

# The effectiveness and costs of population interventions to reduce salt consumption

Background paper prepared by Bruce Neal with assistance from Wu Yangfeng and Nicole Li to the WHO Forum and Technical meeting on "Reducing Salt Intake in Populations" 5–7 October 2006 Paris, France

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# Table of contents

SUMMARY .....	3
BACKGROUND .....	4
Global burden and causes of cardiovascular disease .....	4
Prevention of blood pressure-related diseases.....	5
Effects of sodium on blood pressure.....	7
Effects of sodium on vascular disease.....	7
THE COST-EFFECTIVENESS OF REDUCING DIETARY SODIUM CONSUMPTION.....	8
Study I - 'Cost and health consequences of reducing the population salt intake' .....	8
Aim.....	8
Intervention evaluated .....	8
The model.....	9
Health parameters .....	9
Economic parameters.....	9
Results.....	10
Authors' conclusions.....	11
Additional points for consideration .....	11
Study II – 'Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular disease risk'.....	12
Aim.....	12
Background.....	12
Intervention .....	13
Regions.....	14
The model.....	14
Health parameters .....	16
Economic parameters.....	16
Results for personal and non-personal interventions for blood pressure control.....	17
Authors' conclusions relevant to personal and non-personal interventions for blood pressure control.....	21
Additional points for consideration .....	21
Study III – 'Disease Control Priorities in Developing Countries' .....	22
Study IV – 'Effect of potassium-enriched salt on cardiovascular mortality and medical expenses of elderly men' .....	22
Conclusions.....	23
USING COST-EFFECTIVENESS DATA TO SUPPORT IMPLEMENTATION .....	23
The WHO-CHOICE project .....	23
Preliminary contextualisation for Australia, China and India .....	24
OVERALL CONCLUSION .....	25
ACKNOWLEDGEMENTS .....	26
REFERENCES .....	27
ANNEXES .....	30
Key model parameters for WHO-CHOICE cost-effectiveness analyses .....	30
Australian Cost-Utility/Cost-Effectiveness data for health programmes.....	32
Australian Cost-Utility/Cost-Effectiveness data for uptake of new drug therapies by the national pharmaceutical reimbursement scheme .....	33

## **SUMMARY**

Dietary sodium consumption is a clear determinant of levels of blood pressure in individuals and in the population. Reducing dietary sodium consumption reduces blood pressure and would be anticipated to substantially decrease vascular risk. Furthermore, there are clear epidemiological data to define the likely magnitude of the blood pressure reductions and vascular risk reductions that could be achieved. Both legislative and voluntary strategies for reducing dietary sodium should be effective but the former would be anticipated to produce larger health benefits.

Two studies have provided estimates of the cost-effectiveness of strategies seeking to achieve population-wide reductions in dietary sodium consumption; one reports data for Norway and another makes estimates for fourteen regions of the world defined by geographic proximity and state of epidemiological development. In both studies and for all world regions, strategies for population-wide sodium reduction are identified as either cost saving or very cost effective. In the second study, sodium reduction, either voluntary or legislated, was more cost effective than traditional hypertension control programmes for all but one geographic region. In both studies the estimates of cost-effectiveness were subjected to extensive sensitivity analyses and the findings were shown to be robust.

Despite the demonstration that population-wide strategies for sodium reduction are highly cost effective, cost-effectiveness data appear to have had little impact on the implementation of salt reduction programmes. In part, this may be because national data on the cost-effectiveness of this intervention have been available for only one country. The World Health Organization – Choosing Interventions that are Cost-Effective (WHO-CHOICE) programme, within which the regional estimates of cost-effectiveness were developed, does however offer a specific opportunity for the development of cost-effectiveness estimates in a national context. With such national estimates it should be possible to use the results of cost-effectiveness analyses to impact more directly on decision-makers and national health policies.

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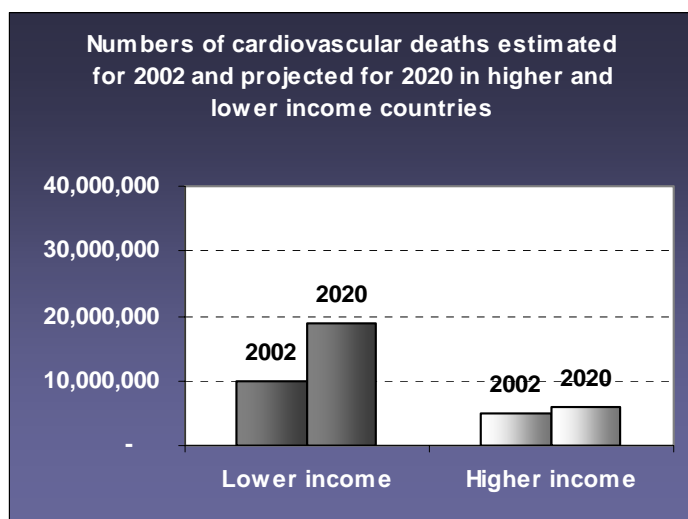
## BACKGROUND

### ***Global burden and causes of cardiovascular disease***

Cardiovascular diseases are a large and growing cause of death and disability in developed and developing countries (Figure 1) (1–4). These conditions currently account for about 20% of all disability adjusted life years (DALYs) in developed countries and 8% of DALYs in developing countries. Furthermore, while the proportion of DALYs due to cardiovascular diseases is projected to remain approximately constant in developed countries it is anticipated to increase sharply in developing countries (5).

The World Health Report 2002 (5) identified a number of key risk factors and quantified the contribution of each to the global burden of cardiovascular disease. These risk factors are tobacco use, alcohol consumption, high cholesterol concentrations, high blood pressure levels, low intake of fruit and vegetables, insufficient physical activity and elevated body mass index. While the impact of these risks overlaps because of the multicausality of cardiovascular disease and joint effects of risk factors (6), the risk making the largest contribution was blood pressure. Worldwide in 2000, about 7.1 million (13%) deaths were calculated to be attributable to blood pressure levels above an optimum systolic pressure of 115 mmHg (5).

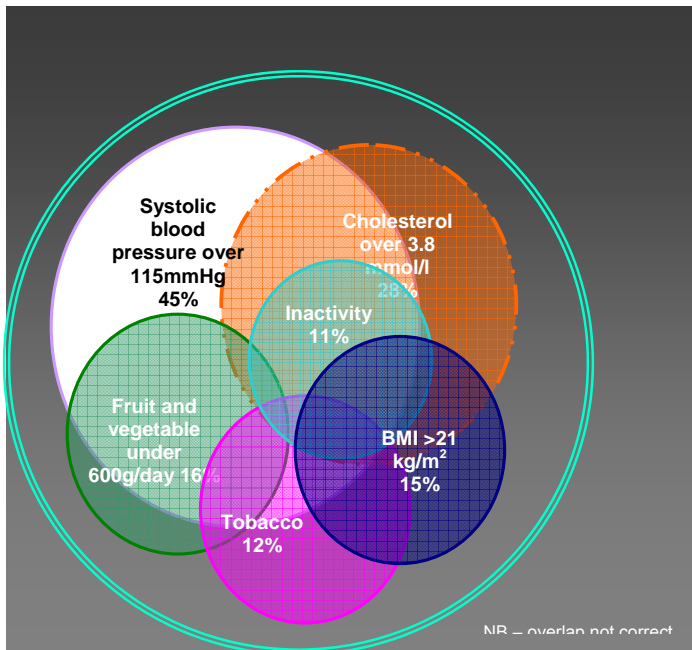
**Figure 1: Numbers of cardiovascular deaths** (adapted from (5))



There are several key underlying considerations that have led to the predominance of blood pressure amongst the risks identified for cardiovascular disease. First, the estimates made for the 2002 World Health Report (5) acknowledged the continuous positive nature of the association of blood pressure with the risks of vascular disease across a broad range of hypertensive and non-hypertensive levels of blood pressure (7, 8). Accordingly, these estimates recognize the role of blood pressure in cardiovascular disease causation at all levels of blood pressure and the full effects of blood pressure on cardiovascular risk. Second, the estimates of the effects of blood pressure on cardiovascular disease were based on epidemiological studies that

incorporated adjustments for the problem of measurement error (the regression dilution bias) (9). Without such adjustment the impact of blood pressure on disease risk is systematically underestimated by about one half. Third, the predominant form of vascular disease in many developing countries is stroke which is significantly more strongly associated with blood pressure than coronary heart disease (8). Many more deaths from cardiovascular disease occur in developing countries than developed countries and because a greater proportion are due to stroke, the relative

**Figure 2: Contribution of blood pressure to the burden of cardiovascular disease** (adapted from (5))



contribution of blood pressure to the global cardiovascular disease burden is increased. The net result is that about one third of DALYs attributable to raised blood pressure occur in developed countries, one third in developing countries with high mortality and one third in developing countries with low mortality (5). As such, strategies for blood pressure control are a public health priority around the globe and not just in developed countries.

### ***Prevention of disease related to blood pressure***

There are currently three main approaches to the prevention of diseases related to elevated blood pressure. First, *hypertension control programmes* that target individuals with blood pressure levels above a specific cut-off; second, *population-wide blood pressure lowering strategies* seeking to reduce community determinants of high blood pressure; and third, *risk-based approaches* seeking to identify and treat those individuals at highest risk of an event caused by a non-optimal blood pressure level (10).

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*Hypertension control programmes* have been the mainstay of blood pressure management for decades (11–13) but are now widely considered to be a relatively inefficient use of resources (14). Blood pressure levels alone are a poor discriminator of the risk of a vascular event and hypertension control programmes result in the treatment of large numbers of individuals at low risk. While some drug-based blood pressure lowering therapies are now very low cost, physician time is expensive and clinical hypertension management remains relatively costly. In addition, individuals at high risk of events related to blood pressure but with ‘normal’ blood pressure levels are denied therapy by such programmes, despite having far more to gain from treatment than individuals with uncomplicated hypertension (15, 16).

*Population-wide blood pressure lowering strategies* seek to achieve relatively small reductions in blood pressure, but by achieving these amongst everyone in the population, achieve large health gains (10). The population-wide approach involves risk factor modification in everyone but gains most of its benefits from the blood pressure reductions achieved in people at moderate and high risk. Huge numbers of individuals at low risk must also be covered by population-wide programmes to achieve these results and in the short and medium term the treatment of such individuals is inefficient. If a longer-term view is taken it can be argued that population-wide approaches to blood pressure control that include lower risk younger individuals will reap large benefits. In the case of sodium reduction, the progressive rise of blood pressure with age attributable to sodium might be attenuated with significant numbers of disease events averted many decades later (17). The cost of the intervention is key to population-wide approaches to disease control because such large numbers of individuals must be included in the programme.

*Risk-based approaches* to cardiovascular disease prevention have gained considerable credence over the last two decades (18). Risk-based approaches embrace the multicausality of cardiovascular diseases and the joint effects of risk factors (6). Individuals are selected for blood pressure lowering on the basis of their risk of a cardiovascular event estimated by an assessment of all their cardiovascular risk factors. While blood pressure levels contribute to this assessment the decision to recommend blood pressure lowering interventions is heavily influenced by the levels of other vascular risk factors. The precise combination and contribution of other risk factors varies between risk calculators but may include age, sex, diabetes, lipid levels, left ventricular hypertrophy and smoking. Risk-based approaches are a very efficient means of preventing events in the short term but are profoundly influenced by age which is the strongest predictor of the risk of cardiovascular death in most models. This results in the majority of treatments being allocated to the elderly and the approach has been criticized for failing to adequately take into account the long-term effects of moderate elevations of risk factors and the health gains that might be accrued from their lowering.

Reduction in dietary sodium consumption could clearly contribute to all three of these approaches to the control of diseases related to elevated blood pressure, but in practice it is to population-wide approaches that it has the most to offer. Significant or sustained reductions in blood pressure are rarely achieved with sodium reduction in the clinical setting (19) and while hypertension guidelines recommend a low salt diet for the

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management of elevated blood pressure levels (13, 20) the utility of these recommendations is widely recognized to be limited.

### ***Effects of sodium on blood pressure***

The effects of sodium on blood pressure are unequivocal with overwhelming data available from a broad range of animal and human studies (21–25). Particularly convincing evidence is provided by large-scale epidemiological studies and randomized trials of sodium reduction. While these studies have required careful and repeated analysis (19) they provide robust epidemiological inputs for cost–effectiveness models.

*Observational studies* – The single most comprehensive and widely-cited observational evaluation of the association of blood pressure with sodium consumption is INTERSALT (17). First reported in 1988, this study identified significant positive associations of 24-hour urinary sodium excretion with systolic and diastolic blood pressure in two sets of investigations: in cross-population analyses for 52 population samples, and at the individual level for the 10 079 participants aged 20–59 years. Overviews of observational studies comparing sodium consumption and blood pressure between populations, and between individuals within the same population, have confirmed these findings. The effects of sodium on blood pressure were observed to be greater amongst older individuals and amongst individuals with higher baseline blood pressure levels (21, 22).

*Intervention studies* – There have been many high quality randomized trials of the effects of reducing dietary sodium consumption on blood pressure and a series of overviews of the outcomes of these studies (23–25). The results of these trials are highly consistent with the findings of the observational studies – reducing dietary sodium decreases blood pressure with greater effects in the elderly and amongst individuals with higher starting blood pressure levels. It is of note that blood pressure lowering effects related to sodium reduction were observed amongst individuals with normal blood pressure as well as amongst people with high blood pressure providing a strong rationale for population-wide implementation of salt reduction programmes.

### ***Effects of sodium on vascular disease***

Direct evidence of the beneficial effects of sodium reduction on major vascular events is absent. Randomized trials of sufficient size to show such effects have not been completed and systematic overviews of the multiple small trials that have been done are inadequately powered to detect the most plausible effects of sodium reduction on vascular events (26). The primary reason for this is that most of the trials have been small, short term and recorded few vascular events. The larger community trials that have been completed have achieved reductions in sodium consumption in the intervention groups too modest to produce detectable effects on blood pressure and major vascular outcomes (27).

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The evidence linking higher sodium consumption to higher blood pressure and lower sodium consumption to lower blood pressure is, however, conclusive (21–23). Similarly conclusive is the link between higher levels of blood pressure and greater risks of vascular events (7, 8) and the lowering of that risk with agents that reduce blood pressure (28). In the context of the profound effects of blood pressure on risk and the clear effects of sodium on blood pressure, the link between sodium and vascular risk is accepted by most. While there are some observational studies reporting neutral or even inverse associations between sodium consumption and vascular disease (29), the confounding to which these studies are prone is too great for their findings to seriously impact upon conclusions about the adverse effects of sodium on vascular disease.

## **THE COST–EFFECTIVENESS OF REDUCING DIETARY SODIUM CONSUMPTION**

A search for studies reporting the cost–effectiveness of interventions to reduce population salt consumption was undertaken and two substantive reports were identified. The first (Study I), published in 2000, estimates the cost and health consequences of reducing population salt intake in the population of Norway (30). The second (Study II), published in 2003, describes the cost–effectiveness of reducing population salt intake in comparison to and in conjunction with a range of interventions for the lowering of blood pressure and/or cholesterol levels (6). The chief components and findings of each study are summarized below. Two further reports were also identified but each was of only limited relevance. One (Study III) is a brief report from the Disease Control Priorities in Developing Countries Project (31), and the other (Study IV) (32) is a trial of the effects of salt substitution that includes a report on the impact of the intervention on health-care expenditure during the trial.

### ***Study I - Cost and health consequences of reducing the population salt intake (30)***

#### **Aim**

To estimate the health and economic consequences of interventions to reduce the intake of salt in line with the recommendations of the Norwegian National Council on Nutrition and Physical Activity (30, 33).

#### **Intervention evaluated**

The proposed intervention was that recommended by the Norwegian National Council on Nutrition and Physical Activity. This comprised the following components:

- population-wide and targeted information campaigns
- decreases in salt content of processed foods
- declaration of salt content of processed foods through labelling
- taxation of processed foods with high salt content

- 
- subsidization of foods with low salt content.

The assumption was that this package of interventions would halve daily salt consumption from a mean of 11 g/day to a mean of 5.5 g/day. This corresponds to a decrease in sodium consumption of 100 mmol/day. The authors noted that in INTERSALT this was associated with a difference in systolic blood pressure of 3–6 mmHg (17). However, for the base case a conservative 2 mmHg lowering of systolic blood pressure was assumed to be achieved with this reduction in daily sodium consumption. Sensitivity analyses were also done assuming 1 mmHg and 4 mmHg lowering of systolic blood pressure.

### **The model**

A Markov model was used with life years saved as the measure of health benefit. There were two principal health states in the model (dead or alive). The model exposed the Norwegian population aged  $\geq 40$  years to age- and sex-specific yearly risks of fatal and non-fatal myocardial infarction, fatal and non-fatal stroke and death from all other causes (34). New generations entered the model as they reached 40 years of age and the baseline population was that of Norway on 1 January 1995. The effects of the intervention were modeled over 25 years with the assumption that they appeared gradually over the first 5 years. Potential life years saved after 25 years of interventions were estimated by applying pre-intervention mortality rates.

### **Health parameters**

Reductions in myocardial infarction and stroke were modeled on the basis of the assumed systolic blood pressure reduction (2 mmHg) and the known association of systolic blood pressure with stroke and heart attack (35). Rates of all other causes of mortality were kept constant at 1995 levels. The ratios of non-fatal to fatal heart attack were set at 2:1 and non-fatal to fatal stroke at 3:1 (36). The strengths of the associations between systolic blood pressure and these vascular outcomes were based on the associations of 2 mmHg systolic blood pressure with stroke mortality (4.2% per 2 mmHg systolic blood pressure) and coronary heart disease mortality (3.8% per 2 mmHg systolic blood pressure) from a cohort study done in Bergen, Norway (37). These estimates include adjustment for the regression dilution bias with adjustment upwards of the strengths of the associations by 1.4 in women and 1.5 in men. It was also assumed that 100% of the effect of higher systolic blood pressure levels on risk could be reversed by blood pressure lowering achieved with dietary sodium reduction.

### **Economic parameters**

All the costs (Table 1) were recorded in 1997 Norwegian Kroner (Kr) but are presented in US\$ (in 1997 US\$ 1 = Kr 7). The programme costs were based on expert opinion and the welfare costs associated with taxation/subsidy were estimated on the basis of weight of salty food purchased each year, the cost per kilo of such food and on the price elasticity of such food depending upon supply and demand. The estimates of cost savings from reduced drug use were based on local data relating systolic blood pressure levels to the odds of being treated (38). Costs of care were derived from local diagnosis-related group (DRG) data (39, 40).

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**Table 1****Key economic parameters used in the model in Study 1**

Parameter	Base case assumptions
Cost of information campaigns and development of new products with less salt (new recipes)	US\$ 2.9 million/year
Welfare losses from taxation/subsidization	US\$ 14 million/year
Cost savings from reduced antihypertensive treatment	US\$ 6 million per 2 mmHg reduction in systolic blood pressure
Cost of in-hospital care for myocardial infarction	US\$ 7143
Cost of care for non-fatal stroke (one year cost)	US\$ 14 286
Cost of care for fatal stroke	US\$ 7857
Cost of in-hospital care for other conditions during extended life	Age/sex specific DRG utilization rates
Mean annual income including employer tax	US\$ 31 429
Proportion non-retired	Age/sex specific rates
Elasticity factor	0.8
Discount rate	5%

Since avoiding strokes meant avoiding nursing-home care as well as hospital inpatient costs, one year of nursing care for each non-fatal stroke was included as a cost saving for each non-fatal stroke averted. Productivity gains were based on known age- and sex-specific retirement rates and average annual incomes adjusted down by 20% (41). The discount rate for both future costs and health gains was set at 5%. For each of these parameters substantive sensitivity analyses were done to test the robustness of the findings (42).

**Results**

*Lives saved* - The reductions in death from stroke and heart attack reduced overall mortality by 1–2% and increased mean life expectancy by 1.8 months for 40 year-old men and 1.4 months for 40 year-old women. During the 25-year treatment period there would be about 7000 fewer fatal heart attacks and 4500 fewer fatal strokes with about 87 000 life years saved. Proportionately more non-fatal events would also be prevented. Six thousand more people would be alive at the end of the 25-year period than without the intervention and those that avoided an event would be expected to live about another 10 years after the programme completed. In total therefore some 147 000 life years would be saved (or 52 000 when discounted at 5%).

*Blood pressure lowering treatment averted* – The number of people requiring blood pressure lowering treatment would be reduced by 4.9%.

*Economic consequences* – An estimated net saving of US\$ 270 million was accrued over the 25 years of the intervention programme (or US\$ 120 million when discounted at 5%). The savings until all treated persons died would be US\$ 240 million (or US\$ 120 million when discounted at 5%).

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*Sensitivity analyses* – There were net cost savings unless the systolic blood pressure fall was only 1 mmHg, unless welfare losses were high (i.e. taxation/subsidy cost a lot) or if productivity gains were disregarded. The cost was greatest if there was only a small blood pressure reduction and welfare costs were high. The intervention was, however, cost saving in the base case and the majority of sensitivity analyses. In the worst case the cost per life year saved was US\$ 70 534.

### **Summary of the study authors' conclusions**

Population decrease in sodium consumption will increase life expectancy and save money. While this conclusion was sensitive to some of the assumptions made, the base case is probably conservative and the non-cost-saving scenarios were considered unlikely to occur in the Norwegian setting.

The main reasons cited for the base case assumptions being conservative were:

- The assumed blood pressure reduction, 2 mmHg systolic pressure, was likely to be an underestimate of what could be achieved.
- The strengths of the associations used between systolic blood pressure and disease were at the lower end of those considered most likely.
- The analyses did not include possible further beneficial effects achieved through slowing of age-related increases in blood pressure.
- Beneficial effects on other outcomes such as gastric cancer (43), osteoporosis (44) asthma (45, 46), cataracts (47), new diabetes (48) and kidney stones (44) were not incorporated. It was also noted that there are no known adverse effects of reducing sodium consumption.

In contrast, possible overestimation of the cost–effectiveness of the intervention may have resulted from inadequate accounting of the additional health-care costs associated with longer life since only hospital costs were included. Future costs incurred would, however, have been minimized by the discounting process utilized.

While there are no earlier published reports of the cost–effectiveness of population sodium reduction, cost–effectiveness analyses of comparable interventions for cholesterol lowering have been reported. Studies done in Norway and the United States of America have suggested that population cholesterol lowering would be cost saving or would cost very little for each life year saved (49, 50). This comparability of findings was considered to provide some reassurance that the conclusions of the present study were likely to be reliable.

### **Additional points for consideration**

In review of this paper there are some additional points to consider. First, associations of blood pressure and disease in epidemiological studies are age-dependent, decreasing in strength with increasing age. This consideration was not specifically incorporated into this analysis and may have important implications; the ages at which events were projected to occur in the cost–effectiveness model may not have been directly comparable with those in the studies on which the estimates of associations between blood pressure and

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disease were based. Second, details of the welfare gains/losses through taxation/subsidy of foods with high/low salt consumption were not provided. In addition, taxation and subsidy of foods based on salt content would probably be politically contentious and may not be achievable. Depending upon how the dollars gained and the dollars lost through this process were structured for these analyses this could have a moderate impact upon the cost-effectiveness of the proposed intervention programme. Furthermore, if taxation and subsidy cannot be achieved it may be that the effectiveness of the programme in terms of blood pressure reductions and risk reductions would be limited. Finally, possible economic gains/losses incurred by the salt, food manufacturing, and food retail industries do not appear to have been incorporated into the model.

## ***Study II – Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular disease risk (6)***

### **Aim**

To analyse the population health effects and costs of non-personal health measures, treatment of individual risk factors and treatment based on various levels of absolute risk (6).

### **Background**

This paper is an output from the World Health Organization - Choosing Interventions that are Cost-Effective (WHO-CHOICE) project (51). This project commenced in 1998 with the objective of providing policy-makers with the evidence they needed to decide on the interventions and programmes which would maximize health for available resources. The paper is not specifically about the cost-effectiveness of strategies for population sodium reduction but includes substantial information about this intervention when implemented alone or in conjunction with other interventions.

**Table 2****Interventions evaluated**

<b>Non-personal interventions</b>		
<b>N1</b>	<b>Salt reduction through voluntary agreements with industry*</b>	95% coverage, 15% reduction in dietary salt intake
<b>N2</b>	<b>Population-wide reduction in salt intake achieved through legislation</b>	95% coverage, 30% reduction in dietary salt intake
<b>N3</b>	Health education focusing on body mass index and cholesterol	80% coverage, 2% reduction in total cholesterol
<b>N4</b>	<b>(N2 and N3 combined) Salt legislation and health education</b>	As above
<b>Personal interventions</b>		
<b>P1</b>	Hypertension treatment programme targeting 160 mmHg or above and treating with combination of diuretic and beta-blocker	All aware treated, 33% reduction between actual systolic blood pressure and target of 115 mmHg
<b>P2</b>	Hypertension treatment programme targeting 140 mmHg or above and treating with combination of diuretic and beta-blocker	
<b>P3</b>	Hypercholesterolaemia programme targeting 6.2 mmol/l or above and treating with statin	All aware treated, 20% reduction in total cholesterol
<b>P4</b>	Hypercholesterolaemia programme targeting 5.7 mmol/l or above and treating with statin	
<b>P5</b>	(P2 and P3) Hypertension programme of 140 mmHg or above and hypercholesterolaemia programme of 6.2 mmol/L or above and treating with statin, diuretic and beta-blocker	As above
<b>P6</b>	Absolute risk treating all with 10-year risk of over 35% and treating with aspirin, statin, diuretic and beta-blocker	All aware treated, 33% reduction between actual systolic blood pressure and target of 115 mmHg,
<b>P7</b>	Absolute risk treating all with 10-year risk of over 25% and treating with aspirin, statin, diuretic and beta-blocker	20% reduction in total cholesterol
<b>P8</b>	Absolute risk treating all with 10-year risk of over 15% and treating with aspirin, statin, diuretic and beta-blocker	and further 20% reduction in relative risk with anti-platelet therapy
<b>P9</b>	Absolute risk treating all with 10-year risk of over 5% and treating with aspirin, statin, diuretic and beta-blocker	
<b>Combined personal and non-personal interventions</b>		
<b>C1</b>	<b>Absolute risk treating all with 10-year risk of over 35% and treating with aspirin, statin, diuretic and beta-blocker plus salt legislation and health education</b>	As above
<b>C2</b>	<b>Absolute risk treating all with 10-year risk of over 25% and treating with aspirin, statin, diuretic and beta-blocker plus salt legislation and health education</b>	As above
<b>C3</b>	<b>Absolute risk treating all with 10-year risk of over 15% and treating with aspirin, statin, diuretic and beta-blocker plus salt legislation and health education</b>	As above
<b>C4</b>	<b>Absolute risk treating all with 10-year risk of over 5% and treating with aspirin, statin, diuretic and beta-blocker plus salt legislation and health education</b>	As above

\*Highlighted interventions pertain specifically to sodium reduction and blood pressure

**Intervention**

In this report 17 proposed interventions were evaluated, targeting salt, blood pressure, cholesterol and/or risk through non-personal and/or personal health service interventions and their combinations (Table 2). In brief, the key features of these interventions were the following:

- 
- Non-personal interventions (N1–N4) – comprising health change achieved through population-wide modification of blood pressure, cholesterol and body mass.
  - Legislated and voluntary (N1 and N2) – the estimates of effect achieved with non-personal interventions were based on either legislated or voluntary processes to reduce sodium consumption through appropriate labelling and stepwise decreases in the salt content of processed foods. For sodium reduction, the legislated interventions were assumed to produce twice the reduction in blood pressure of the voluntary agreements. Only voluntary arrangements for non-personal interventions targeting cholesterol and body mass were evaluated.
  - Personal health services interventions (P1–P9) – included detection and treatment with drugs of people with high concentrations of cholesterol for two thresholds, people with high systolic blood pressure levels for two thresholds, and people with absolute risks of an event in the next 10 years for four different thresholds.
  - Combinations of personal and non-personal interventions (C1–C4) – included four plausible combinations of the personal and non-personal interventions outlined above.

### **Regions**

Separate estimates of cost-effectiveness were made for each of the interventions for each of fourteen regions defined by geographic proximity and basic epidemiology (Table 3). This approach represented a compromise between the ideal of providing country-specific data for use by governments and the practicalities of preparing separate estimates for more than 150 WHO Member States. Results from just three regions were presented in detail in the paper with additional information for the other regions provided in supplementary tables available on *The Lancet* web site:

- <http://image.thelancet.com/extras/02art9368webtable1.pdf>
- <http://image.thelancet.com/extras/02art9368webtable2.pdf>
- <http://image.thelancet.com/extras/02art9368webtable3.pdf>
- <http://image.thelancet.com/extras/02art9368webtable4.pdf>
- <http://image.thelancet.com/extras/02art9368webtable5.pdf>
- <http://image.thelancet.com/extras/02art9368webtable6.pdf>

### **The model**

The model used in this study was a multistate modeling tool, PopMod (52). This is described as a 'standard multistate tool' with effects of interventions modeled by stochastically simulating populations specific for age, sex, and subregion using observed baseline levels and distributions of key cardiovascular risk factors (systolic blood pressure, cholesterol, body mass index and smoking) for each region (for key model parameters see Annex 1). PopMod involves four health states – people with the disorder under study, people with another disorder, people with both conditions and people with neither. Non-personal interventions are assumed to cover 95% of the entire population and personal interventions to cover the entire population eligible for that intervention that are aware that treatment is required. Overall population incidence of disease is calculated after applying the effectiveness of the intervention to the relevant section of the population for

10 years. Population health effects are quantified in terms of DALYs by tracking what happens to each age and sex group of the population over 100 years with and without each intervention. Comprehensive sensitivity analyses were done to evaluate uncertainties in the key assumptions.

**Table 3**

**Regions for which cost–effectiveness estimates were prepared**

<b>WHO Region</b>	<b>Examples of countries included</b>
<b>WHO African Region</b>	
<b>Afr D</b> (high adult and high child mortality)	Northern Africa
<b>Afr E</b> (very high adult and high child mortality)	Sub-Saharan Africa
<b>WHO Region of the Americas</b>	
<b>Amr A</b> (very low adult and very low child mortality)	USA, Canada, Cuba
<b>Amr B</b> (low adult and low child mortality)	Most of South America
<b>Amr D</b> (high adult and high child mortality),	Bolivia, Ecuador, Nicaragua, Peru
<b>WHO Eastern Mediterranean Region</b>	
<b>Emr B</b> (low adult and low child mortality)	Iran, Tunisia, United Arab Emirates
<b>Emr D</b> (high adult and high child mortality)	Afghanistan, Egypt, Iraq, Pakistan
<b>WHO European Region</b>	
<b>Eur A</b> (very low adult and very low child mortality)	Western Europe
<b>Eur B</b> (low adult and low child mortality)	Eastern Europe
<b>Eur C</b> (high adult and low child mortality)	Russian Federation, Ukraine
<b>WHO South-East Asia Region</b>	
<b>Sear B</b> (low adult and low child mortality)	Indonesia, Sri Lanka, Thailand
<b>Sear D</b> (high adult and high child mortality)	Bangladesh, India
<b>WHO Western Pacific Region</b>	
<b>Wpr A</b> (very low adult and very low child mortality)	Australia, Japan, New Zealand, Singapore
<b>Wpr B</b> (low adult and low child mortality)	China, Pacific Islands, Viet Nam

Average cost–effectiveness ratios were calculated for each intervention using total costs in international dollars and total health effects in terms of DALYs. All costs and health effects were discounted at 3% per annum in line with recent recommendations (53). The model calculated the cost–effectiveness of the interventions compared to a baseline scenario with no interventions. The rationale for this approach is that it allows a truly objective view of the value of the interventions rather than assuming that existing interventions should necessarily be maintained.

In defining whether an intervention is cost effective the authors used a recommendation from the Commission on Macroeconomics and Health that interventions with a cost–effectiveness ratio of less than three times gross domestic product (GDP) per head are cost effective (53). Interventions were placed into one of three broad categories on the basis of the cost–effectiveness analyses.

- Very cost effective – cost–effectiveness ratio of less than GDP per head for each DALY gained.
- Cost effective – cost–effectiveness ratio of between one and three times GDP per head for each DALY gained.
- Not cost effective – cost–effectiveness ratio of more than three times GDP per head for each DALY gained.

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This level of categorization was considered to be appropriate to help policy-makers make their decisions about which interventions should be considered as priorities. Expansion paths were also presented to illustrate how to define progressive combinations of interventions which would provide the greatest incremental health benefits for minimum incremental costs.

## **Health parameters**

The effects of sodium reduction on blood pressure were based on overviews of observational studies (21, 22) and randomized trials (23) with separate estimates of the effects of 15% and 30% reductions in dietary sodium used for different age groups (30–44, 45–59, 60–69, 70–79 and > 80 years) and male and female sex in each WHO region. In general, percentage reductions in blood pressure achieved with sodium reduction increased with age and were larger in men. The differences between the groups of countries within each region were relatively small.

The effects of a given blood pressure lowering on the relative risks of stroke and ischaemic heart disease were estimated from overviews of large scale observational studies and randomized trials (7, 8). These effects were considered to be constant across country groupings and sexes but to attenuate with increasing age.

## **Economic parameters**

The costs considered in this analysis included programme-level costs (administration, media, training, etc) and patient-level costs (primary care, diagnosis, medicines, etc). Cost savings related to the prevention of cardiovascular disease (neither costs of care nor productivity losses) were not incorporated on the basis that the primary interest in this study was in ranking interventions to improve population health within a given budget. Costs of intervention programmes were based on the WHO ingredients approach (52) in which a comprehensive data collection process had previously been undertaken by Member States with unit prices for a broad range of inputs defined. The ingredients approach basically defined the numbers of each of these units required for delivery of the intervention and multiplied them to get the cost. The quantities of each input (both patient level and programme level) were defined through a combination of searches of the literature and input from local experts. The ingredients approach was designed to make the results of the analysis as transparent as possible to policy-makers and to allow direct comparison of cost components across regions.

Estimates of cost-effectiveness were based on the assumption that the interventions were implemented inefficiently – in general this meant that 80% capacity utilization was assumed (i.e. a staff member working on the intervention spent 80% of their time occupied on it).

Costs were reported in International Dollars to facilitate comparison across regions. An International Dollar has the same purchasing power as US\$ 1 spent in the USA and is calculated by converting local currency costs using a purchasing power parity exchange rate. The purchasing power parity exchange rate is the

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number of units of local currency required to purchase the same amount of goods/services as US\$ 1 would purchase in the USA. To convert International Dollars to local currency units, the International Dollar figure is multiplied by the purchasing power parity exchange rate. Likewise, to convert local currency units to international dollars the local currency is divided by the purchasing power parity exchange rate.

### **Results for personal and non-personal interventions for blood pressure control**

Legislated reductions in population sodium consumption were estimated to be more cost effective than hypertension programmes targeting individuals with systolic blood pressure levels above 140 mmHg in every WHO region (Table 4). They were also more cost effective than hypertension programmes targeting individuals with systolic blood pressure levels above 160 mmHg in every WHO subregional grouping of countries except Afr E (sub-Saharan Africa).

Likewise, voluntary reductions in population sodium consumption were estimated to be more cost effective than hypertension programmes targeting individuals with systolic blood pressure levels above 140 mmHg in every WHO subregional grouping. They were also more cost effective than hypertension programmes targeting individuals with systolic blood pressure levels above 160 mmHg in every WHO subregional grouping except Afr E (sub-Saharan Africa) and Sear D (principally Bangladesh and India). For Sear D, cost-effectiveness was the same as that estimated for a hypertension programme targeting individuals with blood pressure levels above 160 mmHg.

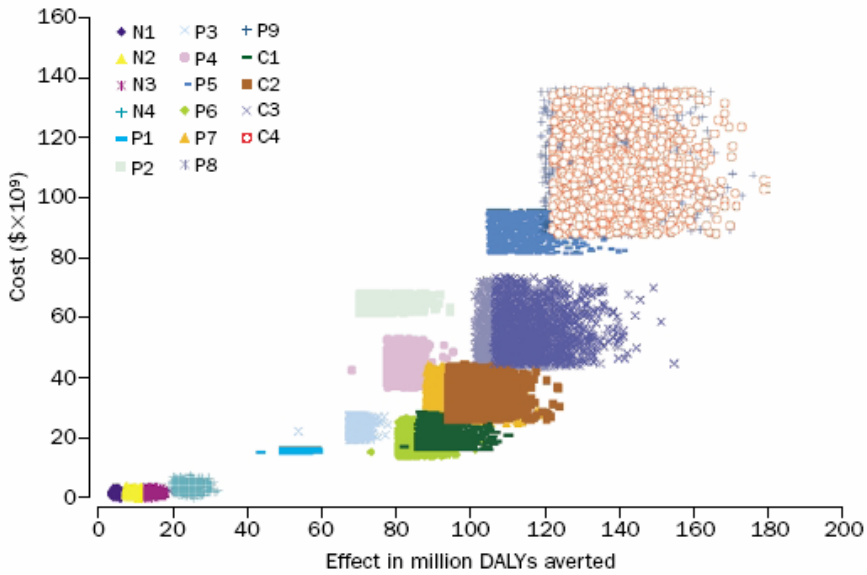
Population salt reduction was deemed to be at least cost effective for every region for both legislated and voluntary programmes. Average cost-effectiveness ratios of voluntary reductions were in general about half of those for legislated reductions but were cost effective or very cost effective in every region. Since costs of the voluntary and legislated intervention programmes were directly comparable in every region the difference in average cost-effectiveness ratios between voluntary and legislated programmes was driven by there being only about half as many DALYs averted by the voluntary compared to the legislated interventions. For all regions the maximum impact of the blood pressure interventions (personal and non-personal) was achieved amongst people of about 60 years of age, with about half the gains above and below this age.

The expansion paths which describe how interventions would be picked up with increasing availability of resources included non-personal interventions targeting sodium consumption either alone or in conjunction with non-personal interventions targeting cholesterol levels for almost every region.

The results of the sensitivity analyses were plotted graphically as 'clouds' of uncertainty (see Figure 3). The uncertainty around the estimates for the effects of strategies targeting sodium reduction was fairly small, primarily because the costs and effects of these strategies lay fairly close to the origin. In almost every case, these clouds of uncertainty did not overlap with the estimates for personal interventions targeting blood pressure and this strongly supports the conclusions about the relatively greater cost-effectiveness of non-personal compared to personal interventions for blood pressure control.

**Figure 3: Example showing sensitivity analyses for sub-region Sear D (mainly Bangladesh and India)**

(6) Reprinted with permission from Elsevier (*The Lancet*, 2003, 361:717–725)



The one exception to this situation is the estimate for Afr E where the point estimate of the cost-effectiveness ratio for the personal intervention is less than for the non-personal intervention. In general, however, while the sensitivity analyses do introduce some uncertainty about which of the non-personal interventions would be introduced first, in almost

every case they indicate that one or other of the non-personal interventions for blood pressure control would be introduced prior to either of the personal interventions targeting blood pressure levels above a specific threshold.

**Table 4**

**Annual costs, effects, and average cost–effectiveness of programmes to reduce sodium intake and hypertension in different WHO Regions (adapted from 6)**

Programme	Country groupings <sup>1</sup> within the WHO Regions of Africa, the Americas and the Eastern Mediterranean																				
	Afr D			Afr E			Amr A			Amr B			Amr D			Emr B			Emr D		
	C <sup>2</sup>	D <sup>3</sup>	C/D <sup>4</sup>	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D
<b>Voluntary Na reduction</b>	85	1	<b>570</b>	118	1	<b>920</b>	92	4	<b>230</b>	82	3	<b>240</b>	16	0.3	<b>500</b>	66	1	<b>540</b>	76	3	<b>250</b>
<b>Legislated Na reduction</b>	85	3	<b>300</b>	118	2	<b>470</b>	92	8	<b>120</b>	82	6	<b>130</b>	16	1	<b>260</b>	66	2	<b>270</b>	76	6	<b>120</b>
<b>Hypertension reduction (SBP &gt; 160 mmHg)</b>	1 464	18	<b>820</b>	499	16	<b>310</b>	6 136	50	<b>1 220</b>	3 122	38	<b>810</b>	417	4	<b>1 140</b>	1 151	16	<b>710</b>	1 249	38	<b>330</b>
<b>Hypertension reduction (SBP &gt; 140 mmHg)</b>	3 375	20	<b>1 680</b>	1 971	19	<b>1 010</b>	19 669	60	<b>3 290</b>	8 066	47	<b>1 860</b>	1 435	4	<b>3 190</b>	3 700	20	<b>1 890</b>	3 790	42	<b>910</b>

<sup>1</sup> see Table 3

<sup>2</sup> C, costs are expressed in International Dollars x 10<sup>6</sup>

<sup>3</sup> D, DALYs are multiplied by 10<sup>5</sup>

<sup>4</sup> C/D, costs per DALY are expressed in International Dollars

Na, sodium; SBP, systolic blood pressure

**Table 4 continued**

Programme	Country groupings <sup>1</sup> within the WHO Regions of Europe, South-East Asia and the Western Pacific																				
	Eur A			Eur B			Eur C			Sear B			Sear D			Wpr A			Wpr B		
	C <sup>2</sup>	D <sup>3</sup>	C/D <sup>4</sup>	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D
<b>Voluntary Na reduction</b>	297	7	<b>440</b>	95	8	<b>120</b>	26	14	<b>20</b>	21	2	<b>140</b>	199	5	<b>370</b>	183	3	<b>540</b>	219	12	<b>190</b>
<b>Legislated Na reduction</b>	297	13	<b>230</b>	95	15	<b>60</b>	26	28	<b>10</b>	21	3	<b>70</b>	199	10	<b>190</b>	183	6	<b>290</b>	219	23	<b>100</b>
<b>Hypertension reduction (SBP &gt; 160 mmHg)</b>	14 777	73	<b>2 030</b>	3 438	74	<b>460</b>	3 910	141	<b>280</b>	1 130	15	<b>770</b>	1 570	44	<b>360</b>	4 789	34	<b>1 400</b>	6 044	127	<b>480</b>
<b>Hypertension reduction (SBP &gt; 140 mmHg)</b>	37 385	82	<b>4 540</b>	6 624	78	<b>850</b>	7 233	149	<b>490</b>	3 652	20	<b>1 830</b>	6 399	71	<b>900</b>	12 991	38	<b>3 420</b>	17 884	154	<b>1 160</b>

<sup>1</sup> see Table 3

<sup>2</sup> C, costs are expressed in International Dollars x 10<sup>6</sup>

<sup>3</sup> D, DALYs are multiplied by 10<sup>5</sup>

<sup>4</sup> C/D, costs per DALY are expressed in International Dollars

Na, sodium; SBP, systolic blood pressure

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### **Summary of study authors' conclusions relevant to personal and non-personal interventions for blood pressure control**

In every case both personal and non-personal interventions to lower blood pressure were very cost effective. This is at odds with the perception that cardiovascular prevention strategies should be the preserve of wealthy countries. The greater cost-effectiveness of non-personal interventions targeting blood pressure control indicated a need for greater investigation and implementation of these strategies. The authors noted that the effectiveness assumptions on which the estimates were based reflected an average of the very substantial successes achieved in North Karelia in Finland (54) and the much lesser impact of programmes carried out in the USA (27). If non-personal programmes with efficacy comparable to that achieved in North Karelia could be achieved in all cases then both the cost-effectiveness and the proportion of the vascular disease burden that could be averted by non-personal interventions could be greatly enhanced. The authors also commented that uncertainties about the impact of sodium reduction on blood pressure and vascular risk were unlikely to reflect a real absence of effect of sodium on these outcomes but rather the limited success that most studies had in reducing sodium consumption.

The authors observed that there was substantial potential for non-personal interventions to bring about reductions in the health inequalities that exist between the rich and poor and that this may be particularly important in developing countries when inequity is greatest and growing most rapidly (53). Treatment targeted at systolic blood pressure levels above 160 mmHg was also very cost effective in every region and a combination of both personal and non-personal interventions for the prevention of blood pressure-related disease would be appropriate for most regions. It was also of note, however, that approaches based on absolute risk might be even more cost effective than personal interventions targeting blood pressure and that these warranted further investigation.

### **Additional points for consideration**

While this report identified non-personal interventions targeting dietary sodium consumption as particularly cost effective, the absolute burden of disease averted by personal interventions was estimated to be much larger. On average 5–15-fold more DALYs were averted using personal interventions based on drug therapy than through non-personal interventions based on sodium reductions. The large proportion of the burden averted by personal interventions was attributed to a clearer comprehension of the epidemiology surrounding the effects of blood pressure on disease and a better understanding of the impact of interventions.

It appears, however, that the effectiveness of personal interventions may have been overestimated. In particular, assuming one third reductions of systolic blood pressure towards the target of 115 mmHg may be a substantial overestimate of what is actually achievable (55). For example, in the case of the personal programme targeting individuals with a systolic blood pressure of > 160 mmHg this would mean an average blood pressure reduction of some 20 mmHg amongst individuals enrolled in the programme. It is unclear whether this could actually be achieved. In addition, a number of the assumptions relating to the proportions of individuals identified and treated by such programmes also appear to be somewhat optimistic (13). By contrast, the assumptions underlying the effects of the non-personal interventions targeting sodium consumption may be conservative. Although evidence to support assumptions of 15% and 30% reductions in

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salt consumption with voluntary and legislated interventions is largely absent, differences in salt consumption of this magnitude between populations have been observed (17). It is quite possible, therefore, that this paper overestimates the disease burden that might be averted by personal interventions targeting blood pressure and the cost-effectiveness of such interventions, while doing the reverse for non-personal interventions.

A further consideration with regard to the value of this report relates to the units of measurement selected. The use of International Dollars and DALYs is underpinned by a strong scientific rationale but may be unfamiliar to policy-makers. Likewise, the reporting of the results by region rather than by country decreases the immediate use of the data by policy-makers. So, while the WHO-CHOICE project provides significant insight into the comparative cost-effectiveness of different interventions in different settings, the presentation of the outputs will require substantial simplification for them to be useful in moving forward the implementation of national strategies for population-wide salt reduction.

### ***Study III – Disease Control Priorities in Developing Countries (31)***

A brief report in the book *Disease Control Priorities in Developing Countries (31)* provides estimates of the cost-effectiveness of reducing population sodium consumption by means of legislation plus public education. However, the level of detail provided about the methods utilized is minimal. The cost-effectiveness estimates for the regions (between US\$ 1325 and US\$ 3056 per DALY) indicate that the intervention would be cost effective or highly cost effective in most regions according to the criteria laid down by the Commission on Macroeconomics and Health (53). However, while this report serves to confirm the conclusions of those reports preceding it, the absence of detail means that it adds little additional insight into the issues surrounding the estimation of cost-effectiveness for population-wide interventions targeting salt reduction.

### ***Study IV – Effect of potassium-enriched salt on cardiovascular mortality and medical expenses of elderly men (32)***

This cluster-randomized trial of the effects of potassium-enriched salt in five retirement homes in China (Province of Taiwan) reported a beneficial effect of the intervention on major cardiovascular events. Included in the report were some data about the medical expenses of the study participants during follow-up (32). This did not constitute a formal cost-effectiveness analysis of the intervention strategy but rather a simple quantification of the inpatient and outpatient medical costs of the trial participants. There was a US\$ 426 per annum lower expenditure on inpatient care for the active treated participants compared to the control treated participants. The same multivariable adjusted models did not, however, identify a significant impact of the salt substitute on either outpatient costs or overall medical costs. The study provides no direct evidence with regard to the cost-effectiveness of programmes seeking to achieve population-wide reduction of salt consumption but does provide some further indirect support to the suggestion that initiatives targeting dietary salt consumption are likely to be cost effective.

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## **Conclusions**

While very different in their design, the Norwegian study and the report from WHO-CHOICE reach a very similar conclusion – non-personal interventions for reducing dietary salt consumption would avert a significant disease burden and would be highly cost effective. This conclusion appears to stand up to comprehensive sensitivity analyses and to apply throughout diverse regions of the world. While far less informative than these first two reports, the data from the Disease Control Priorities in Developing Countries project and the trial in China (Province of Taiwan) provide some additional support for this conclusion and certainly no argument against it. On the basis of the available evidence, it therefore seems likely that the implementation of strategies for population-wide reduction of sodium consumption would be extremely worthwhile from the cost–effectiveness perspective in almost every setting.

## **USING COST–EFFECTIVENESS DATA TO SUPPORT IMPLEMENTATION**

It is unclear that any of the current data on the cost–effectiveness of dietary sodium reduction have significantly impacted upon global efforts to reduce population sodium consumption. This is likely to be due to a number of factors. First, national estimates have been produced for Norway alone and while regional estimates provide a clear indication of the likely cost–effectiveness of the strategy, they are perceived to be difficult for policy-makers to apply in individual countries. Second, the understanding of cost–effectiveness data outside specialized settings remains limited. This problem is compounded by the way in which findings are presented with units such as DALYs and International Dollars being largely incomprehensible to those in the position to make policy decisions. Finally, as with other outputs from medical research, the results of cost–effectiveness analyses require a systematic and concerted programme for implementation if they are to have an impact on policy. If these issues can be surmounted then there would appear to be great potential for the data from analyses such as those done by the investigators in Norway and WHO-CHOICE to impact upon public policy relating to dietary sodium reduction. If implemented, population-wide strategies for sodium reduction would clearly be highly cost effective and compare very favourably with many other interventions already in place.

### ***The WHO-CHOICE project***

The WHO-CHOICE project appears to have great potential to enhance the impact of cost–effectiveness estimates on public policy relating to dietary sodium consumption (51). While the mission of WHO-CHOICE is broad and includes the evaluation of multiple interventions and defines broad goals pertaining to the development of standardized methods for cost–effectiveness analysis, dietary sodium reduction is a target intervention and the development of country contextualization tools is part of the mission. The country-specific data that could emanate from the contextualization process would be likely to have a much greater impact on national policies than the regional estimates currently available. This would be particularly so if the cost–effectiveness estimates could be presented in local currency estimates and in a range of measures, including dollars per DALY but perhaps also dollars per life saved and dollars per year of life saved.

In terms of contextualization WHO-CHOICE advocates the use of a process whereby available regional estimates are tailored to the particular demographic, epidemiological and economic situations of a specific country. The preferred approach is a systematic process involving the review and revision of all model parameters such that output is maximally applicable to the country in question. However, it is acknowledged that national data for every parameter will not necessarily be available and estimates will be required in some situations.

### ***Preliminary contextualization for Australia, China and India***

In collaboration with WHO-CHOICE, we piloted the preparation of country-specific cost-effectiveness estimates for population-wide sodium reduction using Australia, China and India as examples. Working from a list of data inputs provided by the WHO-CHOICE group we reviewed the regional data used to develop the previous estimates for the WHO South-East Asia and Western Pacific Regions. In each case, national estimates were thought to be required because characteristics of other countries included in the regional estimates might make them imprecise indicators of the cost-effectiveness for the individual country of interest. This is likely be less of an issue for Wpr B and Sear D (see Table 3), where the estimates are already heavily weighted by data for China and India respectively. In Wpr A estimates for the subregion would be significantly influenced by Japan which has cost structures and cardiovascular disease patterns substantially different from those in Australia.

The preliminary results show that both legislated and voluntary programmes for population-wide sodium reduction would be highly cost-effective strategies for cardiovascular disease prevention in all three countries. The estimated cost per DALY is about 5% of GDP per head in Australia and just a fraction of a percent of GDP per head in both China and India. These estimates would make population-wide strategies for salt reduction among the most cost effective of all interventions for improving population health. Comparator estimates for the cost-effectiveness of other interventions in Australia are provided in Annex 2. It can be seen that the cost-effectiveness of population-wide strategies for sodium reduction are about five-fold more favourable than that estimated for patient-targeted clinical approaches to the non-pharmacological management of blood pressure, and between 5–200-fold more favourable than recent drug therapies included in the Australian drug subsidization scheme (56) (see Annex 2). It can also be seen that the estimated cost per head of the population is very low for each country.

**Table 5**

**Estimated cost-effectiveness of voluntary and legislated population-wide salt reduction compared to GDP per head for Australia, India and China (preliminary data)**

<b>Country (currency)</b>	<b>1 x GDP per head</b>	<b>Population-wide salt reduction</b>	
		<b>Voluntary (cost/DALY)</b>	<b>Legislated (cost/DALY)</b>
Australia (A\$)	36 000	1 815	1 064
China (RMB)	6 800	36	19
India (IR)	20 000	164	85

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**Table 6**

**Estimated annual cost per head of population for the implementation of voluntary and legislated population-wide salt reduction for Australia, India and China (preliminary data)**

<b>Country (currency)</b>	<b>Population-wide salt reduction</b>	
	<b>Voluntary (cost/person)</b>	<b>Legislated (cost/person)</b>
Australia (A\$)	0.77	0.89
China (RMB)	2.02	2.05
India (IR)	0.15	0.15

The results presented in Tables 5 and 6 represent a preliminary national contextualization of cost-effectiveness estimates for three countries. It is important to note that the contextualization process used to obtain these estimates is an ongoing process and that the estimates require some further refining and updating. The potential for presenting estimates of cost-effectiveness in other units more easily comprehensible to policy-makers is also under discussion. However, it is clear that even if the contextualization process required moderately large changes to some of the inputs to the model, it is very unlikely that the primary conclusions about the cost-effectiveness of population-wide strategies for sodium reduction would be greatly changed. The WHO-CHOICE programme offers an excellent opportunity for the development of nationally contextualized estimates of the cost-effectiveness of population-wide sodium reduction and could produce data useful to national policy-makers worldwide.

## **OVERALL CONCLUSION**

The cost-effectiveness findings for population-wide reductions in dietary sodium consumption argue very strongly for the more widespread introduction of national programmes to reduce dietary salt consumption. The very favourable findings of the cost-effectiveness analyses are consistent and robust to variation in key model parameters providing substantial reassurance of their validity. Cost-effectiveness analysis should be a powerful tool in the argument for cardiovascular disease control strategies based upon reductions in dietary sodium consumption. The currently limited impact of the cost-effectiveness data can be addressed by the development of national estimates, the presentation of the results in more easily comprehensible formats, and the incorporation of cost-effectiveness data into coherent national programmes seeking to change policy related to dietary salt. The WHO-CHOICE programme has great potential to support the preparation of nationally contextualized cost-effectiveness data for groups seeking to advocate for the implementation of this highly effective cardiovascular disease control strategy.

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## ANNEX 1

### ***Key model parameters for WHO-CHOICE cost–effectiveness analyses***

Note that most parameters are required for multiple age and sex groups

Demography:

- births each year
- population structure
- mortality rates.

Incidence, prevalence, remission, case fatality and mortality for acute myocardial infarction (AMI):

- incidence of AMI
- ratio of first-ever AMI to all AMI
- 24-hour case fatality for AMI
- 28-day case fatality for AMI
- out-of-hospital case fatality for AMI
- incidence of long-term AMI survivors
- prevalence of long-term AMI survivors
- case fatality for long-term AMI survivors
- mortality for AMI
- incidence for angina pectoris
- prevalence for angina pectoris
- percentage of long-term AMI survivors that develop congestive heart failure
- incidence of congestive heart failure
- prevalence of congestive heart failure
- case fatality for congestive heart failure.

Incidence, prevalence, remission, case fatality and mortality for stroke:

- incidence for first-ever stroke
- prevalence for first-ever stroke
- 28-day case fatality for stroke
- percentage of 28-day fatal cases that are out-of-hospital for stroke
- percentage of fatal stroke that are ischaemic stroke
- percentage of non-fatal stroke that are ischaemic stroke
- incidence of long-term stroke survivors
- prevalence of long-term stroke survivors
- case fatality for long-term stroke survivors
- percentage of long-term stroke survivors dying from stroke
- mortality for stroke.

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Risk factor levels:

- mean systolic blood pressure (mmHg)
- standard deviation (SD) of mean systolic blood pressure
- mean cholesterol level (mmol/l)
- SD of mean cholesterol levels
- mean body mass index (BMI) ( $\text{kg}/\text{m}^2$ )
- SD of mean BMI
- smoking prevalence
- salt intake (g NaCl per day).

Disability weights:

- for AMI
- for angina pectoris
- for congestive heart failure
- for acute stroke
- for long-term stroke survivors.

Percentage coverage of interventions:

- for AMI during the acute phase (28 days)
- for AMI during the post-acute phase (after 28 days)
- for stroke during the acute phase (28 days)
- for stroke during the post-acute phase (after 28 days)
- for congestive heart failure.

Epidemiology:

- effects of mmHg increase in systolic blood pressure on risk of stroke and AMI
- effects of mmol/l increase in total cholesterol on risk of stroke and AMI
- effects of  $\text{kg}/\text{m}^2$  increase in BMI on risk of stroke and AMI
- effects of smoking on risk of stroke and AMI.

Costs:

- personnel costs
- media and information, education and communication operating costs
- transportation operating costs
- utilities
- building capital costs
- transportation capital costs
- other costs.

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## ANNEX 2

### *Australian cost–utility/cost–effectiveness data for health programmes (56)*

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<b>Health programmes</b>	<b>Adjusted cost (Aus\$) per life year at 1995–1996 prices</b>
<b><i>Health promotion programmes</i></b>	
Sydney quit smoking campaign	19
Non-drug blood pressure reduction clinic	5 969
<b><i>Care/cure programmes</i></b>	
Neonatal intensive care, babies 1000–1500g	1 433–3 582
Kidney transplant	5 455
Neonatal intensive care, babies < 801g	4 298–5 492
Breast cancer screening	7 879–13 132
Cervical cancer screening	36 749
Hospital dialysis	*57 053
AIDS treatment with zidovudine	155 201

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\* cost per QALY

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***Australian cost–utility/cost–effectiveness data for uptake of new drug therapies by the national pharmaceutical reimbursement scheme (56)***

<b>Case</b>	<b>Incremental cost (A\$) per additional life year gained at 1995–1996 prices</b>	<b>Pharmaceutical benefits advisory committee decision</b>
1	5 050	Recommend at price
2	7 665	Recommend at price
3	8 000	Recommend at price
4	15 915	Recommend at price
5	17 174	Recommend at price
6	17 376	Recommend at price
7	18 130	Recommend at lower price
8	20 371	Recommend at price
9	24 531	Recommend at price
10	35 000	Recommend at price
11	36 450	Recommend at price
12	39 083	Reject
13	39 864	Reject
14	39 864	Defer
15	39 864	Recommend at price
16	51 420	Reject
17	53 000	Recommend at price
18	58 311	Reject
19	65 523	Recommend at price
20	68 913	Recommend at price
21	78 157	Recommend at lower price
22	81 343	Reject
23	90 000	Reject
24	209 674	Recommend at lower price
25	212 041	Reject
26	235 200	Reject

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