Chronic Diseases 3

Chronic disease prevention: health effects and financial costs of strategies to reduce salt intake and control tobacco use

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This is the third in a Series of five papers about chronic diseases

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In 2005, WHO set a global goal to reduce rates of death from chronic (non-communicable) disease by an additional 2% every year. To this end, we investigated how many deaths could potentially be averted over 10 years by implementation of selected population-based interventions, and calculated the financial costs of their implementation. We selected two interventions: to reduce salt intake in the population by 15% and to implement four key elements of the WHO Framework Convention on Tobacco Control (FCTC). We used methods from the WHO Comparative Risk Assessment project to estimate shifts in the distribution of risk factors associated with salt intake and tobacco use, and to model the effects on chronic disease mortality for 23 countries that account for 80% of chronic disease burden in the developing world. We showed that, over 10 years (2006–2015), 13·8 million deaths could be averted by implementation of these interventions, at a cost of less than US$0·40 per person per year in low-income and lower middle-income countries, and US$0·50–1·00 per person per year in upper middle-income countries (as of 2005). These two population-based intervention strategies could therefore substantially reduce mortality from chronic diseases, and make a major (and affordable) contribution towards achievement of the global goal to prevent and control chronic diseases.

Introduction

80% of global deaths from chronic diseases—mainly cardiovascular disease, cancer, chronic respiratory disease, and diabetes—are in low-income and middle-income countries. Demographic changes in these countries are expected to increase the proportion of deaths attributable to these causes from just over half in 2002 to 61% by 2015.[1]

The WHO Comparative Risk Assessment project estimated the number of deaths from chronic diseases which could potentially be averted if the distributions of major risk factors were reduced.[2] In this and the following paper of the Series, we aimed to assess selected intervention strategies—for which scaled-up coverage can be justified on the basis of sufficient information and evidence[3]—to see what contribution they could make towards achievement of the goal to reduce rates of mortality from chronic diseases worldwide by an additional 2% per year for the next 10 years.[4] We used the WHO's framework for classification of individual and population-based interventions as core, expanded, or optimum (in terms of their effectiveness, cost, acceptability, and feasibility).[5] In this paper, we address two population-based strategies: salt reduction and tobacco control. The next paper in this Series assesses interventions for treatment of individuals at high risk of cardiovascular disease.[6] Taken together, these population-level and individual-level strategies could be the first elements of a package of chronic disease prevention and control, to which other interventions could be added.

This analysis complements other efforts, including those related to the Millennium Development Goals, to estimate the cumulative financial and health consequences of scaling up coverage for intervention strategies.[7,8] The purpose, methods, and perspective of such analyses are distinct from the economic assessment of the cost-effectiveness of interventions (which aims to identify increased efficiency or best buys across the health sector, and which covers a broader set of potential costs and effects).[5,9] Other research has assessed the cost-effectiveness of salt-reduction and tobacco-control strategies in the context of low-income and middle-income countries, and shown that both are highly efficient uses of societal resources.[10–13]

Key messages

- 23 countries have 80% of the burden of chronic disease in low-income and middle-income regions of the world
- In these countries, 13·8 million deaths could be averted over 10 years from 2006 to 2015 (8·5 million by a salt-reduction strategy and 5·5 million by implementation of four elements of the WHO Framework Convention on Tobacco Control)
- Most deaths averted would be from cardiovascular diseases (75·6%), followed by deaths from respiratory diseases (15·4%) and cancer (8·7%)
- The cost of implementing these two interventions would be less than US$0·40 per person per year in low-income and lower middle-income countries, and US$0·50–1·00 per person per year in upper middle-income countries (as of 2005)
- Although large absolute numbers of deaths could be averted with these selected interventions, they nevertheless account for only a small fraction of the total burden of chronic disease deaths

Modifiable risk factors and interventions

Reduction in salt consumption

Two meta-analyses of randomised controlled trials that examined the long-term effects of salt reduction in people with and without hypertension have shown that moderate reductions in salt intake (of 2–4·6 g per day) can reduce absolute systolic blood pressure by a small but important amount.[14,15] One of these meta-analyses showed that the size of the decrease in blood pressure was correlated with that of the reduction in salt intake.[14] Furthermore, similar reductions in salt intake can cause even greater decreases in blood pressure in people with higher baseline blood pressures.[14,15] These studies add to observational evidence that blood pressure increases rapidly with age in populations which have a high average intake of salt,[16,17] whereas communities in which salt consumption is very low do not have an age-related increase in blood pressure.[16,18] Four prospective studies that directly examined the effects of sodium intake on cardiovascular mortality showed positive associations between dietary sodium intake and increased risk of stroke[19,20] and coronary heart disease.[21,22] WHO recommends a salt intake of no more than 5 g per day.[23]

In low-income and middle-income countries, salt is used predominantly to preserve meat and fish, and in seasoning or sauces used during cooking and at the table.[24] Simple changes in diet—such as avoiding salty food and not adding salt at the table—can reduce sodium intake by about 3–4·5 g per day, which is equivalent to about 30% of the average daily intake.[25,26] Such reductions have been achieved in intensive, short-term community-based interventions in China, Jamaica, and Nigeria.[27,28] However, a controlled trial of a community-health-promotion programme in Ghana—where salt intake is comparatively low—did not cause a change in salt intake (despite a reduction in mean systolic blood pressure).[29] Modification of the salt content of foods such as soy sauce and miso are also feasible,[30] as is salt substitution.[31]

We modelled the effect of a 15% reduction in salt consumption on blood pressure in 23 low-income and middle-income countries that account for 80% of the burden of chronic diseases in developing countries (table 1 and webtable 1). This reduction would be achieved by a voluntary reduction in the salt content of processed foods and condiments by manufacturers, plus a sustained mass-media campaign aimed to encourage dietary change within households and communities.[12,13,29,30] We modelled only the blood-pressure-dependent effects of sodium intake on cardiovascular mortality, and did not quantify reductions in other mortality outcomes that are mediated by blood pressure (eg, renal failure) or by other mechanisms (eg, gastric cancer[32]).

See Online for webtable 1

Reduction in tobacco use

The WHO Framework Convention on Tobacco Control (FCTC) has proposed a set of policies to reduce demand for tobacco.[10,33] We selected some of the FCTC's population-based control measures: increased taxes on tobacco products to reduce smoking prevalence; enforcement of smoke-free workplaces; requirements for FCTC-compliant packaging and labelling of tobacco products combined with public awareness campaigns about the health risks of smoking; and a comprehensive ban on tobacco advertising, promotion, and sponsorship.

Table 1 shows the estimated change in the real price of tobacco and in smoking prevalence that would result from implementation of these four FCTC policies. Webtables 2 and 3 show a detailed breakdown by country, with relevant demographic and administrative characteristics.[1,34–36]

See Online for webtables 2 and 3

We did not do the same analyses for the FCTC's two other population-based policies for reduction of demand for tobacco—regulation of the contents of tobacco products and regulation of tobacco product disclosures (Articles 9 and 10 of the FCTC)—because of information constraints on effect size and resource-need estimates. However, we did include an additional cost estimate for a national household survey every 3 years to ascertain population-wide changes in smoking prevalence, since this underpins many of the modelled intervention strategies.

	30–44 years	45–59 years	60–69 years	70–79 years	80–100 years
Salt-reduction intervention					
Reduction in salt intake (g per day)*	1·70 (0·42)	1·69 (0·46)	1·68 (0·46)	1·68 (0·46)	1·68 (0·46)
Decrease in mean systolic blood pressure (mm Hg)†	1·24 (0·26)	1·70 (0·37)	2·34 (0·52)	2·83 (0·64)	3·46 (0·82)
Tobacco-control interventions‡					
Increase in real price of tobacco§	43·2% (15·8%)	43·2% (15·8%)	43·2% (15·8%)	43·2% (15·8%)	43·2% (15·8%)
Change in smoking prevalence caused by non-price interventions	12% (0·7%)	12% (0·7%)	12% (0·7%)	12% (0·7%)	12% (0·7%)
Change in smoking prevalence caused by combined price and non-price interventions‡	20·8% (0·6%)	20·8% (0·6%)	20·8% (0·6%)	20·8% (0·6%)	20·8% (0·6%)

Data are mean (SD). *15% decrease in mean sodium intake. †Values are for the final year of the intervention (2015). ‡Population-level tobacco policies were assumed to apply equally to all categories of smokers. §Increase in real price sufficient to reduce smoking prevalence by 10%.

Table 1: **Effect sizes of salt-reduction and tobacco-control interventions for different age-groups in 23 countries (2006–15)**

Analytical framework

For each of the 23 countries, and for all years between 2006 and 2015, we used methods from the WHO Comparative Risk Assessment project to estimate the effects of successful implementation of the two strategies.[37] We calculated the proportion of chronic disease deaths from specific causes (see webtable 4) that could be averted if the distributions of mean systolic blood pressure and tobacco exposure were shifted to lower levels (the "potential impact fraction") for different age-groups and sexes in adults.[37] Technical details are in a webappendix.[1,2,38–42] We then calculated the absolute numbers of deaths that would be averted for each disease outcome of interest by multiplying the potential impact fraction by total mortality from that disease outcome in the corresponding year. We added these results to give the total mortality that could be averted over 10 years. Cause-specific mortality data for diseases related to blood pressure and tobacco for 2006–15 were from updated projections in the Global Burden of Disease project.[1]

See Online for webtable 4

See Online for webappendix

Assessment of distributional shifts in risk-factor exposures

Salt interventions

We used data from the Intersalt study, which had the most comprehensive and consistent cross-population estimates of urinary salt excretion to date, to estimate projected salt intake if future consumption continued to follow recent trends (business-as-usual salt intake).[17] Accurate longitudinal data for trends in salt consumption in low-income and middle-income countries are scarce, although recent reviews of mean salt consumption within populations showed that, with the exception of a few countries, mean sodium intakes have changed little over the past 20 years.[24] We therefore ran the models on the basis that, in the absence of any interventions, salt consumption would stay constant. We obtained baseline blood pressure levels in 2006 and business-as-usual projections of mean systolic blood pressure to 2015 from the WHO Global InfoBase.[43]

We then calculated the effects of the predicted reduction in salt intake on population mean systolic blood pressure. We used the relationship between change in sodium intake and change in systolic blood pressure for specific age-groups and sexes with different starting blood pressures, which were obtained by Law and colleagues from comparisons between populations.[17,25,44,45] The Intersalt study also estimated these effects, but not for different age-groups or sexes.[16] It therefore potentially underestimated the effects of dietary salt reduction in older people, for whom starting blood pressures are higher. We used coefficients from the series of studies by Law and colleagues[17,44] in the primary analysis, and uncorrected coefficients from the Intersalt study in the sensitivity analysis.

We obtained relative risks of mortality as a result of reduced mean systolic blood pressure from the WHO Comparative Risk Assessment study.[46] On the basis of a review of the time taken for risk reversal after a sustained reduction in blood pressure,[46] we expected that risk reversal would be achieved 3 years after salt intake was reduced for hypertensive and cerebrovascular diseases (where risk reversal is defined as the diminishing excess risk among those who had formerly been exposed to the same levels as those who were never exposed). By contrast, for coronary heart disease and other cardiovascular disease outcomes, two-thirds of the risk reversal would take place in the first 3 years, and the rest over the subsequent 7 years.[46]

Tobacco interventions

We calculated baseline exposure to tobacco for each age-group and sex from the accumulated smoking history and the phase of the tobacco-exposure epidemic in each country with projected rates of mortality from lung cancer for 2006–15 as an indicator of tobacco-associated hazardous effects in continuing and former smokers.[1,39,40] We expressed business-as-usual tobacco exposures as "smoking impact ratios" (the prevalence of smokers within the study population who had accumulated smoking histories that were equivalent to those of a reference population for whom increased risk had been measured previously; webappendix).[41]

We modelled the increases in taxation that would be sufficient to reduce smoking prevalence by 10% on the basis of data on tobacco taxation from recent World Bank and WHO studies (Yurekli A, International Development Research Centre, Canada, and Onder Z, Bilkent University, Turkey; personal communication).[47] The total price elasticity of demand (percentage change in demand in response to a 1% increase in price) for tobacco products in low-income and middle-income countries ranges between –0·4 and –1·2.[48] Half or more of the estimated effect on the demand for tobacco products results from a reduction in smoking prevalence,[49] and the rest is attributable to reduced smoking intensity in continuing smokers. To be conservative, we calculated that the prevalence elasticity (percentage change in smoking prevalence in response to a 1% change in price) was half of the total price elasticity of demand. We did not account for changes in mortality in continuing smokers due to decreases in smoking intensity, which are likely to be smaller than mortality reductions due to smoking cessation, and thus we slightly underestimated the total effect of tobacco-control policies. We moderated all estimates of the health impact of higher tobacco taxes to account for the proportion of the tobacco market that evades taxation as a result of smuggling.

For non-price interventions, we estimated that comprehensive bans on smoking in the workplace would reduce smoking prevalence by 3·8%,[50] in the context of the labour-participation rate in each country. We did not analyse the effects of enforcement of indoor-air laws on public transport. We calculated that dissemination of

	Men					Women					All ages and sexes
	30–44 years	45–59 years	60–69 years	70–79 years	80–100 years	30–44 years	45–59 years	60–69 years	70–79 years	80–100 years	
Cardiovascular diseases	141 (1·0%)	141 (9·1%)	1482 (10·8%)	1704 (12·4%)	1245 (9·0%)	38 (0·3%)	464 (3·4%)	901 (6·5%)	1674 (12·1%)	1548 (11·2%)	10 449 (75·8%)
Respiratory diseases	12 (0·1%)	12 (1·6%)	270 (2·0%)	362 (2·6%)	409 (3·0%)	4 (0·0%)	65 (0·5%)	87 (0·6%)	255 (1·8%)	441 (3·2%)	2126 (15·4%)
Cancers	35 (0·3%)	35 (2·0%)	311 (2·3%)	248 (1·8%)	121 (0·9%)	8 (0·1%)	42 (0·3%)	51 (0·4%)	73 (0·5%)	43 (0·3%)	1202 (8·7%)
All diseases	188 (1·4%)	188 (12·7%)	2064 (15·0%)	2314 (16·8%)	1774 (12·9%)	50 (0·4%)	570 (4·1%)	1040 (7·5%)	2001 (14·5%)	2032 (14·7%)	13 778 (100·0%)

Data are thousands of deaths (percentage of all deaths averted).

Table 2: **Deaths averted by implementation of tobacco and salt interventions, by age, sex, and type of disease (2006–15)**

health information (warnings about tobacco) would reduce smoking prevalence by 2%,[51] although the effects could be higher in low-income and middle-income countries where the harmful effects of tobacco smoke are less well known.[52] We estimated that media campaigns would reduce smoking prevalence by 7%, and bans on tobacco advertising would reduce it by 2%.[53] Effects of price and non-price interventions on the prevalence of smoking were analysed individually and in combination (table 2 and webtable 2). We assumed that proportional reductions in smoking prevalence would apply equally to all categories of smoker.

We used relative risks of death as a result of tobacco exposure from published analyses of the reference population.[41,54,55] We also calculated the reversibility of the relative risk of tobacco-related mortality,[54,55] according to the time since cessation of smoking, from a reanalysis of data on the reference group.[41] We adjusted reversibility estimates for non-lung-cancer mortality outcomes to account for the rapid reversal of tobacco-related cardiovascular mortality risk after cessation of smoking, and the slower reversal of risk of death from chronic obstructive pulmonary disease.[42]

Financial costs of implementation

Our selected population-based interventions will not require expenditures by patients or health-care providers. However, the interventions will depend on programmatic resource inputs for planning, implementation, and monitoring. Examples of activities with substantial resource consequences include: national and provincial meetings for strategic planning and monitoring of the programmes; national surveillance at the household level to assess changing rates of consumption of salt and tobacco; human resources for programme management, communication, enforcement, and regulation; awareness campaigns through mass-media channels; and supplies and equipment (including transport costs). Apart from vehicles, we did not include the costs of any capital items, such as land purchase or office construction.

We calculated resource needs on the basis of previous analyses of tobacco-control and salt-reduction strategies in different regions.[10,12,56] The human resources needed at national, provincial, and district levels in different regions have been previously calculated, taking into account the capacities of these regions to raise taxes or to introduce and enforce new tobacco-control measures.[10] We assessed the capacity of the 23 countries in our study to implement the interventions as either weak, moderate, or strong (webtable 3). For mass media, we included the costs of television and radio advertising, newspaper advertisements, wall posters, and information leaflets. We based our estimates on a tested approach to communication for behavioural impact,[57] which included specific proposals for the frequency and intensity of TV, radio, and newspaper advertisements needed to effect behavioural change.

To take account of expected synergies for implementation of a range of tobacco-control strategies, we combined the resource needs for legislation, promotion, and enforcement of indoor-air laws and a comprehensive ban on tobacco advertising into one estimate. Similarly, we estimated the joint resource needs associated with dissemination of health information and advertising to counter that of tobacco companies. Webtable 5 shows estimates for specific resource inputs in the categories of strategic development and assessment, human resources, and media and communications activities for a salt-reduction programme. Resource inputs for tobacco-control measures were likewise estimated (data not shown). Necessary quantities of office supplies and equipment for full-time employees of each programme are available elsewhere.[58] We did not estimate any future reductions in health-care use that might result from a reduced incidence of cardiovascular disease.

See Online for webtable 5

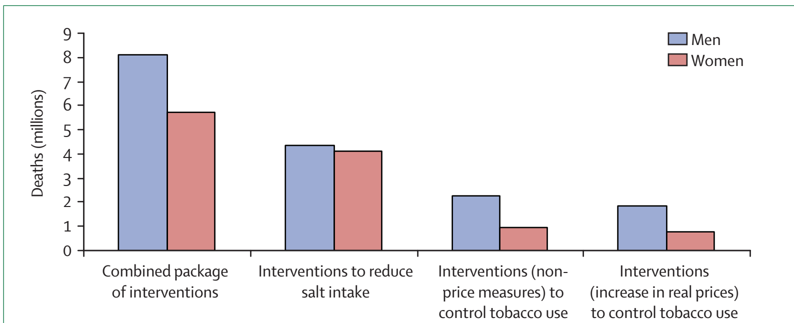

Figure 1: **Deaths averted by population-level interventions (2006–15)**

Since these interventions are nationally applicable instruments of public policy, we worked on the basis that the full costs of implementation would apply over 10 years (ie, we did not envisage that they would be gradually scaled up). All costs are expressed in US dollar prices for the year 2005. Prices of resource items, such as salaries, per diems, equipment costs, and mass-media emissions, were obtained from the WHO-CHOICE database,[58] which uses gross national income per person (plus other explanatory variables) to predict country-specific unit costs.[59]

Sensitivity analysis

We assessed the effects of doubling the reduction in salt consumption to achieve a 30% decrease from baseline values, and of decreasing salt intake to the limit recommended by the WHO of 5 g per day. We also tested the sensitivity of the results by substitution of alternative coefficients for the conversion of salt intake to changes in blood pressure, from the Intersalt study (webtable 6).[16,60,61] For tobacco interventions, we incorporated higher and lower estimates of the effects of non-price interventions, and the effect of an increase in the real price of tobacco to a cost that would reduce smoking participation rates by 20%. We also assessed how resource needs would be affected if each country had a weak or a strong capacity for implementation and if input prices were 20% higher or lower.

See Online for webtable 6

Deaths averted

Our findings show that over 10 years (2006–15), 13·8 million deaths could be averted if the selected measures to reduce tobacco and salt exposure were implemented (figure 1). 8·5 million deaths would be averted by implementation of the salt-reduction strategy alone, and 5·5 million by implementation of the four elements of the WHO FCTC alone. Most of the deaths averted (75·6%) would be from cardiovascular diseases, followed by deaths from respiratory disease (15·4%) and cancer (8·7%) (table 2).

58·7% of deaths averted would be in men, which stems from their higher and longer exposures to tobacco in low-income and middle-income countries. Deaths averted in men older and younger than 70 years would be about equal, whereas for women, many more deaths (71%) would be averted at older ages (>70 years), which reflects the later onset of cardiovascular mortality in women and the greater benefit of salt reduction in older age-groups for whom starting blood pressures are higher.

Most deaths would be averted in China and India (4·5 million and 3·1 million, respectively), as would be expected from the sizes of their populations. However, figure 2 shows that the highest gains in crude avertable mortality rates per 100 000 population older than 30 years would be in Russia (166) and in eastern European countries (Ukraine [153] and Poland [160]). These results reflect the very high rates of cardiovascular disease in

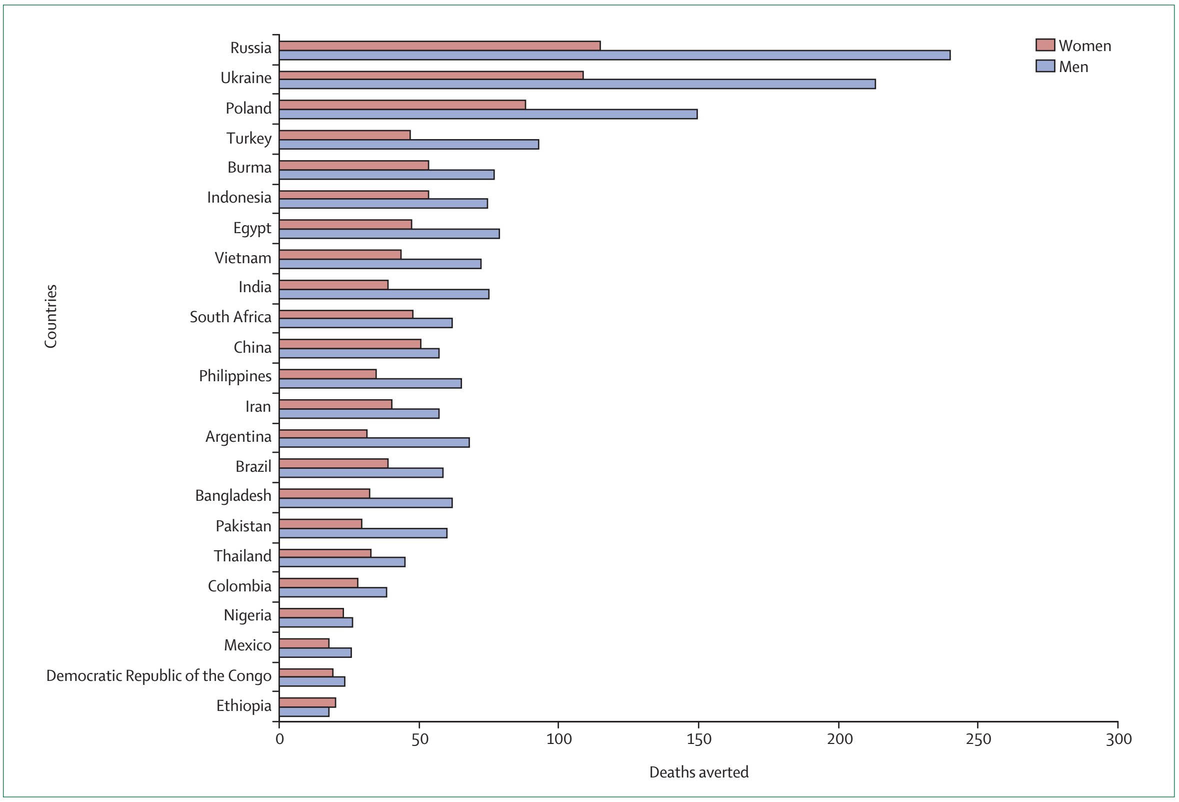

Figure 2: **Deaths averted per 100 000 population older than 30 years (2006–15)**

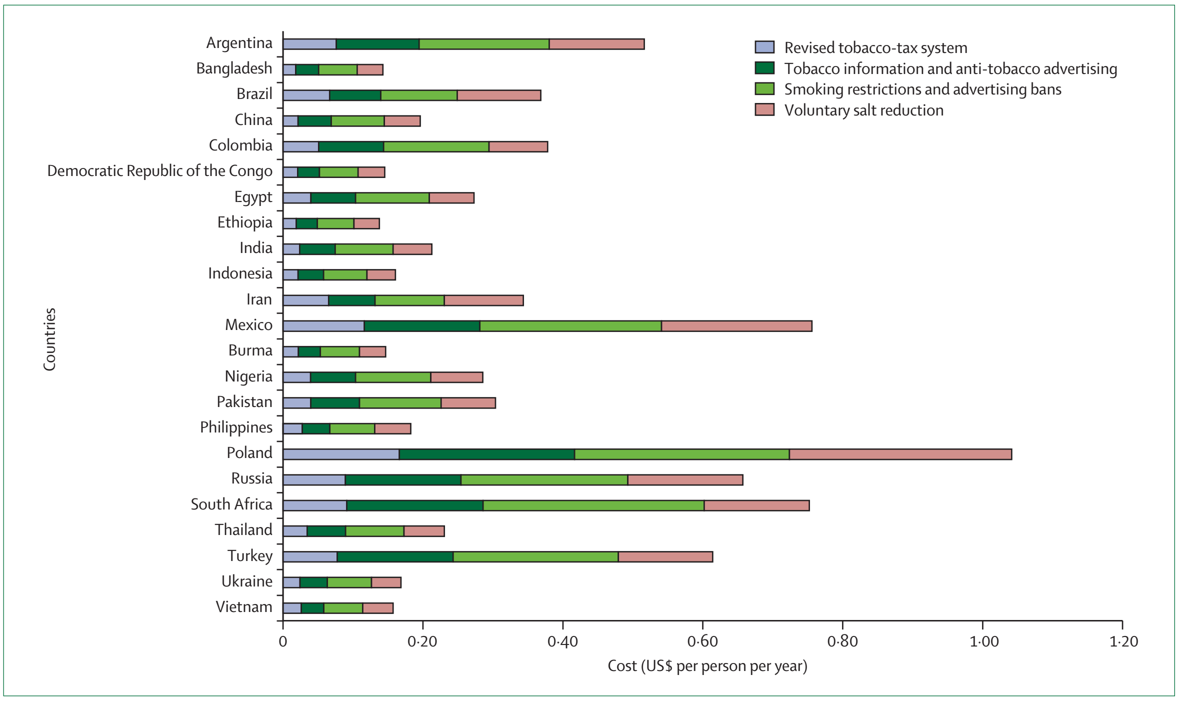

Figure 3: **Cost to implement the package of interventions (US$ per person per year, 2005)**

these populations, and their high baseline blood pressure and exposure to tobacco. Rates of avertable mortality for salt interventions alone were similarly high in these countries. Avertable mortality rates for tobacco interventions were highest for Poland, Vietnam, China, and Indonesia. The main reason so many deaths could be averted in Poland and Indonesia is that underlying tobacco exposures (and smoking impact ratios) are high, and therefore tobacco-reduction strategies could achieve large gains in these countries. In Vietnam and China, where tobacco exposures (as measured by smoking impact ratio) are lower, the high rates of potentially avertable mortality can be largely explained by the high death rates from tobacco-related causes—thus, small absolute decreases in tobacco exposure could still avert many deaths.

Potential impact fractions

Potential impact fractions for tobacco-control interventions (deaths averted by the interventions as a proportion of total possible deaths from chronic diseases) were highest in Indonesia, Poland, Thailand, and South Africa. In these countries, high tobacco exposures are combined with large price elasticities for tobacco products; thus, the moderate increases in real price that we modelled would manifest as many deaths averted. Potential impact fractions for salt-reduction interventions were highest in the Philippines, China, and Egypt; this reflects high baseline salt intakes in these societies. The scope to increase the intensity of the interventions can be seen by comparison of the potential impact fractions that would be achieved with the modelled intensity of interventions (7%) with those that might be achieved if exposure to risks from tobacco and blood pressure were reduced to the best possible levels (31%).

Financial cost estimates

Figure 3 and webtable 7 show the estimated financial costs associated with implementation of the selected interventions. Total expenditure for implementation of both strategies would range from $0·14 to $0·38 per person per year in low-income and lower middle-income countries, and from $0·52 to $1·04 per person per year in upper middle-income countries (webtable 7). The ranges in each group are primarily caused by differences in the prices or unit costs of programme inputs (such as salaries). Across all 23 countries, the mean implementation cost per person was $0·36, which on average was equivalent to 0·5% of government spending on health; for the nine low-income countries studied, the proportion was 4·7%. Expressed in terms of total costs, which largely reflected the range of population sizes (37 to 1282 million), expected expenditure needs ranged from less than $10 million per year in Democratic Republic of the Congo, Ethiopia, Burma, and Ukraine, to more than $200 million per year in China and India.

See Online for webtable 7

Most of the combined cost (67–80%) would arise from implementation of the population-based interventions of the FCTC. Half of this would be spent on legislation for and enforcement of comprehensive advertising bans and clean indoor-air laws (figure 3). The cheapest component of the FCTC package would be enactment of

	Risk-factor reduction			Deaths averted			
	Salt intake (g per day)†	Systolic blood pressure (mm Hg)‡	Smoking prevalence (%)	Cardiovascular disease	Respiratory disease	Cancer	Total (PIF)
Salt intervention*							
15% reduction in mean salt intake	1·69	1·7	..	8 452 197	..	..	8 452 197 (7·1%)
15% reduction in mean salt intake (Intersalt coefficients)	1·69	0·72	..	2 448 710	..	..	2 448 710 (2·1%)
30% reduction in mean salt intake	3·38	3·4	..	16 036 338	..	..	16 036 338 (13·4%)
Reduction in salt intake to 5 g per day	6·28	6·17	..	28 301 186	..	..	28 301 186 (23·7%)
Tobacco intervention							
Increase in real price to reduce smoking prevalence by 10% in combination with mid-range estimates for non-price interventions	..	..	20·8%	2 193 269	2 125 795	1 202 326	5 521 390 (2·8%)
Increase in real price to reduce smoking prevalence by 20% in combination with mid-range estimates for non-price interventions	..	..	29·6%	3 120 282	3 011 540	1 703 556	7 835 377 (4·0%)
Increase in real price to reduce smoking prevalence by 10% in combination with lower range estimates for non-price interventions	..	..	17·3%	1 825 257	1 767 480	999 700	4 592 437 (2·4%)
Increase in real price to reduce smoking prevalence by 10% in combination with upper range estimates for non-price interventions	..	..	24·2%	2 545 424	2 467 862	1 395 781	6 409 067 (3·3%)

PIF=potential impact fraction. *All salt-intervention estimates used coefficients from Law and colleagues,[18,44] unless otherwise specified. †Age-weighted average. ‡Age-weighted average for the final year of the intervention (2015).

Table 3: **Sensitivity analysis**

revised levels of taxation on tobacco products ($0·02–0·17 per person). The main costs of the strategy to reduce salt consumption would be awareness campaigns through mass-media outlets and regulation of food products by public-health officers, with a total cost ranging from $0·04 to $0·32 per person for the countries analysed. In terms of expenditure categories, the largest cost would be the human resources needed for management and supervision of tobacco-control and salt-reduction programmes (over 50% of total costs), most of which would be incurred at the provincial and district levels.

Results of sensitivity analysis

Table 3 shows the sensitivity of estimates for avertable mortality and impact fraction to variations in the reduction of exposure to risks from tobacco and salt that could be achieved, and in the effectiveness of non-price interventions for tobacco control. Moreover, the results varied according to the coefficients used to calculate the conversion of changes in salt intake to reduced blood pressure (webtable 6). We calculated that the number of deaths that would be averted by salt interventions would be more than two-thirds lower with coefficients from the Intersalt study than with those used in our analysis. However even by this conservative estimate, simple measures to reduce salt consumption by 15% would avert 2·4 million deaths. The most pessimistic scenario for all interventions combined would avert almost 7 million deaths between 2006 and 2015; the most favourable would avert 35·3 million deaths over the same period.

In a best-case cost scenario—in which input prices were 20% less than predicted, and resource requirements reflected a strong capacity for implementation—mean expenditure estimates for the 23 countries would be 40% lower ($0·21 per person). By contrast, in the worst case—in which input prices were 20% more than predicted and the implementation environment was weak—expenditure estimates for the 23 countries would be 40% higher ($0·50 per person). In this worst-case scenario, investment per person would need to be $0·15–0·30 in low-income countries, and $0·50–1·70 in middle-income countries.

Discussion

Our investigation has highlighted the continuing high toll of tobacco deaths in regions where the tobacco epidemic is developing fastest, and the large number of potentially avertable deaths from cerebrovascular and hypertensive diseases in regions of high salt consumption. Our results show that 13·8 million deaths from chronic diseases could be averted over a 10-year period (2006–15) in 23 low-income and middle-income countries by implementation of a few population-based interventions. This potential health gain amounts to 38% of the global goal for reduction of chronic disease proposed by WHO in 2005, and just under 60% of the global goal for the 23 low-income and middle-income countries in our analysis. The addition of individual-level interventions with a multidrug regimen on the basis of opportunistic contact with the health service, as discussed in the next paper in this Series,[6] could raise this figure to about 32 million deaths averted, which indicates the feasibility of achieving the global goal in these countries.

To show the potential effects of these interventions, we have modelled them for 23 countries which account for most of the burden of chronic disease in developing regions of the world. But the interventions should be feasible in all low-income and middle-income countries. As expected, the largest absolute avertable burdens would be in the most populous countries in the world (China and India). However, when the effects of the interventions on chronic disease burdens in individual countries were considered, we showed that Poland, Indonesia, and the Philippines would have most to gain from implementation. The only potentially adverse effect of the interventions would be an increase in prevalence of iodine-deficiency diseases from reduced consumption of iodised salt. However, if salt could be supplemented with sufficient iodine to protect people who ate 5 g of salt per day, rather than the existing estimated intake of 10 g per day, the prevalence of iodine deficiency should not increase.[24]

The two interventions we selected would not reduce exposure to salt and tobacco to the minimum. Furthermore, the diseases under consideration are affected by many additional risk factors that fall beyond the scope of the selected intervention strategies. Previous analyses have shown that at least 45–50% of the chronic disease burden in low-income and middle-income countries can be attributed to a combination of known risk factors.[62,63] Thus, the intensity of the selected interventions could be expanded incrementally to reduce risk-factor exposures to lower levels, and new interventions could be added to tackle risk factors (such as obesity) which would not be addressed by our package, as evidence for their effectiveness becomes available.

Others have attempted to assess the global costs associated with scaling up health interventions.[7,8] For example, the cost of providing universal access to basic health services has been estimated to exceed $30 per person per year.[64] We used the same method as these other costing exercises, and obtained much lower expenditure estimates. The selected interventions should be cheap, because they are made at the population level; are easy to introduce and maintain; and should not incur patient-level health-care expenditures. In the case of tobacco taxation, implementation costs would be largely if not completely offset by the revenues that are generated.

These interventions might also avert the costs of future health care, because of fewer events that cause admission to hospital. For example, economic studies that have taken the future health-care costs of salt reduction into account have assessed that interventions become cost-saving under plausible assumptions.[13,65] We omitted these potential offsets because this was a financial (rather than an economic) analysis (for example, averted events imply economic savings with respect to inpatient bed days but would actually be unlikely to reduce financial outlays because freed bed-space would quickly be redeployed to address other acute health needs).

The main limitations of our analyses stem from the underlying uncertainties in the data sources we used. Because data about salt consumption in low-income and middle-income countries were not available for many of the countries modelled, they had to be inferred from regional estimates. Furthermore, we did not have time trends for these data. Projections of mortality and exposure trends for smoking impact ratio and for blood pressure were, from necessity, based on many explicit assumptions. The ultimate effects of reduction in tobacco exposure were underestimated because the effects of reduction in smoking intensity were not modelled. Furthermore, because of the short timeframe of our study, we excluded the effects on smoking uptake in young people and their future mortality. We examined the sensitivity of our estimates to further feasible reductions in exposure distributions. A more ambitious approach, which would aim to reduce dietary salt to the recommended intake of 5 g per day and to increase the real price of tobacco to a cost that would result in a 20% fall in smoking prevalence, would avert 18·1% of deaths from the causes of chronic disease that we considered, compared with the 7·1% achieved with the selected set of interventions. Finally, our model assessed the number of deaths that would be averted in each year during the period 2006–15; we did not dynamically account or adjust for deaths of people who survived into subsequent years as a result of the specified interventions. Analysis of the global goal presented in the first paper of this series suggests that such people might survive for 18 years on average.[66]

A small number of population-based interventions, which could be implemented without great cost or the need for structural change to the health system, especially in the 20 out of 23 countries that are signatories to the FCTC, could make a major contribution to the goal of reducing rates of death from chronic diseases by an additional 2% per year. Although the absolute numbers of deaths that would be averted with these selected interventions are substantial, they nevertheless account for only a small fraction of the total burden of deaths from chronic diseases. This point emphasises the need for a combination of individual-level and population-level interventions, implemented in line with the best available evidence and in a stepwise manner that progresses from core to expanded and optimum strategies, to slow the looming threat of chronic disease epidemics in low-income and middle-income countries.

Conflict of interest statement

We declare that we have no conflict of interest.

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