



Policy options to reduce population salt intake

High dietary salt has detrimental effects on blood pressure and cardiovascular outcomes. The question, say **Francesco Cappuccio and colleagues**, is how to reduce salt intake. In the run up to the United Nations summit on non-communicable diseases, they make the case for population level policy interventions

Blood pressure and cardiovascular disease

Raised blood pressure is the dominant cause of death and disability in adults worldwide,¹ responsible for approximately 50% of deaths from coronary heart disease and over 60% of those from stroke. The risk of cardiovascular disease increases with increasing blood pressure,² and causality is supported by randomised controlled clinical trials, in which lowering blood pressure over five years reduces cardiovascular disease by approximately the amount predicted from larger observational studies.³ But the majority of cardiovascular disease events attributable to blood pressure occur in people with untreated “normal” pressure (about 130/80 mm Hg), with additional events occurring even with blood pressure levels down to 115/75 mm Hg.² Even a small downward shift in the distribution of blood pressure in the whole population would achieve a large drop in cardiovascular disease.²

Evidence relating salt to blood pressure

Evidence from a very wide variety of studies shows a consistent direct relation between salt intake and blood pressure. A 4.6 g reduction in daily dietary intake of salt (equivalent to a 1840 mg reduction in daily sodium) decreases blood pressure by about 5.0/2.7 mm Hg in individuals with hypertension and by 2.0/1.0 mm Hg in normotensive people.⁴ Randomised controlled trials have consistently shown dose-response effects.⁵ The blood pressure lowering effect of reducing salt intake is effective in men and women, in all ethnic groups, in all age groups, and all starting blood pressures.

Next month the United Nations will stage its first summit looking at the world epidemic of non-communicable diseases—in particular, cardiovascular disease, cancer, diabetes, and chronic obstructive disease (*BMJ* 2011;342:d3823). This article is part of the *BMJ*'s pre-summit coverage, looking at the risk factors linking these diseases.

See also **FEATURES**, p 396



Table 1 | Population dietary salt targets set worldwide

Country/region	Organisation	Targets for daily salt intake (g per person per day)
Worldwide	WHO	5
Europe	EC High Level group	4% reduction/year over 4 years (by 2012)
Austria	DACH	6
Belgium	Government	6
Bulgaria	Government	5
Cyprus	Government	5
Czech Republic	Government	5
Denmark	Government	5
Estonia	Government	6 (men), 5 (women)
Finland	Government	7 (men), 6 (women)
France	Government	8
Germany	DACH	6
Greece	Government	5
Hungary	Government	5
Iceland	Nordic Nutrition	7 (men), 6 (women)
Ireland	Government	6 (by 2010)
Italy	INRAN	6
Latvia	Government	5
Lithuania	Government	5
Netherlands	Industry	6
Norway	Government	5
Poland	Government	6
Portugal	Government	6
Romania	Government	5
Slovenia	Government	5
Spain	Government	5
Sweden	Nordic Nutrition	7 (men), 6 (women)
Switzerland	Government	8
UK	Government	6 (by 2015), 3 (by 2025)
Americas	PAHO/WHO	5 (by 2025)
Argentina	Government	6
Barbados	Government	6
Brazil	Government	5
Canada	Government	5.75 (by 2016)
Chile	Government	5
Uruguay	Government	5
USA	Government	5.8
Australasia		
Australia	NGO	6
Fiji	Government	5
New Zealand	NGO	6
Singapore	Government	5
Asia		
China	NGO	6
Indonesia	Government	6
Japan	NGO	6

EC=European Commission, DACH=D, Germany, A, Austria, CH, Switzerland, INRAN= National Research Institute for Food and Nutrition, PAHO=Pan American Health Organization, NGO=non-governmental organisation. Source references available on bmj.com^{m13-w20}

Table 2 | Worldwide policy interventions and implementation strategies to reduce dietary salt intake in populations

Country/Region	Leadership	Documented baseline levels of salt intake (g per person per day)	Salt in food	Documented consumer behaviours	Monitoring ongoing	Food reformulation	Consumer education
Europe							
Belgium	Government	11.0*	Yes	Yes	Yes	Voluntary	Yes
Bulgaria	Government	12.0†	Yes		Yes	Voluntary	
Czech Republic	Government	11.0-12.0†					
Cyprus	Government			Yes	Yes‡	Voluntary	Yes
Denmark	Government	7.0-11.0*	Yes		Yes	Voluntary	Yes
Finland	Government	7.6-10.0*	Yes		Yes	Voluntary	Yes (NGO)
France	Government	8.4†	Yes		Yes	Voluntary	Yes
Georgia	Government			Yes‡			
Hungary	Government	16.0-18.0†	Yes	Yes‡	Yes	Voluntary	Yes‡
Ireland	Government	7.4-10.4*	Yes	Yes	Yes	Voluntary	Yes
Italy	Government	10.8†	Yes‡		Yes	Voluntary	
Latvia	Government		Yes	Yes‡	Yes	Voluntary	Yes‡
Lithuania	Government	11.0†				Voluntary	Yes‡
Netherlands	Industry	7.6-9.7*	Yes	Yes	Yes	Voluntary	Yes (NGO)
Norway	Government	10.0†	Yes‡			Voluntary	Yes‡
Poland	Government					Voluntary	Yes‡
Portugal	Government	11.9†				Mandatory‡	Yes
Slovenia	Government	9.9-13.0*	Yes	Yes‡	Yes	Voluntary	Yes‡
Spain	Government	8.4-11.5*	Yes‡			Voluntary	Yes
Sweden	Government	10.0-12.0†					
Switzerland	Government	8.1-10.6*	Yes‡	Yes		Voluntary‡	Yes‡
UK	Government	9.5*	Yes	Yes	Yes	Voluntary	Yes
Ukraine	Government		Yes	Yes			
Americas							
Argentina	Government	12.5†	Yes	Yes‡	Yes	Mandatory‡	
Barbados	Government	12.0-15.0	Yes		Yes	Voluntary	Yes
Brazil	Government	9.6†	Yes		Yes	Voluntary	
Canada	Government	7.8†	Yes	Yes	Yes	Voluntary	Yes (NGO)
Chile	Government	10.0†	Yes			Voluntary	Yes
Costa Rica	Government	7.0†	Yes‡	Yes‡	Yes‡		
Ecuador	Government	10.0†					
Guatemala	Government	19.0†					
Mexico	Government		Yes‡		Yes	Voluntary‡	
United States	Government	8.6†	Yes		Yes	Voluntary	Yes (NGO)
Australasia							
Australia	NGO	6.5-12.0*	Yes	Yes	Yes	Voluntary	Yes
Fiji	Government	5.2-5.4†	Yes‡	Yes‡	Yes	Voluntary	Yes
Malaysia	NGO	6.4†	Yes‡		Yes‡	Voluntary	Yes (NGO)
New Zealand	NGO	5.4-7.6†	Yes	Yes	Yes	Voluntary	Yes (NGO)
Philippines	Government				Yes‡		
Singapore	Government	8.8†	Yes	Yes‡		Voluntary	Yes
Thailand	Government			Yes‡	Yes‡		
Vietnam	Government			Yes‡	Yes‡		
Asia							
Bangladesh	Government			Yes‡	Yes‡		
China	NGO	12.0†					Yes
India	Government			Yes‡	Yes‡		
Iran	Government				Yes‡		
Japan	NGO	13.2†			Yes		Yes (NGO)
Kuwait	Government				Yes‡		
South Korea	Government		Yes	Yes	Yes‡		
Africa							
South Africa	Government		Yes		Yes‡		

NGO=non-governmental organisation.

*24 h urine.

†Dietary survey.

‡Planned.

Source references available on bmj.com.^{w13-w20}

Population based interventions indicate that when salt intake is reduced, blood pressure in the community falls. An intervention study in two Portuguese villages over two years achieved a difference between intervention and control villages of about 50% in salt intake and a difference of 13/6 mm Hg in blood pressure.⁶ A randomised community based intervention trial in villages in northeastern Japan, which tested the effects of dietary counselling for one year, reduced mean salt intake by 2.3 g/day (920 mg of sodium) as measured by 24 h urinary sodium, and was associated with a decrease of 3.1 mm Hg in systolic blood pressure.⁷ Citizens in most countries eat salt far in excess of healthy physiological requirements (about 1 g per day).

Evidence relating salt to cardiovascular disease

No randomised controlled trials have studied the effect of reducing the salt intake of populations on cardiovascular disease—the ethical and methodological problems with such trials are similar to those with trials involving tobacco and obesity⁸—but the link is strong and is now accepted. In cohort studies, a 5 g per day higher salt intake (2000 mg of sodium) is associated with a 17% greater risk of total cardiovascular disease, and, crucially a 23% greater risk of stroke.⁹

Since the 1970s, Finland has aimed to reduce the population's salt intake¹⁰ by collaboration with the food industry to develop food products with reduced salt and by raising awareness among consumers. Over 30 years salt intake has reduced by a third (6 g per person per day). Systolic blood pressure fell by over 10 mm Hg, while mortality from stroke and coronary heart disease decreased 75-80%, with an increase of five to six years in life expectancy.¹⁰ Similarly, in Japan, a government campaign to reduce salt intake saw a fall from 13.5 g/day to 12.1 g/day (from 5400 mg to 4840 mg sodium) in a decade. This was associated with a substantial reduction in stroke mortality,¹¹ despite increases in the population's fat intake, cigarette smoking, alcohol consumption, and body mass index.

The economic imperative

All countries need to satisfy stringent cost effectiveness criteria within a general climate of ageing populations, escalating healthcare demands, and recently reduced financial resources. Several economic modelling studies have assessed the health effects and financial cost of reducing population salt intake. Despite methodological differences, they all have consistently shown that a reduction in salt intake is associated with substantial cost savings (see webtable and web references^{w1-w12}). For example, in the United States, a mean population salt reduction of 3 g per day would result in an estimated annual gain of 194 000-392 000 quality adjusted life years (QALYs), a measure of

Table 3 | Policy options for reduction in population salt intake

Policy options	Evidence base	Synergies	Likely salt reduction (per person per day)
Professional education and health promotion	Primary care in UK	–	Negligible
Social marketing	UK, New York City	Politically popular	0.1 g*
Labelling	Finland, European Community	Will also benefit fat and sugar	0.5 g†
Product reformulation	Finland, UK	Will also benefit fat and sugar	1 g‡
Substitution	China	–	Not reported
Taxation	Finland, New York City	Consistent with fat and sugar tax	2 g†
Regulation and marketing control	Finland, Belgium and Italy (bread), New York City	Greatest benefit in deprived groups—reduce inequalities	3 g†

*Estimated, no data available.

†Data from Finland.

‡Data from Finland and Food Standards Agency of England and Wales.

added healthy life, and savings of \$10bn to \$24bn (£6-15bn, €7-17bn) in healthcare costs.¹¹ This represents a \$6-12 return on investment for each dollar spent on the regulatory programme. Cost savings are also estimated for a reduction in salt intake of 15% in low and middle income countries, with 13.8 million deaths averted over 10 years at an initial cost of less than \$0.40 per person per year.¹⁵

The prevention imperative

Unsurprisingly, the prevention of cardiovascular disease is now agreed as a top priority for action worldwide.¹² Among the five priority interventions, reduction of populations' salt intake is listed as second after global tobacco control. It is estimated that a 15% reduction in salt intake would avert 8.5 million deaths over 10 years worldwide.

The global goal set by WHO is to reduce salt intake to less than 5 g (2000 mg of sodium) per person per day by 2025,¹² with some countries aiming for even lower levels in the longer term (table 1).¹³⁻²⁰ Progress towards this target could begin through mass media campaigns and reformulation of existing and new food products by industry. Since in most developed economies the majority of dietary salt is added during commercial food production, government regulation will also be needed.^{12 13}

Many countries have committed themselves to salt reduction initiatives, often led by government, sometimes led by non-governmental organisations, but rarely led by industry (table 2).¹⁴ In 2004 the British government, through the Food Standards Agency, started a programme of population salt reduction through a media campaign to increase public awareness and demand for change, engagement with the food industry on a voluntary basis to set targets for sodium content in foods, and to obtain reformulation of many common food categories, and repeated national surveys using 24 h urine collections to monitor intake. Ministers also proposed legislation if the industry refused to make reductions voluntarily. As a result the mean salt intake in the UK fell from 9.5 g (3800 mg sodium) per day in 2001 to 8.6 g (3440 mg sodium) per day in 2008. In England and Wales, the government target is now 6 g (2400 mg sodium) per day by 2012, sadly remaining higher than the target of 4 g (1600

mg sodium) per day achieved in the US DASH trial and of 3 g (1200 mg sodium) recommended by NICE by 2025.¹⁵ A reduction of 3 g per day in salt intake would result in a blood pressure fall of at least 2.5/1.4 mm Hg.¹⁵ This would reduce strokes by about 12-14% and coronary heart disease by 9-10%,^{9 15} equivalent to approximately 6500-8000 deaths from stroke and 7500-12 000 deaths from coronary heart disease per year.¹⁵

In the United States, a reduction in salt intake of 3 g per day would reduce the annual number of new cases of cardiovascular disease by approximately 10% (around 60 000-120 000 fewer cases of coronary heart disease, 32 000-66 000 strokes, and 54 000-99 000 heart attacks) with a corresponding reduction in all cause mortality.¹¹ The expected reductions in vascular events would be comparable with those currently projected for interventions targeting tobacco, obesity, or primary prevention with statins and antihypertensives.¹⁵

Changing salt policies and perceived barriers

As with tobacco, some vested interests in the salt and food industries are fighting a rearguard action. The salt industry is reluctant to facilitate a reduction in salt intake across populations, but not because their major market is in food; less than 10% of the salt sold worldwide enters the food chain. Yet the use of salt in food is indirectly a source of revenue for food and beverage manufacturers more widely. High salt intake downregulates taste buds for saltiness, and makes food more palatable, thus increasing demand. Salt in meat products, in conjunction with other water binding chemicals, increases the amount of water that can be bound into the meat, increasing weight by up to 20% at no cost. High salt intake increases thirst and demand for sugary drinks.¹⁰ These increase calorie intake, particularly in younger people who are major consumers, thus contributing to obesity.¹⁶

The UK experience indicates that in the early stages of a salt reduction programme it is possible to take 5-15% of the salt out of a product gradually without noticeable change in flavour, sales, or complaints about taste. As salt intake falls, the salt taste receptors in the mouth adapt and become more sensitive to lower concentrations of salt within

months.¹⁷ Once salt intake is reduced, people prefer the taste of food with less salt.¹⁸

Reports of paradoxical increases in cardiovascular risk in those on a low sodium intake have recently sparked some debate.¹⁹⁻²⁴ However, these studies are seriously flawed.²⁵⁻²⁸

The International Council for the Control of Iodine Deficiency Disorders estimates that about 1.5 billion people worldwide live in areas of iodine deficiency. In 1996, in conjunction with WHO and Unicef, they started a universal salt iodisation programme, using salt as a vehicle to deliver supplementary iodine in the diet. If salt intake is reduced, these policies will remain compatible, cost effective, and of great public health benefit, if the level of iodine fortification can be adjusted to changing sodium intake.

Various policy interventions are currently being tested or implemented worldwide through national and international initiatives (table 3).¹⁴ International schemes have led to high level agreements among many governments for the implementation of national programmes to reduce population dietary salt for the prevention of cardiovascular disease. Salt substitution policies are being tested in China, where this alternative approach might be feasible. However, a regulatory approach is both necessary and acceptable,¹³ as demonstrated in Finland. This is more effective and cost effective than the voluntary approach alone.¹²

Conclusions

Health policy makers and governments have to decide how best to reduce population salt intake at a population level, to save most lives and public money in shrinking economies; likewise, in low and middle income countries with very limited budgets, how best to afford cheaper and effective planning to prevent, ameliorate, and control their rapidly increasing burden of non-communicable diseases.

Changing personal behaviour and choice alone is not an effective or realistic option when the majority of salt is added to food before it is sold and food marketing relies on taste. Furthermore, the commercial addition of salt to food is becoming a global trend as the worldwide food economy changes. A four pronged approach is therefore required and should form the base for a comprehensive policy:

- Communication—establishing and evaluating public awareness campaigns
- Reformulation—setting progressive salt targets for reformulating existing processed food and engaging with the food industry in setting standards for new foods
- Monitoring—surveying population salt intake, progress of reformulation, and effectiveness of communication
- Regulation—engagement with industry, including regulation, to create a level playing field so as not to disadvantage more

enlightened and progressive companies.

The huge responsibility of food manufacturers in contributing to the epidemic of cardiovascular disease must be acknowledged, and prevention implemented through food reformulation and effective voluntary, market intervention, or mandatory action throughout the industry.¹⁹ Civil society, governments, academia, and health organisations all have a part to play. Denial and procrastination will be costly in terms of both avoidable illness and expenses.

Francesco P Cappuccio Cephalon professor of cardiovascular medicine and epidemiology, head of WHO collaborating centre, University of Warwick, Warwick Medical School, WHO Collaborating Centre for Nutrition, Coventry CV2 2DX, UK

Simon Capewell chair of clinical epidemiology, University of Liverpool, Liverpool, UK

Paul Lincoln chief executive, National Heart Forum, London, UK

Klim McPherson visiting professor of public health epidemiology, University of Oxford, Oxford, UK

Correspondence to: F P Cappuccio fp.cappuccio@warwick.ac.uk
Accepted: 31 July 2011

We thank Robert Beaglehole and the reviewers for helpful and constructive comments.

Contributors: FPC prepared an Expert Opinion paper presented to NICE, took part in discussions, and drafted the manuscript. SC, PL, and KMCP all contributed to the discussions and made substantial contributions to the draft manuscript. FPC acts as guarantor.

Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/col_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an

interest in the submitted work in the previous three years. No other relationships or activities that could appear to have influenced the submitted work, apart from FPC who is unpaid member of CASH, WASH, unpaid technical adviser to WHO and PAHO, individual member of the National Heart Forum and member of the executive committee and trustee of the British Hypertension Society; SC who is a trustee of the Heart of Mersey, and PL, KM, and SC who are chief executive, chair, and trustee, respectively, of the UK National Heart Forum. All the authors were members of the NICE cardiovascular disease population prevention guideline development group. This paper does not necessarily reflect the views of NICE nor does it represent the decisions or the stated policy of WHO and the designations employed and the presentation of material do not imply the expression of any opinion on the part of WHO.

Provenance and peer review: Commissioned, externally peer reviewed.

- 1 Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet* 2006;367:1747-57.
- 2 Lewington S, Clarke R, Qizilbash N, Peto R, Collins R. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet* 2002;360:1903-13.
- 3 Blood Pressure Lowering Treatment Trialists' Collaboration. Effects of different blood pressure lowering regimens on major cardiovascular events: results of prospectively designed overviews of randomised trials. *Lancet* 2003;362:1527-35.
- 4 He FJ, MacGregor GA. Effect of modest salt reduction on blood pressure: a meta-analysis of randomized trials. Implications for public health. *J Hum Hypert* 2002;16:761-70.
- 5 He FJ, MacGregor GA. How far should salt intake be reduced? *Hypertension* 2003;42:1093-9.
- 6 Forte JG, Miguel JM, Miguel MJ, de Padua F, Rose G. Salt and blood pressure: a community trial. *J Hum Hypertens* 1989;3:179-84.

- 7 Takahashi Y, Sasaki S, Okubo S, Hayashi M, Tsugane S. Blood pressure change in a free-living population based dietary modification study in Japan. *J Hypertens* 2006;24:451-8.
- 8 Strazzullo P. Benefit assessment of dietary salt reduction: while the doctors study, should more people die? *J Hypertens* 2011;29:829-31.
- 9 Strazzullo P, D'Elia L, Kandala N-B, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. *BMJ* 2009;339:b4567.
- 10 Karppanen H, Mervaala E. Sodium intake and hypertension. *Prog Cardiovasc Dis* 2006;49:59-75.
- 11 Sasaki N. The salt factor in apoplexy and hypertension: epidemiological studies in Japan. In: Yamori Y, ed. Prophylactic approach to hypertensive diseases. Raven Press, 1979, pp 467-74.
- 12 Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, et al. Priority actions for the non-communicable disease crisis. *Lancet* 2011;377:1438-47.
- 13 Cappuccio FP. Salt and cardiovascular disease. *BMJ* 2007;334:859-60.
- 14 Webster JL, Dunford EK, Hawkes C, Neal BC. Salt reduction initiatives around the world. *J Hypertens* 2011;29:1043-50.
- 15 National Institute for Health and Clinical Excellence. Prevention of cardiovascular disease at population level. NICE public health guidance 25. 2010.
- 16 Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. *Am J Clin Nutr* 2006;84:274-88.
- 17 Blais CA, Pangborn RM, Borhani NO, Ferrell MF, Prineas RJ, Laing B. Effect of dietary sodium restriction on taste responses to sodium chloride: a longitudinal study. *Am J Clin Nutr* 1986;44:232-43.
- 18 Teow BH, Nicolantonio RD, Morgan TO. Sodium chloride preference and recognition threshold in normotensive subjects on high and low salt diet. *Clin Exper Hypertens* 1985;7:1681-95.
- 19 Shama LL, Teret SP, Brownell KD. The food industry and self-regulation: standards to promote success and to avoid public health failures. *Am J Public Health* 2010;100:240-6.

Cite this as: *BMJ* 2011;343:d4995

ANSWERS TO ENDGAMES, p 427 For long answers go to the Education channel on bmj.com

STATISTICAL QUESTION

Meta-analyses: sources of bias

Answers a, b, c, and d are all types of bias that might have influenced the validity of the meta-analysis.

CASE REPORT Abdominal distension in a 4 year old

- 1 The most likely diagnoses are coeliac disease, exocrine pancreatic insufficiency (including cystic fibrosis and Shwachman-Diamond syndrome), giardiasis, malignancy, inflammatory bowel disease, and dietary idiosyncrasy.
- 2 Coeliac disease.
- 3 Duodenal biopsy is the gold standard for diagnosis of coeliac disease. Before a biopsy is done, IgA tissue transglutaminase and immunoglobulins are used as screening tests for coeliac disease.
- 4 After the diagnosis is confirmed, coeliac disease is managed with complete adherence to a gluten free diet. Until this point, children should remain on a gluten containing diet. The long term outcome is good. Undiagnosed or untreated coeliac disease can lead to growth failure, including delayed puberty.

PICTURE QUIZ Intractable headache after lumbar puncture

- 1 Diffuse pachymeningeal enhancement (fig 1), crowding and caudal displacement ("sagging") of the posterior fossa structures of the brain, engorgement of the epidural venous plexuses, and a thoracic epidural collection (fig 2).
- 2 The most likely diagnosis is that of a low pressure CSF headache secondary to lumbar puncture. Other conditions to consider include recurrent or partially treated meningitis, intracranial abscess or empyema, venous sinus thrombosis, and subdural haematoma.
- 3 If the site of the potential leak is uncertain, or symptoms do not respond to an epidural blood patch, further imaging modalities include computed tomographic myelography, magnetic resonance myelography, and radioisotope cisternography.
- 4 Supportive measures include keeping the patient recumbent and well hydrated, and the use of mild analgesics and drugs such as caffeine and sumatriptan. Invasive procedures include epidural blood patch and targeted surgery to seal the dural tear.

Fig 1 (right) | Coronal post-contrast T1 weighted magnetic resonance imaging of the brain showing diffuse pachymeningeal enhancement (arrows)

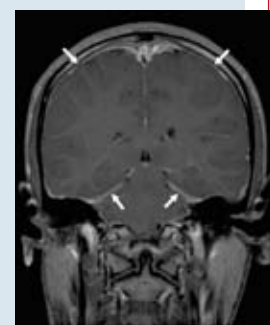


Fig 2 (below) | Midline sagittal T2 weighted (a) and T1 weighted (b) magnetic resonance imaging of the cervical spine showing crowding of structures in the foramen magnum (arrows). (c) Post-contrast parasagittal T1 weighted magnetic resonance imaging of the cervical spine showing engorgement of the venous sinuses and epidural venous plexuses (asterisk), and thoracic epidural collections (arrowheads)

