Evaluation of a front-of-pack nutrition label

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Consuming a diet complying with front-of-pack label criteria may reduce cholesterol levels: A modeling study

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Abstract

Introduction: Front-of-pack nutrition labels can help consumers to make healthier choices and stimulate healthier product development. This is the first modeling study to investigate the potential impact on cholesterol levels of consuming a diet consisting of products that comply with the criteria for a 'healthier choice logo'.

Methods: National food consumption and food composition data were used to estimate the nutrient intake of the Dutch adult population (18-70 years old) before and after replacing foods that did not comply by foods that did comply with the Choices front-of-pack label criteria. Different scenarios were established. The difference in cholesterol levels in the Dutch population was assessed before and after replacement by means of equations from meta-analyses that calculate how blood lipids change when diet composition changes.

Results: After replacing non-complying products with products which comply with the label's criteria (maximum scenario), saturated fatty acids intake reduced from 14.5 to 9.8 energy%. Trans fatty acids reduced from 0.95 to 0.57 energy%. The average predicted changes in LDL and total cholesterol levels were -0.25 and -0.31 mmol/l, respectively. Because HDL cholesterol levels reduced as well (-0.05 mmol/l), overall, the result was a slightly positive change in the total cholesterol/HDL ratio (-0.03).

Conclusions: Our findings suggest that the consumption of foods complying with the criteria for a front-of-pack label may contribute moderately to cardiovascular risk reduction via influencing blood lipids. These findings were independent of other potential effects on related health outcomes.

Introduction

The World Health Organization recommends limiting the intake of sodium, sugar, saturated fatty acids (SAFA) and trans fatty acids (TFA) in order to reduce the prevalence of diet-related chronic diseases (1). Front-of-pack nutrition labels are tools that can assist with this. They aim to help consumers to make healthier choices and can encourage food manufacturers to develop healthier products. Many countries, food manufacturers, retailers and consumer organizations have developed their own labels, with different designs and criteria (2, 3).

In the Netherlands, since 2006, the front-of-pack label 'Choices' has been present on a variety of food products in supermarket chains and food services. An independent international scientific committee developed the label's criteria. Products that contain lower levels of sodium, sugar, SAFA, TFA and energy and increased levels of dietary fiber compared with similar products within the same product category can obtain the label. The detailed background of the label has been described elsewhere (4, 5). We found that health-motivated consumers not only reported purchasing but also actually purchased more labeled products (5, 6), although our randomized controlled trial in worksite cafeterias did not show an effect of labeling on lunchtime food purchases (7). We also found that the label has caused food manufacturers to reformulate existing products and to develop new products with a healthier nutrient composition (8).

It is hypothesized that an increased availability of reformulated products due to front-of-pack labels will eventually contribute to better nutrient intake and subsequently a healthier population. Earlier studies combined food consumption data with food composition data in order to explore the potential impact of the Choices criteria on a population's nutrient intake. They found that consuming a diet which complies with the label's criteria can potentially lead to substantial improvements in nutrient intake (9, 10). However, these studies only calculated the nutrient intake for the Dutch population of young adults. Furthermore, nutrient intake was the outcome measure, and these studies did not model the potential impact on health-related risk factors. One other study did model the effects of a front-of-pack label on health-related risk factors and assessed its cost-effectiveness. Sacks and colleagues assumed that health outcomes could be modeled via a change in body weight, and found that traffic light labeling is likely to be an excellent value-for-money obesity prevention measure (11). To the best of our knowledge, no studies have yet calculated the effect of consuming a diet which is compliant with the criteria of a front-of-pack label on a specific cardiovascular risk factor, such as cholesterol levels. There is a large body of evidence on the association between one's intake of different fatty acids and cholesterol levels and subsequently with coronary heart disease (CHD) (12-14). Therefore, this study aimed to model the potential impact of consuming a diet which is compliant with the Choices criteria on cholesterol levels for the total Dutch adult population.

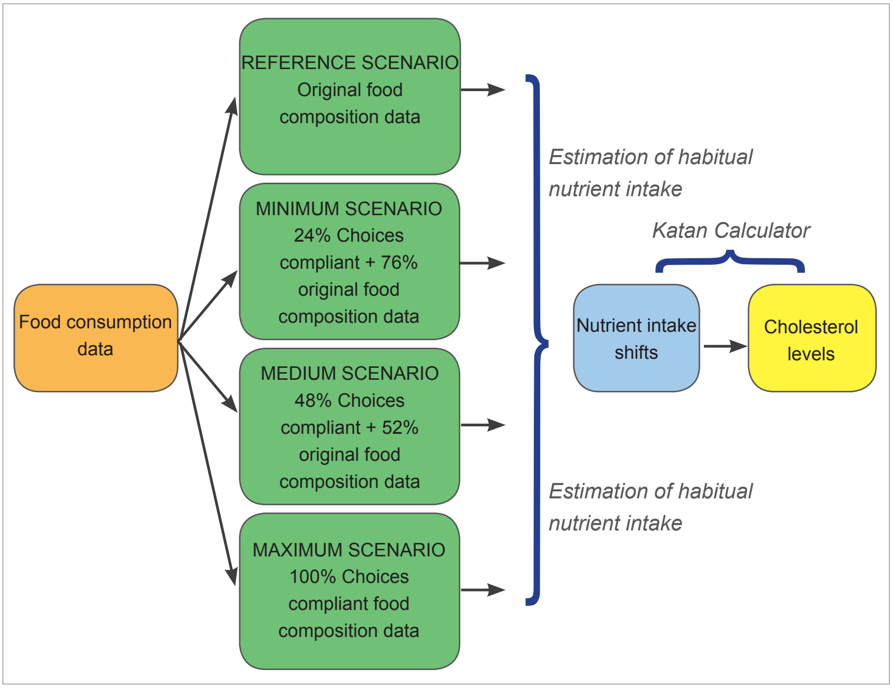
Methods

First, we developed four different nutrient intake scenarios for the Dutch adult population (18-70 years). Second, we calculated the nutrient intake distribution in the population for each of the scenarios. Third, we estimated the effect of shifts in several fatty acids on average cholesterol levels. Figure 1 illustrates the design of this study. Please note that this study focused on modeling the effects on cholesterol levels. It did not investigate other potential effects on related intermediaries and health outcomes, such as BMI, blood pressure, stroke, diabetes and cancer.

Food consumption data

We used data from the Dutch National Food Consumption Survey 1997-1998 (15). These data are currently the most recent food consumption data available for the total population of the Netherlands. The survey was conducted among 6250 Dutch participants aged > 1 year old. This group is considered to be representative in terms of sex, age, level of education and place of residence for the general Dutch population. Trained dieticians instructed the participants to keep a two-day-diary. In the present study, we focused on the adult population aged 18-70 years old (n=4336).

Figure 1. Study design



Food composition data

We also used food composition data from the Dutch food composition database (16) for the following nutrients: SAFA (expressed as percentage of total energy intake (en%)), trans fatty acids (TFA; en%), sodium (g), energy (kcal) and fiber (g) (the Choices nutrients) and monounsaturated fatty acids (MUFA; en%), polyunsaturated fatty acids (PUFA; en%), protein (en%) and cholesterol (mg) (needed for calculating the effects on cholesterol) (17). Added sugar (en%) was estimated based on imputation of the mean value for comparable products within the same product group. Foods were scored according to the Choices criteria for each food group. Alcoholic beverages and special diet products were excluded as there are no Choices criteria for these product groups. Foods were compliant with the front-of-pack label if they met all of the criteria for each nutrient (SAFA, TFA, sodium, energy and fiber). The scoring resulted in 516 products that complied with the label's criteria, 999 non-compliant products, and 57 which could not be scored due to missing nutrient data.

Replacement procedure

All consumed products which did not comply with the Choices criteria were replaced by products complying with the criteria and which were available in the Dutch food composition database. We only replaced products within the defined Choices product groups, as the program assumes that consumers choose products within certain product groups. If we found no similar product suitable for replacement, the product was not replaced (which was the case for 36% of the non-compliant products). Products that already complied were not replaced. Three trained investigators (ELV, MAHH, AJCR) systematically compared all of the replacements.

Reference scenario

We combined the Dutch food consumption data with data from the Dutch food composition database in order to estimate the nutrient intake of the Dutch adult population aged 18-70 years old. This reference scenario was compared to each of the three scenarios explained below.

Minimum scenario

We estimated the nutrient intake of the Dutch population if 24% of the population replaced their food with products which complied with the label's criteria. This was based on our supermarket observations which showed that 24% of consumers' supermarket purchases consist of labeled products (6). If 24% of a population's intake comes from products complying with the label's criteria, it was assumed that it would be possible to calculate the population's nutrient intake as if 24% of the population ate only products complying with the label's criteria.

Medium scenario

We assume that the current trend for innovation and healthy behavior will continue, due to the increasing interest of food manufacturers in product reformulation and the increasing health education of consumers. Therefore, we also performed calculations for a scenario in which 48% of the population replaced their food products with products which complied with the label's criteria (twice the minimum scenario).

Maximum scenario
We finally performed calculations in which 100% of the population replaced their food products with products which complied with the label's criteria.

Analyses
Nutrient intake. The habitual intake for all nutrients was calculated based on the two-day diaries, correcting for within-individual variation (e.g., day-to-day correlation and interview sequence), using the Iowa State University (ISU) method (SIDE/IML version 1.11, 2001; Iowa State University, Ames, IA, USA) for the reference and the maximum scenarios. In order to take into account the uncertainty regarding which subjects will actually replace their food products with compliant food products in the minimum and medium scenarios, a probabilistic procedure was applied. A random sample was drawn from the study population, corresponding to the proportion of the study population who would substitute their food products with products which complied with the label's criteria (24% and 48%). We assumed that the subjects who were not selected (76% and 52%) continued to consume their regular foods. This sampling procedure was repeated 100 times. For each sample, habitual nutrient intake was calculated. The results presented are the median values for all of the samples. We compared the median intake to the recommended intake levels developed by the Health Council of the Netherlands (18) and, if these data were not available, to the recommendations of the WHO (19). Additionally, insight in the contribution of nutrients by various product groups was obtained to investigate which product groups contributed most to the changes in nutrient intakes. First, the relative reduction per product group for each individual was calculated, and subsequently, the distribution of changes was derived for the whole population per food group.
Cholesterol. In order to calculate the effects of the shift in nutrient intake on cholesterol levels, we used the Katan Calculator, an online tool (www.katancalculator.nl) that calculates how blood lipids change when the subject's diet composition changes (17) This online tool is based on high-quality scientific data (13, 20-22). Body weight is assumed to remain constant in this calculation tool, because changes in body weight may also influence cholesterol levels and otherwise would bias the outcomes of the calculations. The minimum, medium and maximum scenarios were compared with the reference scenario using the different SAFA, TFA, MUFA, PUFA, protein and cholesterol intake values as the input. The outcomes recorded were changes in LDL, HDL, total cholesterol and in the ratio total cholesterol/HDL.

Results
Nutrient intake
Table 1 shows the median (5th percentile; 95th percentile) habitual intake of the different nutrients for the four scenarios for the total adult population (18-70 years old). The nutrients SAFA, TFA, sodium, added sugar and energy (which were used as criteria in the replacement procedure) showed reductions for all scenarios, while fiber levels increased. When looking at the other nutrients, increases in the subjects' intake were shown for PUFA, protein and cholesterol, and a decrease was found for MUFA. The probability approach for the minimum and medium scenario showed median intake estimates (P5 and P95 of the 100 iterations) ranging between 13.27 to 13.35 en% for SAFA and 0.84 to 0.85 en% for TFA in the minimum scenario; and

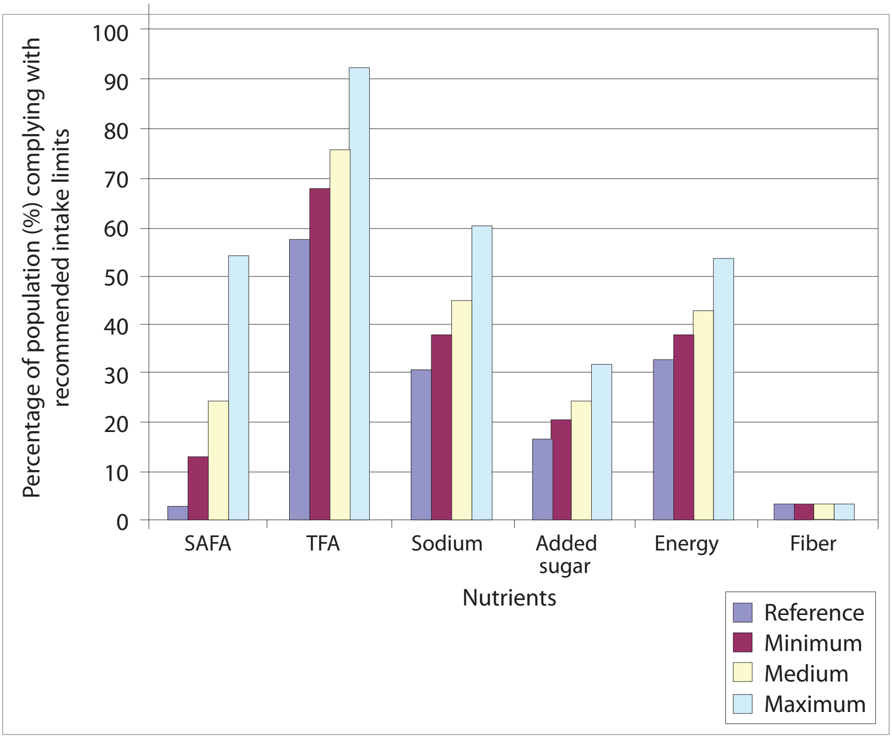
Table 1. Median (5^{th} percentile; 95^{th} percentile) habitual intake of different nutrients in the different scenarios among the total Dutch adult population.

Nutrients	Reference	Minimum[1]	Medium[1]	Maximum	Rec[a]
SAFA[2] (en%)	14.5 (10.5; 18.7)	13.3 (8.6; 18.6)	12.1 (7.6; 17.8)	9.8 (7.3; 12.8)	<10
TFA[2] (en%)	0.95 (0.59; 1.49)	0.8 (0.4; 1.5)	0.7 (0.3; 1.4)	0.57 (0.29; 1.09)	<1
MUFA[2] (en%)	11.5 (8.9; 14.6)	11.4 8.5; 14.7)	11.2 (8.2; 14.6)	10.7 (7.6; 14.5)	MUFA + PUFA: 8 - 38
PUFA[2] (en%)	6.9 (4.5; 10.4)	7.1 (4.6; 10.4)	7.2 (4.8; 10.5)	7.5 (5.2; 10.4)	MUFA + PUFA: 8 - 38
Protein (en%)	15.3 (11.5; 20.3)	16.2 (11.7; 22.4)	17.1 (12.2; 23.9)	19.3 (14.6; 25.3)	<10
Cholesterol (mg)	227.0 (132.4; 376.8)	214.7 (122.5; 362.6)	202.7 (115.2; 344.3)	178.9 (108.2; 288.8)	<300
Sodium (g)	2.8 (1.7; 4.4)	2.6 (1.5; 4.2)	2.5 (1.4; 4.0)	2.2 (1.3; 3.5)	<2.4
Added sugar (en%)	18.8 (5.0; 39.2)	17.5 (4.2; 37.8)	16.2 (3.6; 36.1)	13.7 (2.7; 31.3)	<10
Energy (kcal)	2241 (1402; 3357)	2171 (1342; 3279)	2100 (1296; 3187)	1956 (1226;2924)	<2000
Fiber (g)	20.7 (11.7; 33.1)	21.0 (12.0; 33.3)	21.3 (12.4; 33.5)	22.0 (13.2; 33.8)	30-40

[1] Median of multiple sampling (100 times)
[2]SAFA: saturated fatty acids; TFA: trans fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids
[a] Rec: Recommended daily intake (upper limit) for SAFA, TFA, sodium, energy, fiber, MUFA, PUFA and protein as recommended by the Dutch Health Council (18). There are no recommendations for added sugar and cholesterol in the Netherlands; therefore, the recommendations for these nutrients were based on WHO recommendations (added sugar recommendations are for free sugars) (19).

12.04 to 12.13 en% and 0.74 to 0.76 en% for SAFA and TFA respectively in the medium scenario. The other nutrients showed similar narrow ranges.
The last column of Table 1 shows the recommended daily intakes. Figure 2 illustrates the percentage of the total adult population who complied with the recommendations for the nutrients used in the replacement procedure. It is shown that 54.0% of the population complied with the recommendations for SAFA in the maximum scenario, 60.2% for sodium and 53.3% for energy. For TFA, the reference median intake already complied with the recommendation of <1 en%. It is shown that for

Figure 2. Percentage of total adult population complying with recommendations for SAFA, TFA, sodium, added sugar, energy and fiber in the different scenarios[1].



[1]Recommended daily intake (upper limit) for SAFA, TFA, sodium, energy and fiber as recommended by the Dutch Health Council (see Table 1 for values) (18). There is no recommendation for added sugar; therefore this recommendation was based on WHO recommendations (19).

added sugar, 32.2% of the population complied with the recommendations in the maximum scenario, but that only 3.8% complied with the recommendations regarding fiber.

Table 2 shows the five product groups which contributed most to changes in SAFA and TFA median intakes (two nutrients of importance regarding cholesterol levels), the number of non-complying products which were replaced by complying products from the food composition table, and some replacement examples that are responsible for the changes. The table illustrates that replacing cheese products and processed meats contributed most to the SAFA reduction when comparing the maximum scenario with the reference intake. Replacing oils, fats and fat containing spreads caused the largest reduction in TFA intake.

Table 2. The five product groups which contributed most to the changes in SAFA and TFA median intakes, the number of non-complying products which were replaced by complying products from the Dutch food composition table (2006), and some replacement examples responsible for the changes.

Product group	P50 change (%) SAFA[1]	P50 change (%) TFA[1]	Number of products replaced (total number of non-complying products)	Product example	Replaced by
Bread	-10.3	-25.9	33 (42)	All types of cracker	Light crackers
				All types of bread	Tarvo bread
				Bread without gluten	NOT REPLACED
Processed meat, meat products and meat substitutes	-57.3	-50.8	96 (156)	All types of processed beef products	Beefsteak (pre-prepared)
				Organ meats, croquettes, sausages	NOT REPLACED
Dairy products	-38.2	-34.7	77 (142)	Full-fat yoghurt	Low-fat yoghurt
				Fall-fat fruit yoghurt	Low-fat fruit yoghurt
				Creamers, crème fresh	NOT REPLACED
Oils, fat and fat-containing spreads	-36.9	-87.1	43 (55)	All types of butter	Low-fat margarine
Cheese (products)	-61.4	-61.4	44 (59)	All types of regular cheese	Low-fat cheese
				All types of cheese spread	Low-fat cheese spread
				Special cheeses	NOT REPLACED

[1]Percentage of changes in saturated fatty acids (SAFA) and trans fatty acids (TFA) median (P50) intakes when comparing the median intakes of the maximum scenario with the reference scenario per product group.

Cholesterol
Table 3 shows the effects of the different scenarios on the cholesterol level of the total adult population. It is shown that LDL and total cholesterol levels reduced slightly when the minimum, medium and maximum scenarios were compared with the reference scenario. HDL was found to be reduced as well, resulting in a small change in the total/HDL ratio.

Table 3. Effect of scenarios on cholesterol levels for total Dutch adult population, using Katan Calculator (17) (Input: P50 of SAFA, MUFA, PUFA, TFA, cholesterol, protein; minimum, medium and maximum scenario compared with reference scenario). [1]

Scenario	Minimum	Medium	Maximum
Change LDL (mmol/l)	-0.07	-0.13	-0.25
Change HDL (mmol/l)	-0.01	-0.03	-0.05
Change total chol. (mmol/l)	-0.08	-0.16	-0.31
Change Total/HDL Ratio	-0.01	-0.02	-0.03

[1] *SAFA: saturated fatty acids; TFA: trans fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.*

Discussion

This is the first study that has investigated the potential impact of consuming a diet which complies with the criteria for the Choices logo, a front-of-pack 'healthier choice' logo, on cholesterol levels by conducting a modeling study. Our findings show that when all foods that can be replaced by foods that comply with the criteria for the Choices front-of-pack label are replaced (maximum scenario), population cholesterol levels are likely to reduce slightly.

Nutrient intake
Whereas the minimum and the medium scenario reveal a small move in nutrient intake towards the recommendations, the median intakes reached the recommended levels for the nutrients SAFA, sodium and energy in the maximum scenario only. However, sodium intake will be higher in reality, because added sodium was not taken into account. If one aims to achieve the recommended levels for the total population, these findings show that these scenarios are just a starting point from which to further stimulate food reformulation and healthy food choices. A more positive effect on intake and consequently on public health could be achieved by applying more stringent logo criteria for nutrient levels in each food group. With regard to added sugar and fiber, the intakes in the maximum scenario are still far from the recommendations, stressing the importance of paying extra attention to these nutrients.

Cholesterol and CHD
In all scenarios, a small reduction in mean cholesterol levels was predicted, which may result in a reduction of the risk of CHD. Interestingly, there is a large body of evidence regarding the negative health effects of excessive SAFA intake on cholesterol levels and CHD, and the positive effects of replacing SAFA with PUFA (12-14). Therefore, it is recommended that a shift towards greater PUFA consumption in place of SAFA would significantly reduce rates of CHD (14). In our scenarios, we did find a reduction in SAFA, but we did not find a large increase in PUFA. It would be interesting to further explore the possibilities for product reformulation by food manufacturers, and the technological feasibility of (partly) replacing SAFA with PUFA.
Furthermore, while some review studies use total cholesterol as a marker to predict CHD and others use LDL cholesterol levels, the total/HDL cholesterol ratio appears to be one of the strongest predictors of CHD risk, although the precise role of HDL in relation to CHD is not yet clear (23, 24). Epidemiological studies suggest that a one unit change in total/HDL cholesterol is associated with a 53% change in the risk of myocardial infarction (MI) (25), which could be translated to an MI risk reduction of 1.59% for our maximum scenario. Although this is a very small risk reduction on an individual level, it may be substantial on a population level. As Rose states in his book 'The strategy of preventive medicine' (26): *When many people each receive a little benefit, the total benefit may be large.* This can be explained by the fact that those people who are slightly above the centre of the population distribution will move to a lower risk. For an individual, the risk reduction may be negligible, but collectively, on a population level, the effect is large. Browner and colleagues modeled that if Americans reduced their fat intake from 37 en% to 30 en%, the risk of CHD in elderly people may be reduced by 5% (27). At a population level, the researchers translate this risk reduction to 60 million years of additional life for the American population. However, on an individual level, this means a possible gain of three or four months in life expectancy. These benefits will be greater for high-risk groups, but may equal zero for someone with no risk factors. We did not differentiate between high-risk groups in our study, which could be an interesting topic for future studies. The risk of CHD obviously depends on many other risk factors as well such as prior coronary events, blood pressure, glucose tolerance, inflammatory markers, body mass index, physical activity, age and total dietary pattern (24, 28).

Study limitations
Scenario modeling has its inherent limitations, especially because of its many assumptions. In the first place, what foods may be replaced by which alternatives is theoretical; we attempted to tackle this to some extent by using three independent researchers to decide upon likely replacements. Second, we assumed that people would eat as much of the replacement foods as they ate of their traditional choice. It may be that people will eat more of products they perceive to be healthier. Provencher and colleagues showed that the perception that a cookie was healthy increased the actual intake of the food (29). Nevertheless, Steenhuis and colleagues showed no increased intake when comparing the consumption of a cake with the Choices logo to the same cake without it (30) (note that this cake was not perceived as healthy). These studies focused on only one product and therefore further research is required regarding overall dietary patterns. A third limitation is that the minimum

scenario was based on a single study that may not be fully representative of the population at large (6). The assumption that 24% of adults would change to a diet that is fully compliant with the label's criteria may thus be too optimistic, although we currently have no evidence about what would be a more realistic scenario. Future studies could explore what percentage of compliant products is typical for an average consumer, and include this percentage in more realistic scenario calculations (for example 24% of the population consuming a diet with 10% of products that are compliant). However, if lower than 24% is more realistic than the present 'minimum' scenario, then the effects on nutrient intakes and subsequently on cholesterol levels will be even smaller. Fourth, the available national representative food consumption data used were based on self-reports, and were somewhat outdated.

Future research

In spite of these limitations, this study provides unique initial insights into the potential effects of consuming a diet which complies with the criteria for a front-of-pack label on cholesterol levels. This study focused on modeling the effects on cholesterol levels. It did not examine other potential effects on related intermediaries and health outcomes, such as BMI, blood pressure, stroke, diabetes and cancer, which are obviously interrelated. Therefore, it would be interesting for future modeling studies to develop a model which takes other intermediaries and health outcomes into account.

Further, we realize that modeling studies are limited by the fact that all outcomes are potential outcomes. Further research should therefore also focus on actual health outcomes in real-life settings. Ireland and colleagues showed that nutrition education about the front-of-pack symbol Pick the Tick (from Australia and New Zealand) significantly decreased urinary sodium excretion (31). We recommend that future studies follow, for example, a cohort of consumers consuming a diet which complies with the criteria for a front-of-pack label and to measure biomarkers, such as blood lipid levels and urinary sodium excretion.

Conclusions

Our findings suggest that the consumption of foods which comply with the criteria for a front-of-pack label may contribute moderately to cardiovascular risk reduction via influencing blood lipids. These findings did not take into account other potential effects on related intermediaries and health outcomes, such as blood pressure, BMI, stroke, diabetes and cancer. Further research should focus on biomarkers in real-life settings in order to investigate the real public health impact of front-of-pack nutrition labels on our society.

Conflicts of interest and authors' affiliations

Annet Roodenburg is seconded at the VU University Amsterdam and employed by Unilever R&D, the Netherlands. Hans Verhagen works at the National Institute for Public Health and the Environment (RIVM), the Netherlands. He was requested by the Dutch Ministry of Health, Welfare and Sports (MinVWS) to actively participate in the project group in order to assure agreement on the quality, however leaving the responsibility for the project with the Choices Foundation; the RIVM is an agency of the MinVWS. Rest of the authors declare no conflicts of interest. Marieke Hendriksen

and Joop van Raaij are also employed by the RIVM. Ellis Vyth, Ingrid Steenhuis and Jacob Seidell are employed by the Department of Health Sciences and the EMGO Institute for Health and Care Research, VU University Amsterdam, the Netherlands. Johannes Brug is employed by the Department of Epidemiology and Biostatistics, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, the Netherlands.

References

1. WHO. Global strategy on diet, physical activity and health. Fifty-seventh World Health Assembly. WHA57.17. Geneva: World Health Organization, 2004.
2. Institute of Medicine. Examination of Front-of-Package Nutrition Rating Systems and Symbols: Phase I Report. In: Wartella E, Lichtenstein A, Boon C, eds. Washington DC: Institute of Medicine, 2010.
3. Stockley L. Review of 'front of pack' nutrition schemes. Brussels: European Heart Network, 2007.
4. Dötsch-Klerk M, Jansen L. The Choices programme: a simple, front-of-pack stamp making healthy choices easy. Asia Pac J Clin Nutr 2008;17:383-386.
5. Vyth EL, Steenhuis IH, Mallant SF, et al. A Front-of-Pack Nutrition Logo: A Quantitative and Qualitative Process Evaluation in the Netherlands. J Health Commun 2009;14:631-45.
6. Vyth EL, Steenhuis IH, Vlot JA, et al. Actual use of a front-of-pack nutrition logo in the supermarket: consumers' motives in food choice. Public Health Nutr 2010;13:1882-9.
7. Vyth EL, Steenhuis IH, Heymans MW, Roodenburg AJ, Brug J, Seidell JC. Influence of placement of a nutrition logo on cafeteria menu items on lunchtime food Choices at Dutch work sites. J Am Diet Assoc 2011;111:131-6.
8. Vyth EL, Steenhuis IH, Roodenburg AJ, Brug J, Seidell JC. Front-of-pack nutrition label stimulates healthier product development: a quantitative analysis. Int J Behav Nutr Phys Act 2010;7:65.
9. Roodenburg AJC, Temme EHM, Howell Davies O, Seidell JC. Potential impact of the Choices Programme on nutrient intakes in the Dutch population. Nutrition Bulletin 2009;34:318-323.
10. Temme EH, van der Voet H, Roodenburg AJ, Bulder A, van Donkersgoed G, van Klaveren J. Impact of foods with health logo on saturated fat, sodium and sugar intake of young Dutch adults. Public Health Nutr 2011: doi:10.1017/S1368980010002089.
11. Sacks G, Veerman JL, Moodie M, Swinburn B. 'Traffic-light' nutrition labelling and 'junk-food' tax: a modelled comparison of cost-effectiveness for obesity prevention. Int J Obes 2010;doi:10.1038/ijo.2010.228
12. Jakobsen MU, O'Reilly EJ, Heitmann BL, et al. Major types of dietary fat and risk of coronary heart disease: a pooled analysis of 11 cohort studies. Am J Clin Nutr 2009;89:1425-32.
13. Mensink RP, Zock PL, Kester AD, Katan MB. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. Am

J Clin Nutr 2003;77:1146-55.
14. Mozaffarian D, Micha R, Wallace S. Effects on coronary heart disease of increasing polyunsaturated fat in place of saturated fat: a systematic review and meta-analysis of randomized controlled trials. PLoS Med 2010;7:e1000252.
15. The Netherlands Nutrition Centre. The Dutch National Food Consumption Survey 1997-1998. The Hague: The Netherlands Nutrition Centre, 1998.
16. National Institute for Public Health and the Environment R. Dutch Food Composition Database. Bilthoven, 2006.
17. Katan MB. Katan calculator: predicted effect of diet on blood lipids and lipoproteins. Web tool available at www.katancalculator.nl. Accessed: January 2011.
18. The Health Council of the Netherlands. Guidelines for a healthy diet 2006. The Hague: The Health Council of the Netherlands, 2006.
19. FAO/WHO. Diet, Nutrition and the Prevention of Chronic Diseases. Report of a Joint FAO/WHO Expert Consultation. Geneva: World Health Organisation, 2003.
20. Katan MB. Alternatives to low-fat diets. Am J Clin Nutr 2006;83:989-90.
21. Mozaffarian D, Katan MB, Ascherio A, Stampfer MJ, Willett WC. Trans fatty acids and cardiovascular disease. N Engl J Med 2006;354:1601-13.
22. Weggemans RM, Zock PL, Katan MB. Dietary cholesterol from eggs increases the ratio of total cholesterol to high-density lipoprotein cholesterol in humans: a meta-analysis. Am J Clin Nutr 2001;73:885-91.
23. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). JAMA 2001;285:2486-97.
24. 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.
25. Stampfer MJ, Sacks FM, Salvini S, Willett WC, Hennekens CH. A prospective study of cholesterol, apolipoproteins, and the risk of myocardial infarction. N Engl J Med 1991;325:373-81.
26. Rose G. The strategy of preventive medicine. New York: Oxford university press, 1992.
27. Browner WS, Westenhouse J, Tice JA. What if Americans ate less fat? A quantitative estimate of the effect on mortality. JAMA 1991;265:3285-91.
28. Astrup A, Dyerberg J, Elwood P, et al. The role of reducing intakes of saturated fat in the prevention of cardiovascular disease: where does the evidence stand in 2010? Am J Clin Nutr 2011; doi: 10.3945/ajcn.110.004622.
29. Provencher V, Polivy J, Herman CP. Perceived healthiness of food. If it's healthy, you can eat more! Appetite 2009;52:340-4.
30. Steenhuis IH, Kroeze W, Vyth EL, Valk S, Verbauwen R, Seidell JC. The effects of using a nutrition logo on consumption and product evaluation of a

sweet pastry. Appetite 2010;55:707-9.
31. Ireland DM, Clifton PM, Keogh JB. Achieving the salt intake target of 6 g/day in the current food supply in free-living adults using two dietary education strategies. J Am Diet Assoc 2010;110:763-7.