthermore, the effects of reducing dietary sodium on blood pressure are similar at different levels of sodium intake. We have also assessed the baseline risk of Canadians with and without hypertension based on data from the Framingham study. To our knowledge, the Framingham study provides the only prospective data with sequential blood pressure measurements on the proportion of cardiovascular events that occur in those with hypertension and normotension. Nevertheless, a greater or lesser proportion of cardiovascular events can occur in hypertensive and normotensive Canadians. Our study also did not assess cardiovascular events that do not result in hospitalization or death and, therefore, underestimated the overall reduction in cardiovascular events. Finally, high dietary sodium intake is associated with increased cardiovascular risk through non-blood pressure mechanisms (30). Our model of sodium reduction and its effects on reduced cardiovascular events through blood pressure reduction did not account for any other potential benefits associated with reduced sodium and may actually underestimate the number of cardiovascular disease events or the extent of target organ damage prevented by sodium reduction at a population level.

CONCLUSIONS

Reducing cardiovascular disease in Canada is important to improve the health of Canadians. There are numerous modifiable risk factors for cardiovascular disease. Sodium reduction is one area that has the potential to be effective in reducing prevalence of hypertension and cardiovascular disease. The health and economic benefit of sodium reduction through a coordinated national effort is likely to be substantial. A government priority should be to develop policies and, if required, regulations on sodium additives to food by the food manufacturing and retail industry.

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