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Potential benefits of healthy food and lifestyle policies for reducing coronary heart disease mortality in Turkish adults by 2025: a modelling study

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ABSTRACT

Objective: This study uses a modelling approach to compare the potential impact of future risk factor scenarios relating to smoking, physical activity levels, dietary salt, saturated fat intake, mean body mass index (BMI) levels, diabetes prevalence and fruit and vegetable (F&V) consumption on future coronary heart disease (CHD) mortality in Turkey for year 2025.

Design: A CHD mortality model previously developed and validated in Turkey was extended to predict potential trends in CHD mortality from 2008 to 2025.

Setting: Using risk factor trends data from recent surveys as a baseline, we modelled alternative evidence-based future risk factor scenarios (modest/ideal scenarios). Probabilistic sensitivity analyses were conducted to account for uncertainties.

Subject: Projected populations in 2025 (aged 25–84) of 54 million in Turkey.

Results: Assuming lower mortality, modest policy changes in risk factors would result in ~25 635 (range: 20 290–31 125) fewer CHD deaths in the year 2025; 35.6% attributed to reductions in salt consumption, 20.9% to falls in diabetes, 14.6% to declines in saturated fat intake and 13.6% to increase in F&V intake. In the ideal scenario, 45 950 (range: 36 780–55 450) CHD deaths could be prevented in 2025. Again, 33.2% of this would be attributed to reductions in salt reduction, 19.8% to increases in F&V intake, 16.7% to reductions in saturated fat intake and 14.0% to the fall in diabetes prevalence.

Conclusions: Only modest risk factor changes in salt, saturated/unsaturated fats and F&V intake could prevent around 16 000 CHD deaths in the year 2025 in Turkey, even assuming mortality continues to decline. Implementation of population-based, multisectoral interventions to reduce salt and saturated fat consumption and increase F&V consumption should be scaled up in Turkey.

Strengths and limitations of this study

- This is the first comprehensive modelling study that examines the impact of changes in multiple risk factors and healthy food consumption on coronary heart disease (CHD) mortality trends in Turkey, and a cumulative adjustment for simultaneous risk factor improvements (since a CHD death can only be prevented once) was made.
- The demographic information was obtained from the census data that covered the whole country; the risk factor trends were obtained from national epidemiological studies.
- In the Turkish IMPACT model, we assessed the CIs by using rigorous probabilistic sensitivity analyses which systematically examine the influence of these uncertainties and the assumptions used in the studies. We used plausible estimates for changes in risk factor scenarios.
- The model included only those adults aged 25–84 years because of very limited data in older age groups. The lag times were not explicitly considered in this model.
- We measured only deaths from CHD and disregarded 'competing causes' such as cancer.

BACKGROUND

Cardiovascular diseases (CVDs) are the leading cause of death in the world.[1] Low-income and middle-income countries are disproportionally affected from the burden of CVDs; more than 80% of global CVD deaths take place in these countries.[1] The main types of CVDs are coronary heart disease (CHD) and stroke, and it is estimated that 80% of premature (<80 years old) deaths from these diseases can be prevented.[2 3] Turkey is a developing upper-middle-income country according to the World Bank with a population of ~74 million.[4] According to the National Burden of Disease Study, 8% of the total burden of disease was due to CHD in 2004, and CHD was the leading cause of morbidity among adults in Turkey.[5] CHD prevalence was 5.0% in men and 2.6% in women over the age of 20 in 2011.[6] The burden of CVDs is rising rapidly all over the world as a result of population growth, ageing and due to increases in major CVD risk factors.[1] The major modifiable risk factors of CVDs are diabetes

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mellitus (DM), high blood pressure, high saturated fat intake, hyperlipidaemia, smoking, physical inactivity, obesity and low fruit and vegetable (F&V) intake.[7] Many population-based interventions have been proven to be effective for reducing CVD mortality.[8] For example, decreasing saturated fat intake by 1% of total energy reduces CHD deaths by 3.6% due to the decline in blood cholesterol; decreasing salt intake by 1 g/day reduces CHD deaths by 3.4% due to decline in blood pressure; and increasing F&V intake by 1 portion/day results in a 4.0% reduction in CHD deaths due to declines in blood pressure and cholesterol.[9 10]

It has been estimated that ~24 000 CHD deaths were prevented or postponed by risk factor changes in Turkey between 1995 and 2008, mainly due to decreasing trends in systolic blood pressure (SBP) levels and smoking rates.[11] However, increases in obesity and diabetes were estimated to have resulted in over 9000 additional deaths in 2008.[11] Recently, the Turkish Ministry of Health (MoH) prepared strategies and action plans in order to reduce the burden of cardiovascular risk factors in Turkey,[12] but this strategic plan is not comprehensive and evidence based. Modelling studies are useful to determine the policy priorities through an evidence-based approach.

The aim of this study is to appraise the potential reductions in CHD mortality achievable by modest and ideal decreases in smoking, diabetes, physical inactivity, body mass index (BMI), consumption of saturated fat, salt and increases in consumption of F&V in Turkey by year 2025.

METHODS

The IMPACT model

The IMPACT model for Turkey has been previously published to explain past trends in CHD mortality (1995–2008). This model was validated by comparing the model-predicted CHD death rates in 2008 with observed CHD deaths (International Classification of Diseases, 10th revision (ICD-10) codes I20–I25) in 2008, stratified by age and gender.[11] The model has also recently been validated for forward prediction in European populations.[13] Appendices detailing the methods and data sources used for this model have already been published and are available from here (http://www.biomedcentral.com/content/supplementary/1471-2458-13-1135-s1.docx). We summarise in brief the data sources below. Microsoft Excel program was used in order to implement the model.

Estimating future CHD mortality to 2025

Future CHD mortality in 2025 was estimated using two approaches, recognising the uncertainty inherent in future predictions. First, 'lower mortality' values for 2025 were determined by fitting age-specific and gender-specific negative exponential decay models on historical CHD mortality rates between 1995 and 2008 using an iterative non-linear least squares model: $y=a\times\exp(-b\times\text{year})$, where a is the CHD mortality rate and b is the constant decay rate. Second, a 'no mortality change' estimate for CHD mortality in 2025 was calculated using an indirect standardisation approach, multiplying age-specific and gender-specific mortality rates for 2008 by the projected population for each 10-year age group in the year 2025.

Data sources

All data were stratified by gender and 10-year age groups for persons aged 25–84 years. Information on population, mortality and demographic changes was obtained from the census (1995) and Address Based Population Registration System (2008) of the Turkish Statistical Institute (TURKSTAT).[14] Although the TURKSTAT data collection method changed between 1995 and 2008, population projections based on the census were very close to the population of address-based registration in 2008.[15] We obtained estimates of the projected population in 2025 from the State Planning Organization in Turkey.[16]

For the baseline year of the prediction model (2008), an extensive search was carried out for published and unpublished results.[11] Population risk factor trend data, including SBP, total cholesterol, hypertension and smoking prevalence, were obtained from nationally representative surveys.[17–20]

Current and projected population-level trend data for diabetes and BMI were obtained from another published model for Turkey.[17 18 21] Physical inactivity and F&V consumption trend data were generated by using information from national and regional surveys.[6 22–24] All risk factor data trends for year 2025 were projected by using the available data and applying linear regression method by year and related prevalence rates assuming the same trend will continue in the future.

Method of estimating trends in mortality for a given risk factor change

Relative risks (RRs) estimated by expert working groups for the WHO's Global Burden of Disease 2001 Study were used for changes in smoking, physical activity[25] and diabetes.[26] Regression coefficients from meta-analyses of cohort studies were used to quantify the effect of reducing salt intake on the change in mean SBP in the population[27] and on the effect of replacing dietary saturated fat intake by either polyunsaturated fats or monounsaturated fats.[28] Regression coefficients from meta-analyses of cohort studies were also included in the model to quantify the relationship between change in other risk factors (SBP, total cholesterol, F&V consumption, BMI) and change in CHD mortality.[10 29–31]

A population-attributable risk fraction (PARF) approach was used to determine the number of deaths prevented or postponed (DPPs) in 2025 resulting from improvements in smoking, physical inactivity and diabetes trends. The PARF was calculated conventionally for 2008 and 2025 as $(P\times(RR-1))/(1+P\times(RR-1))$,

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where P is the prevalence of the risk factor and RR is the relative risk for CHD mortality associated with the individual risk factor. The number of deaths prevented was calculated as the number of deaths in 2025 multiplied by the decrease in PARF between 2008 and 2025. Premature deaths were defined as deaths that occur before a person reaches the age of 85.

The number of CHD deaths potentially prevented in 2025, as a result of improved levels of BMI, F&V consumption, cholesterol and SBP in the population, was then estimated as the product of the three variables: the number of CHD deaths observed in 2008, the estimated absolute change in that risk factor between 2008 and 2025 and the adjusted regression coefficient quantifying the independent relationship between population change in a specific cardiovascular risk factor and the consequent change in mortality from CHD.

Cumulative adjustment for risk factor changes done simultaneously

CHD deaths are caused by multiple risk factors acting simultaneously. Enumerating mortality changes from risk factor trends should ideally therefore not use a simple additive approach. Instead, the effects of risk factor changes were jointly estimated using the cumulative relative benefit approach. This can be stated in the following equation:

$$\begin{aligned}&\textit{Cumulative}\ \text{relative benefit} =\\ &1-((1-\text{relative reduction in mortality for risk factor A})\\ &\times(1-\text{relative reduction in mortality for risk factor B})\times\cdots\\ &\times(1-\text{relative reduction in mortality for risk factor N})),\end{aligned}$$

where N is the total number of additional risk factors (in this case 6 as in total we modelled 7). This approach is explained with an example in the online supplementary appendix.

This cumulative effect of change in all risk factors over the study period was calculated by age and gender. The ratio of the cumulative effect to the corresponding additive effect was then calculated, yielding 72 adjustment factors, which were used to scale down the additive DPPs for each risk factor. These adjusted DPPs, summed over all seven risk factors, then equalled the estimated total combined DPPs, capturing the multiplicative net impact of positive and adverse changes in risk factors. All risk factor DPPs quoted in the results tables refer to the adjusted DPPs.

Scenario design

When we evaluated CHD risk factor changes in Turkey between 1995 and 2008,[11] smoking prevalence and the mean SBP decreased by 42% and 2%, respectively. In the same period, diabetes prevalence and mean BMI rose by 22% and 6%, respectively. Furthermore, there was a little decrease in total cholesterol, physical inactivity and an increase in F&V consumption.[32] Recently, the MoH in Turkey developed strategic plans to control non-communicable diseases. However, national targets for cardiovascular risk factor reductions were not defined explicitly.[12] The WHO set targets for reducing cardiovascular risk factors in order to decrease premature deaths from non-communicable diseases by 25% until 2025.[33] The scenarios for 2025 were generated based on the information on recent trends in CVD risk factors in Turkey, from different surveys and targets set by the WHO.[33]

1. *Salt consumption*: Average daily salt consumption in Turkey decreased rapidly by 22% (from 18 to 15 g/day) from 2008 to 2012.[34 35] In many countries, the average daily salt consumption varies between 9 and 12 g, and the WHO recommends <5 g daily salt consumption.[33] We therefore evaluated the impact of modest and ideal changes in salt consumption, to 10 and 5 g/day, respectively.
2. *Saturated/unsaturated fat consumption:* Reduction in saturated fatty acid (SFA) consumption is a major focus of dietary recommendations to reduce the concentration of plasma lipoprotein cholesterol fractions.[36] It is recommended that energy intake from dietary SFA should not exceed 10%, and recommended range for energy from total polyunsaturated fatty acid (PUFA) can range between 6% and 11%.[36] In a recent national nutrition survey in Turkey, the percentage of total energy obtained from dietary SFA and PUFA among adults over 20 was 12% and 9%, respectively.[37] The percentage of PUFA in the daily energy intake is in the recommended range in Turkey. Therefore, we only estimated the impact of reaching recommended levels of SFA intake in the Turkish population. Hence, we evaluated the impact of reaching modest and ideal targets in energy from dietary SFA of United Nations, 11% and 10%, respectively.
3. *Physical inactivity*: We estimated the impact of a 5% and 10% relative reduction in the prevalence of insufficient physical activity, the global targets set by the WHO in our modest and ideal scenario.[33]

a. *BMI:* It is estimated that mean BMI of Turkish population (aged 25–84) will increase between 2008 and 2025, from 29.0 to 30.4 kg/m^2.[21] Finucane *et al*[38] estimated the mean BMI trends between 1980 and 2008 worldwide increased by ~0.04 kg/m^2 per year. Hence, we estimated that the increase in BMI in 17 years will be 0.68 kg/m^2 reaching to 29.7 kg/m^2 in 2025. Hence, we modelled a 0.7 unit or 2.3% decrease from the recent trend in BMI in our modest scenario. In the ideal scenario, we assumed that mean BMI of Turkish population will not change by 2025, remaining at 29.0 kg/m^2. As a result, we modelled the benefit of a 1.4 kg/m^2 or 4.6% reduction in mean BMI by 2025.

4. *Diabetes:* A recent US study reported that even if the most effective population prevention strategy was implemented, diabetes prevalence would still increase by about 65% over the 20 years (between 2010 and 2030) due to population ageing and

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increasing BMI.[39] For this reason, we assumed that diabetes prevalence would be maximum 29% (10% lower than that suggested by recent trends[21]) in 2025 in the ideal scenario and 31% in the modest scenario (5% lower than suggested by recent trends).

5. *Smoking:* Smoking prevalence started to decline in Turkey after the implementation of the Framework Convention on Tobacco Control since 2008. According to the Turkish Global Adult Tobacco Survey (GATS) conducted in 2008 and 2012, smoking prevalence decreased by 13% in adults.[19] Therefore, we modelled the impact of a 30% relative reduction in smoking prevalence by 2025[33] as the ideal scenario and 15% relative reduction as the modest scenario.
6. *F&V consumption:* There is enough evidence that F&V consumption plays a role in the prevention of CVDs. We examined the targets for F&V consumption set out by the European Union (EU) and WHO, which were 5 and 7 portions/day, ~40% and 100% relative increase, respectively.[40 41]

Risk factor changes in the base year 2008 and projections to 2025 under two assumptions (modest and ideal scenarios) are presented as a summary in table 1.

Sensitivity analyses

Multivariate probabilistic sensitivity analyses using Monte Carlo simulation were conducted for all assumptions and variables. Distributions used for main input parameters in the model are presented in the online supplementary appendix. The 95% credible estimates reported are based on the 2.5th and 97.5th centiles of results generated from 1000 iterations of the model. The number of DPPs was rounded to the nearest whole number; maximum and minimum estimates are presented in the tables and figures, but only the best estimate is presented in the text to aid clarity.

RESULTS

The projected population in 2025 (adults aged 25–84) was 54 million in Turkey. Table 2 shows the estimated CHD deaths prevented by achieving risk factor policy targets (modest and ideal) for no mortality change scenario in men and women. If we assume no mortality change in 2025, modest changes in risk factor policy could result in 47 140 (minimum 38 175; maximum 56 310) fewer CHD deaths, a reduction of ~30% of the number expected in 2025.

In both risk factor scenarios, ~36.1–33.6% of the fewer CHD deaths could be attributed to reductions in salt intake, 13.6–15.6% to decreased saturated fat energy consumption levels, 13.1–19.2% to increased F&V consumption levels and 21.2–14.1% to decrease in diabetes prevalence if no mortality change occurs by 2025 (table 2, figure 1).

Table 3 shows the number of CHD deaths that are estimated for the lower mortality change scenario for 2025. Approximately 25 630–45 950 CHD deaths were prevented or postponed by modest and ideal scenarios, respectively.

If we assumed that mortality continued to decline and applied ideal scenarios in major risk factors by 2025, the breakdown of DPPs would be as follows:

A. *Salt intake:* Approximately 15 265 deaths will be prevented or postponed, assuming relative decrease in dietary salt intake by 70% (WHO target 5 g/day salt intake).
B. *Saturated/unsaturated fat:* Approximately 7690 deaths will be prevented or postponed, assuming absolute decrease in per cent energy from dietary saturated fat by 2% (target 10% energy from dietary saturated fat).
C. *F&V consumption:* Approximately 9095 deaths will be prevented or postponed, assuming relative increase in F&V consumption by 100% (target 7 portions/day F&V intake).

Table 1 Risk factor changes in the base year 2008 and projections to 2025 under two assumptions (modest and ideal scenarios)

	Modest scenario			Ideal scenario		
	Changes (%)	2008	2025	Changes (%)	2008	2025
Absolute smoking prevalence rate reduction	3.0	22%	19%	6.0	22%	16%
Relative decrease in dietary salt intake	40.0	18 g/day	10 g/day	70.0	18 g/day	5 g/day
Absolute diabetes prevalence rate reduction from the recent trends	2.0	32%	30%	4.0	32%	28%
Relative decrease in mean BMI from the recent trends	2.3	30.4%	29.7%	4.6	30.4%	29.0%
Absolute decrease in per cent energy from dietary saturated fat	1.0	12%	11%	2.0	12%	10%
Relative increase in F&V consumption	40.0	3.5 portion/day	5 portion/day	100.0	3.5 portion/day	7 portion/day
Absolute physical inactivity prevalence reduction	3.0	64%	61%	6.0	64%	58%

BMI, body mass index; F&V, fruit and vegetable.

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Table 2 Estimated CHD deaths prevented by achieving risk factor policy options for no mortality change scenario, by sex, in Turkey

	Modest scenario				Ideal scenario			
Risk factors	Men (95% CI)	Women (95% CI)	Total (95% CI)	%	Men (95% CI)	Women (95% CI)	Total (95% CI)	%
Salt intake	7715 (7285 to 8155)	9280 (8340 to 10 250)	16 995 (15 625 to 18 405)	**36.1**	13 100 (12 420 to 13 795)	15 210 (13 765 to 16 655)	28 310 (26 185 to 30 450)	**33.6**
Saturated/unsaturated fat	2785 (2660 to 2885)	3625 (3510 to 3770)	6410 (6170 to 6655)	**13.6**	5690 (5490 to 5900)	7470 (7240 to 7770)	13 160 (12 730 to 13 670)	**15.6**
Fruit and vegetable	3360 (1960 to 4740)	2830 (1530 to 4095)	6190 (3490 to 8835)	**13.1**	8775 (5090 to 12 515)	7380 (3925 to 10 820)	16 155 (9015 to 23 335)	**19.2**
Diabetes	4885 (3955 to 5870)	5100 (3950 to 6255)	9985 (7905 to 12 125)	**21.2**	5820 (4775 to 6925)	6060 (4750 to 7355)	11 880 (9525 to 14 280)	**14.1**
BMI	785 (45 to 1540)	655 (−230 to 1540)	1440 (−185 to 3080)	3.1	1560 (890 to 2235)	1550 (935 to 2205)	3110 (1825 to 4440)	3.7
Smoking	1215 (1045 to 1385)	1080 (895 to 1275)	2295 (1940 to 2660)	4.9	2505 (2150 to 2860)	1570 (1305 to 1840)	4075 (3455 to 4700)	4.8
Physical inactivity	2370 (1985 to 2835)	1455 (1255 to 1710)	3825 (3240 to 4545)	8.1	4645 (3895 to 5540)	2855 (2465 to 3340)	7500 (6360 to 8880)	8.9
Total	23 115 (18 925 to 27 415)	24 025 (19 250 to 28 895)	47 140 (38 175 to 56 310)	100.0	42 095 (34 705 to 49 765)	42 095 (34 390 to 49 980)	84 190 (69 095 to 99 745)	100.0

BMI, body mass index; CHD, coronary heart disease.

D. *Diabetes:* Approximately 6415 deaths will be prevented or postponed, assuming absolute diabetes prevalence rate reduction by 4% (target 10% lower than recent trends).
E. *BMI:* Approximately 1555 deaths will be prevented or postponed, assuming that relative decrease in mean BMI value will be 4.6% (target a mean reduction in BMI of 1.4 units in 17 years).
F. *Smoking:* Approximately 2025 deaths will be prevented or postponed, assuming that absolute smoking prevalence rate reduction will be 6% (30% relative reduction by WHO target).
G. *Physical inactivity:* Approximately 3905 deaths will be prevented or postponed, assuming that absolute physical inactivity prevalence reduction will be 6% (10% relative reduction by WHO target).

The largest contributions come from reductions in salt intake, energy from saturated fat and increase in F&V consumption (table 3, figure 2). For both scenarios, reductions in mean BMI, physical inactivity and smoking prevalence made <15% contribution to changes in CHD deaths in Turkey.

DISCUSSION

This study provided information by modelling the impact of improvements in the burden of main risk factors such as smoking, diabetes, physical inactivity, BMI, consumption of saturated fat, salt and consumption of F&V on avoidable CHD mortality in Turkey for year 2025. We present the estimates for one year only; benefits would be expected in other years if the improvements are made and sustained. Our modest change scenario estimates suggest that if there is lower mortality change, feasible risk factor improvements in Turkey could prevent or postpone ~25 600 deaths from CHD by 2025, a reduction of ~16% of CHD deaths expected in 2025. However, more ideal changes in risk factors could avoid about 46 000 CHD deaths, a reduction of ~30% of CHD deaths expected in 2025.

Based on all scenarios, the most substantial contributions came from the changes in salt intake, energy intake from saturated fat and F&V consumption. These results were well supported by other modelling studies performed in the UK.[42 43] These three nutritional changes in combination could result in 68–63% reduction in CHD deaths in Turkey in the year 2025. Other modelling studies found that ~20% and 40% of all premature CVD deaths might be averted by optimising various dietary risk factors in the UK[41] and USA,[44] respectively. The even higher contribution of salt on potential reductions of CHD mortality in Turkey compared with other countries is due to very high baseline intake of salt.[34] Reductions in salt and saturated fat intake have powerful impacts on blood pressure and total cholesterol levels. As already demonstrated in many countries (Finland, Mauritius, UK, USA and Ireland), considerable CHD mortality reductions would come

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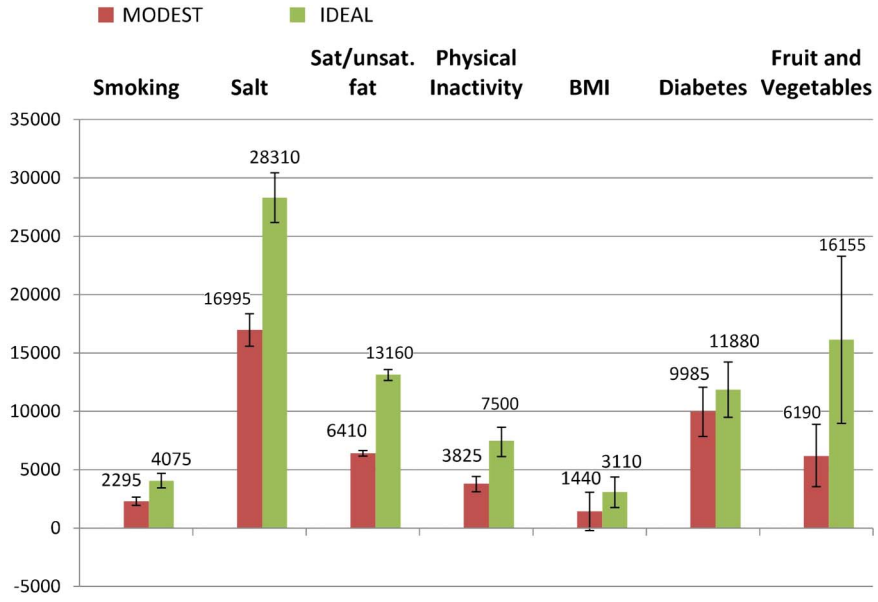

Figure 1 Predicted decrease in deaths, assuming no mortality in 2025. BMI, body mass index.

from decreases in blood total cholesterol and blood pressure.[45–49]

High salt consumption (15 g/day) is an important problem that can be ameliorated.[35] Salt consumption was lowered by about 15% in 7 years in the UK by a national salt reduction programme which was considered to be a relatively weak intervention (relying mainly on voluntary agreements with the food industry, rather than more powerful legislative and fiscal policies).[50] Greater falls in Turkey could be achieved by adopting wider salt reduction strategies, including working with the food industry, public health campaigns, monitoring progress and sustaining the strategies.[51] Approximately 70–80% of sodium consumption comes from processed foods and ready meals in Western countries. However, the most important sources of sodium in the diet are sauces and adding salt in food preparation in Asian and African countries.[52] In Turkey, the most important sources of sodium in diet are adding salt to food during preparation (56%), bread (32%) and adding salt on table (13%).[35] Thus, a higher proportion of salt consumption in Turkey is 'discretionary' (added during cooking or eating) and potentially amenable to rapid reduction. Turkish cuisine also includes salty tomato paste that is added to home-made meals, salty pickles, olives and salty cheese. Therefore, strategies to reduce the salt in bread, remove salt from the table in restaurants and campaigns to inform the public about the harms of salt may be more effective. The recent National Salt Reduction Action Plan 2015 in Turkey has adopted salt reduction strategies, including reducing the amount of salt in bread and processed products by introducing legislation and to educate people to avoid adding salt on the table through health promotion campaigns.[52] Recent modelling studies have estimated that the most cost-effective options to reduce salt intake in Turkey would be to implement three policy actions simultaneously (reformulation of products, product labelling and public health campaigns).[53]

The total daily energy intake from dietary SFA among adults over 20 years was 12% in Turkey, only slightly above the recommendations of the United Nation Agriculture Organisation (10%).[36 37] It is still important to reduce consumption of SFA at a population level because of the significant impact on CHD deaths. According to a very conservative estimate, a 1% reduction in saturated fat energy intake would result in ~9800 fewer CHD deaths in Europe.[54] The main effective strategies suggested to reduce SFA intakes are to encourage and support farmers to replace production from animal fat to healthy foods, to work with the food industry on product reformulation, reducing portion sizes, and to increase availability of healthier foods such as F&V.[55]

This study highlights the potentially large impact that increasing F&V intake could have on reducing CHD deaths in Turkey. The EU and WHO recommend to reach 5 and 7 portions/day F&V intake, respectively.[40 41] Currently, daily F&V consumption (3.5 portions) is inadequate in Turkey,[11] despite being a Mediterranean country. Fast food consumption has become widespread in urban areas, especially in children and young people. Also, consumption of bread and grain products is increasing due to socioeconomic problems and social inequalities in Turkey. A comprehensive study showed that increased F&V consumption up to an optimal level of intake could reduce the global burden of CHD by about 31%.[56] There are some intervention strategies to increase F&V consumption such as point-of-purchase (POP) information, reduced prices and coupons, increased availability, variety and convenience, promotion and advertising.[57] POP information is described as the use of shelf labels and/or signage that specifies healthy food choices in grocery stores, based on established criteria.[57] Fresh F&V are more accessible and

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Table 3 Estimated CHD deaths prevented by achieving risk factor policy options for lower mortality change scenario, by sex, in Turkey

	Modest scenario				Ideal scenario			
Risk factors	Men (95% CI)	Women (95% CI)	Total (95% CI)	%	Men (95% CI)	Women (95% CI)	Total (95% CI)	%
Salt intake	4010 (3780 to 4250)	5125 (4565 to 5710)	9135 (8345 to 9960)	**35.6**	6850 (6500 to 7225)	8415 (7545 to 9280)	15 265 (14 045 to 16 505)	**33.2**
Saturated/unsaturated fat	1625 (1565 to 1705)	2115 (2050 to 2170)	3740 (3615 to 3875)	**14.6**	3325 (3200 to 3470)	4365 (4205 to 4505)	7690 (7405 to 7975)	**16.7**
Fruit and vegetable	1895 (1065 to 2705)	1595 (805 to 2415)	3490 (1870 to 5120)	**13.6**	4945 (2720 to 7160)	4150 (2065 to 6410)	9095 (4785 to 13 570)	**19.8**
Diabetes	2745 (2150 to 3385)	2615 (1890 to 3330)	5360 (4040 to 6715)	**20.9**	3265 (2600 to 3970)	3150 (2325 to 3945)	6415 (4925 to 7915)	**14.0**
BMI	420 (−5 to 850)	360 (−195 to 910)	780 (−200 to 1760)	3.1	840 (445 to 1230)	715 (195 to 1240)	1555 (640 to 2470)	3.4
Smoking	640 (535 to 750)	495 (405 to 580)	1135 (940 to 1330)	4.4	1315 (1095 to 1540)	710 (590 to 835)	2025 (1685 to 2375)	4.4
Physical inactivity	1270 (1060 to 1520)	725 (620 to 845)	1995 (1680 to 2365)	7.8	2485 (2080 to 2975)	1420 (1220 to 1660)	3905 (3300 to 4635)	8.5
Total	12 605 (10 145 to 15 165)	13 030 (10 145 to 15 960)	25 635 (20 290 to 31 125)	100.0	23 025 (18 635 to 27 575)	22 925 (18 145 to 27 875)	45 950 (36 780 to 55 450)	100.0

BMI, body mass index; CHD, coronary heart disease.

relatively cheap in Turkey than other countries because of ideal climate and widespread production. Thus, POP information, promotion and advertising might be more effective than other interventions in Turkey.

Increasing F&V consumption limits the consumption of high-fat foods. For this reason, positive messages to increase the consumption of F&V might be more effective than the messages that fatty foods should not be consumed.[58] In addition, high sugar-sweetened beverage (SSB) consumption increases with high salt and fat consumption. SSB consumption is one of the main causes of obesity and diabetes. Hence, SSB should be replaced with fresh F&V. There are some strategies to encourage low salt, sugar and fat levels among food products in the framework of the Turkey Healthy Diet and Active Life Program.[59] Turkey has banned the sale of SSBs and high-calorie foods such as fried foods and crisps in elementary schools. Replacement of these harmful products by selling healthy foods such as milk, yoghurt and fruit was recommended by the MoH.[21]

Some risk factors such as prevalence of DM and mean BMI values were increasing rapidly in Turkey,[21] where they caused 9000 additional deaths in 2008.[11] In our case, we might have underestimated the 2025 death rates as we did not take into account the impact of increasing trends in DM and BMI on CHD mortality. It is also likely that the contrasting trend of these factors might cancel out much of the benefits that would be attained from improvements in other risk factors. Hence, it calls for a better application of public health policies on reducing burden of DM and high BMI, as well as working to accelerate positive trends in salt, smoking and physical inactivity.

Owing to the high prevalence of diabetes, obesity and physical inactivity in Turkey,[6] the MoH has action plans for preventing obesity, physical inactivity and diabetes, named the 'Obesity Prevention and Control Program of Turkey' and 'Diabetes Prevention and Control Program'.[21] The MoH aims to increase the number of environments suitable for physical activity in the community.[59] Environmental regulations are needed to achieve this goal by cooperating with municipalities. However, there is neither sufficient political will nor resources to implement this across the country. Despite compulsory increased physical activity and low energy intake in Cuba for 4 years, the mean BMI of population decreased by only 1.5 units;[60] to date, sustained falls in BMI have been hard to achieve at a population level.

The prevalence of smoking in adults significantly decreased by 13% between 2008 and 2012, due to the regulations related with Framework Convention on Tobacco Control in Turkey.[19] Turkey implemented all MPOWER strategies,[61] and it is regarded as one of the most successful countries in battling against smoking. The MoH is planning to prevent young people from starting to smoke by increasing monitoring, supervision and creating negative attitudes towards tobacco use in society.[62]

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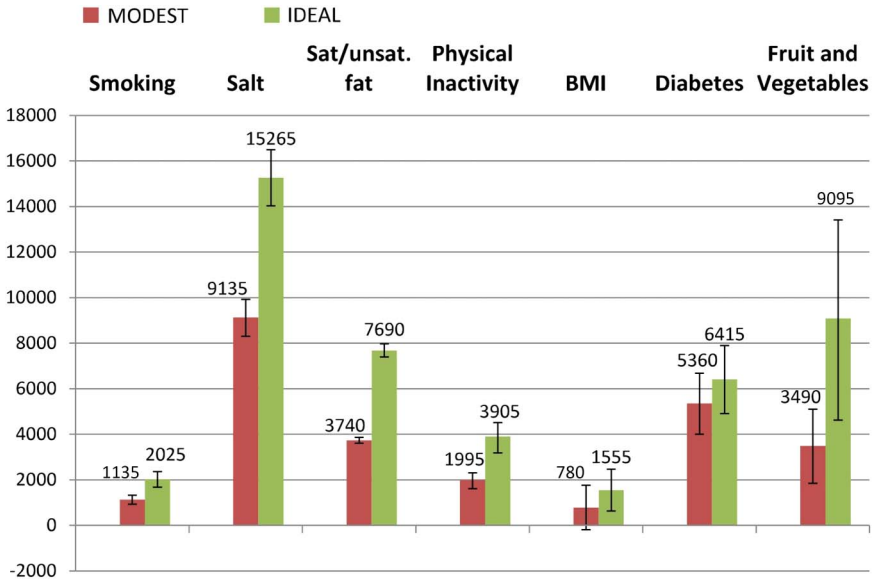

Figure 2 Predicted decrease in deaths, assuming lower mortality in 2025. BMI, body mass index.

Strengths and limitations

Models are practical and helpful tools for policy development. They merge and concurrently regard all data from many different sources. The validated Turkish IMPACT model was developed further in this study.[11] Data were updated and additional components were added to the model to translate reductions in salt intake or energy from saturated fat intake into reductions in SBP or total cholesterol, respectively. We also made a cumulative adjustment for simultaneous risk factor improvements (since a CHD death can only be prevented once). This is not routinely implemented in modelling studies.[25] This is the first comprehensive modelling study that examines the impact of changes in multiple risk factors and healthy food consumption on CHD mortality trends in Turkey.

The demographic information was obtained from the census data that covered the whole country; the risk factor trends were obtained from national epidemiological studies. In the Turkish IMPACT model, we assessed the potential maximum and minimum plausible effects of risk factors using rigorous probabilistic sensitivity analyses which systematically examine the influence of these uncertainties and the assumptions used in the studies. We used plausible estimates for changes in risk factor scenarios.

Our study has several potential limitations. The model included only those adults aged 25–84 years because of very limited data in older age groups. The lag times were not explicitly considered in this model. We measured only deaths from CHD and disregarded 'competing causes' such as cancer. Trends in treatment uptakes were not considered in this model, though they were already high in previous studies[11] and are unlikely to deteriorate.

The risk/protective factors included in the study (physical inactivity, dietary salt, saturated fat intake, mean BMI levels, diabetes prevalence, smoking prevalence and F&V consumption) are highly interrelated. Some of the RRs or β coefficients were not adjusted for each factor due to the feature of the studies. This might cause a relatively small overestimation while calculating DPPs, after all cumulative adjustments. Multivariate probabilistic sensitivity analyses were conducted to deal with this limitation.

Conclusion

Only modest risk factor changes in salt, saturated fat and F&V intake could prevent around 16 000 CHD deaths in the year 2025 in Turkey, even assuming mortality continues to decline. The most impressive strategies in recent years will be those affecting healthy food policies. This model can be a useful tool to explore potential benefits of implementing certain strategies to prevent the future burden of CHD. Implementation of population-based, multisectoral interventions to encourage healthy food consumption should be scaled up.

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REFERENCES

1. WHO. Global status report on noncommunicable diseases 2010. In: Ala Alwan AD-G, ed. Geneva: World Health Organisation, 2011:16.
2. Lozano R, Naghavi M, Foreman K, *et al*. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;380:2095–128.
3. WHO. *World Health Organization diet, nutrition and the prevention of chronic diseases*. Geneva: World Health Organization, 2002.
4. Bank W. Country data for Turkey. Secondary Country data for Turkey 2014. http://data.worldbank.org/country/turkey
5. Republic of Turkey MoH. Türkiye Hastalık Yükü Çalışması 2004. In: Ünüvar N, Mollahaliloğlu S, Yardım N, eds. Ankara: Ministry of Health, 2006:19.
6. Republic of Turkey MoH. Chronic diseases and risk factors survey in Turkey. In: Belgin Ünal GE, ed. Ankara: Public Health Agency of Turkey, 2013:197–8.
7. WHO. *Global Atlas on cardiovascular disease prevention and control*. Geneva: World Health Organization, 2011.
8. Pomerleau J, Lock K, Knai C, *et al*. Interventions designed to increase adult fruit and vegetable intake can be effective: a systematic review of the literature. *J Nutr* 2005;135:2486–95.
9. Strazzullo P, D'Elia L, Kandala NB, *et al*. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. *BMJ* 2009;339:b4567.
10. Dauchet L, Amouyel P, Hercberg S, *et al*. Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. *J Nutr* 2006;136:2588–93.
11. Unal B, Sözmen K, Arık H, *et al*. Explaining the decline in coronary heart disease mortality in Turkey between 1995 and 2008. *BMC Public Health* 2013;13:1135.
12. Republic of Turkey MoH. *Strategic Plan 2013–2017*. Ankara: Ministry of Health, 2012.
13. Andersen K, Aspelund T, Bandosz P, *et al*. Euroheart II project, CHD mortality projections to 2020, comparing different policy scenarios. Euroheart II Work Package 6. 2014.
14. TURKSTAT. Statistics by theme/Population and demography/vital statistics/statistical tables and dynamic search/death statistics Secondary Statistics by theme/Population and demography/vital statistics/statistical tables and dynamic search/death statistics 2014. http://tuikapp.tuik.gov.tr/adnksdagitapp/adnks.zul
15. TURKSTAT. New method for 2010 population and housing census of Turkey considerations about data quality and coverage Secondary New method for 2010 population and housing census of Turkey considerations about data quality and coverage 2014. http://www.unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.41/2008/sp.3.e.pdf
16. DPT. 1927–2025 Population Estimates and Projections of State Planning Organisation (Turkey) Secondary 1927–2025 Population Estimates and Projections of State Planning Organisation (Turkey) 2014. http://www3.kalkinma.gov.tr/DocObjects/Download/12637/1927-_2025_Nüfus_Tahmin_ve_Projeksiyonları.xls
17. Satman I, Yilmaz T, Sengül A, *et al*. Population-based study of diabetes and risk characteristics in Turkey: results of the Turkish diabetes epidemiology study (TURDEP). *Diabetes Care* 2002;25:1551–6.
18. Satman I, Omer B, Tutuncu Y, *et al*. Twelve-year trends in the prevalence and risk factors of diabetes and prediabetes in Turkish adults. *Eur J Epidemiol* 2013;28:169–80.
19. Republic of Turkey MoH. *Global adult tobacco survey Turkey 2012*. Ankara: Public Health Institution of Turkey, 2014.
20. Onat A, Senocak MS, Surdum-Avci G, *et al*. Prevalence of coronary heart disease in Turkish adults. *Int J Cardiol* 1993;39:23–31.
21. Sozmen K, Unal B, Capewell S, *et al*. Estimating diabetes prevalence in Turkey in 2025 with and without possible interventions to reduce obesity and smoking prevalence, using a modelling approach. *Int J Public Health* 2015;60(Suppl 1):S13–21.
22. Ünal B, Sözmen K, Uçku R, *et al*. High prevalence of cardiovascular risk factors in a Western urban Turkish population: a community-based study. *Anadolu Kardiyol Derg* 2013;13:9–17.
23. Ergör G, Soysal A, Sözmen K, *et al*. Balcova heart study: rationale and methodology of the Turkish cohort. *Int J Public Health* 2012;57:535–42.
24. National household survey 2003 basic findings. In: Unuvar N, Mollahaliloglu S, Yardım N, *et al*, eds. Ankara: Republic of Turkey, Ministry of Health, 2006:41–2.
25. WHO. Comparative quantification of risk. Global and regional burden of disease attributable to selected major risk factors. In: Ezatti MLA, Rodgers A, Murray CJL, eds. Geneva, 2004:899–912.
26. Yusuf S, Hawken S, Ounpuu S. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study (vol 364, pg 937m 2004). *Lancet* 2004;364:2020–20.
27. He FJ, Li J, Macgregor GA. Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomised trials. *BMJ* 2013;346:f1325.
28. Clarke R, Frost C, Collins R, *et al*. Dietary lipids and blood cholesterol: quantitative meta-analysis of metabolic ward studies. *BMJ* 1997;314:112–17.
29. Lewington S, Clarke R, Qizilbash N, *et al*. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet* 2002;360:1903–13.
30. Lewington S, Whitlock G, Clarke R, *et al*. Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55,000 vascular deaths. *Lancet* 2007;370:1829–39.
31. Bogers RP, Bemelmans WJ, Hoogenveen RT, *et al*. Association of overweight with increased risk of coronary heart disease partly independent of blood pressure and cholesterol levels: a meta-analysis of 21 cohort studies including more than 300 000 persons. *Arch Intern Med* 2007;167:1720–8.
32. Sözmen K, Ünal B, Saidi O, *et al*. Cardiovascular risk factor trends in the Eastern Mediterranean region: evidence from four countries is alarming. *Int J Public Health* 2015;60(Suppl 1):S3–11. .
33. WHO. *Global status report on noncommunicable diseases*. Geneva, Switzerland: World Health Organization, 2014.
34. Erdem Y, Arici M, Altun B, *et al*. The relationship between hypertension and salt intake in Turkish population: SALTURK study. *Blood Press* 2010;19:313–18.
35. Türkiye'de tuz tüketimi çalışması SALTURK2. Secondary Türkiye'de tuz tüketimi çalışması SALTURK2 2012. http://www.turkhipertansiyon.org/ppt/SALTurk2.ppt
36. FAO. Fats and fatty acids in human nutrition: report of an expert consultation. Rome: Food and Agriculture Organization of the United Nations. 2010.
37. MOH. *National nutrition and health survey of adults. Beslenme Durumu ve Alışkanlıklarının Değerlendirilmesi Sonuç Raporu*. Ankara: Ministry of Health of Turkey, 2014.
38. Finucane MM, Stevens GA, Cowan MJ, *et al*. National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. *Lancet* 2011;377:557–67.
39. Gregg EW, Boyle JP, Thompson TJ, *et al*. Modeling the impact of prevention policies on future diabetes prevalence in the United States: 2010–2030. *Popul Health Metr* 2013;11:18.
40. Pomerleau J, Lock K, McKee M. The burden of cardiovascular disease and cancer attributable to low fruit and vegetable intake in the European Union: differences between old and new Member States. *Public Health Nutr* 2006;9:575–83.
41. O Flaherty M, Flores-Mateo G, Nnoaham K, *et al*. Potential cardiovascular mortality reductions with stricter food policies in the United Kingdom of Great Britain and Northern Ireland. *Bull World Health Organ* 2012;90:522–31.
42. Hughes J, Kabir Z, Bennett K, *et al*. Modelling future coronary heart disease mortality to 2030 in the British Isles. *PLoS ONE* 2015;10:e0138044.
43. O'Keeffe C, Kabir Z, O'Flaherty M, *et al*. Modelling the impact of specific food policy options on coronary heart disease and stroke deaths in Ireland. *BMJ Open* 2013;3.
44. Danaei G, Ding EL, Mozaffarian D, *et al*. The preventable causes of death in the United States: comparative risk assessment of dietary, lifestyle, and metabolic risk factors. *PLoS Med* 2009;6:e1000058.
45. Vartiainen E, Puska P, Pekkanen J, *et al*. Changes in risk factors explain changes in mortality from ischaemic heart disease in Finland. *BMJ* 1994;309:23–7.
46. Dowse GK, Gareeboo H, Alberti KG, *et al*. Changes in population cholesterol concentrations and other cardiovascular risk factor levels after five years of the non-communicable disease intervention programme in Mauritius. Mauritius Non-communicable Disease Study Group. *BMJ* 1995;311:1255–9.

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47. Unal B, Critchley JA, Capewell S. Small changes in United Kingdom cardiovascular risk factors could halve coronary heart disease mortality. *J Clin Epidemiol* 2005;58:733–40.
48. Capewell S, Ford ES, Croft JB, *et al*. Cardiovascular risk factor trends and potential for reducing coronary heart disease mortality in the United States of America. *Bull World Health Organ* 2010;88:120–30.
49. Kabir Z, Bennett K, Critchley JA, *et al*. Can small changes in cardiovascular risk factors predict large future reductions in coronary heart disease mortality in Ireland? *Eur J Epidemiol* 2007;22:83–9.
50. Brinsden HC, He FJ, Jenner KH, *et al*. Surveys of the salt content in UK bread: progress made and further reductions possible. *BMJ Open* 2013;3.
51. Farrand C, He FJ, MacGregor GA. Reducing population salt intake in the Eastern Mediterranean Region—time for urgent action. *East Mediterr Health J* 2015;20:761–4.
52. MOH. *Türkiye Aşırı Tuz Tüketiminin Azaltılması Programı 2011–2015*. Ankara: Republic of Turkey, Ministry of Health, 2011.
53. Mason H, Shoaibi A, Ghandour R, *et al*. A cost effectiveness analysis of salt reduction policies to reduce coronary heart disease in four Eastern Mediterranean countries. *PLoS ONE* 2014;9:e84445.
54. Lloyd-Williams F, O'Flaherty M, Mwatsama M, *et al*. Estimating the cardiovascular mortality burden attributable to the European Common Agricultural Policy on dietary saturated fats. *Bull World Health Organ* 2008;86:535–41A.
55. Heart of Mersey. Prevention of cardiovascular disease at a population level: evidence on interventions to address dietary fats. Secondary Prevention of cardiovascular disease at a population level: evidence on interventions to address dietary fats. 2009.
56. Lock K, Pomerleau J, Causer L, *et al*. The global burden of disease attributable to low consumption of fruit and vegetables: implications for the global strategy on diet. *Bull World Health Organ* 2005;83:100–8.
57. Glanz K, Yaroch AL. Strategies for increasing fruit and vegetable intake in grocery stores and communities: policy, pricing, and environmental change. *Prev Med* 2004;39(Suppl 2):S75–80.
58. Lapointe A, Weisnagel SJ, Provencher V, *et al*. Using restrictive messages to limit high-fat foods or nonrestrictive messages to increase fruit and vegetable intake: what works better for postmenopausal women? *Eur J Clin Nutr* 2010;64:194–202.
59. MOH. *Türkiye Sağlıklı Beslenme ve Hareketli Hayat Programı (2014–2017)*. Ankara: Republic of Turkey, Ministry of Health, 2013.
60. Franco M, Bilal U, Ordunez P, *et al*. Population-wide weight loss and regain in relation to diabetes burden and cardiovascular mortality in Cuba 1980–2010: repeated cross sectional surveys and ecological comparison of secular trends. *BMJ* 2013;346:f1515.
61. WHO report on the global tobacco epidemic, 2008: The MPOWER package. *Popul Dev Rev* 2008;34:581–1 .
62. Republic of Turkey MoH. *Ulusal Tütün Kontrol Programı Eylem Planı (2015–2018)*. Ankara: Ministry of Health, 2015.

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