Changes in Serum Cholesterol and Diet in North Karelia and All Finland

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ABSTRACT

Finland in the 1960s, and especially North Karelia in the eastern part of the country, had the highest cardiovascular mortality in the world. The classical cardiovascular risk factors were all common, but serum cholesterol level was extremely high because of the very high intake of saturated fats, mainly from dairy products. The North Karelia Project was started as a comprehensive preventive program to reduce serum cholesterol levels by reducing the intake of saturated fats and increasing the intake of polyunsaturated fats in the whole population. Cross-sectional population surveys were done in North Karelia and nearby Kuopio province every 5 years starting in 1972. After 1982, surveys were started in 2 other areas. Blood cholesterol was measured from serum samples, and diet was assessed by a questionnaire in all surveys—since 1982 by 3-day food record, since 1997 by 24-hour recall, and since 2002 by 48-hour recall. Between 1972 and 2012, the population in North Karelia reduced serum cholesterol from 6.92 mmol/l to 5.46 mmol/l (21%) in men and from 6.81 mmol/l to 5.37 mmol/l (21%) in women. In men, serum cholesterol level reduced more in North Karelia than in the reference province of Kuopio during the first 5 years from 1972 to 1977. Since that time, changes in serum cholesterol level have been very similar in different parts of the country. Saturated fats were reduced from 20% of energy intake to 12% in 2007 but increased from 2007 to 2012 to 14%. In conclusion, serum cholesterol reduction by dietary changes is feasible on the population level but requires active work and large-scale cooperation between all the meaningful sectors in the society.

Before the 1970s, North Karelia was a poor, rural area. Small farming and forest industry were the main occupations. After the Second World War, the living standard started to improve rapidly. The dairy industry developed and people had enough food to eat. Dairy products were highly valued and a diet with a high intake of butter, crème, full milk, cheese, and milk were regarded as especially healthy. It was, therefore, painful to recognize that this diet seemed to be one of the main reasons for high mortality rates from cardiovascular diseases.

During the 1960s, Finland grew painfully aware of its massive burden of ischemic heart disease. The Seven Countries Study showed that Finnish men had higher serum cholesterol level than any other population in the world [1,2]. Intake of saturated fats especially in the rural areas was 20% of energy intake in late 1960s and intake of polyunsaturated fats was little over 3%. The main source of fat was milk fat in different forms. Domestic vegetable oils were not available until late 1980s, when the rapeseed oil production was developed in the country.

Because all the classical risk factors—serum cholesterol, blood pressure, and smoking—were high among the population in North Karelia, as in all Finland, reduction of these risk factors become the goal of the North Karelia Project. Because serum cholesterol levels were exceptionally high owing to the local diet, changes in population nutrition become a key target in the intervention through a comprehensive nutrition program.

NUTRITION PROGRAMS IN NORTH KARELIA AND NATIONALLY

The nutrition program aimed to reduce serum cholesterol level among the whole North Karelian population. The main intermediate objective was reduction of saturated fat consumption. Other intermediate objectives were to increase polyunsaturated fats, to decrease dietary cholesterol and to increase dietary fiber. The following advice was given to population:

- Use low-fat milk, nonfat milk, or sour milk instead of high-fat or whole milk;
- Use other low-fat dairy products instead of high-fat products;
- Cut down the amount of butter or margarine on bread and change to soft margarine or soft butter (mixture of butter and oil);
- Cut visible fat off of meat, choose lean meat and sausages, and prefer fish and poultry;
- Prepare food without adding extra (animal) fat; in cooking prefer boiling and baking;
- Use vegetable oil in salad dressing and when baking;

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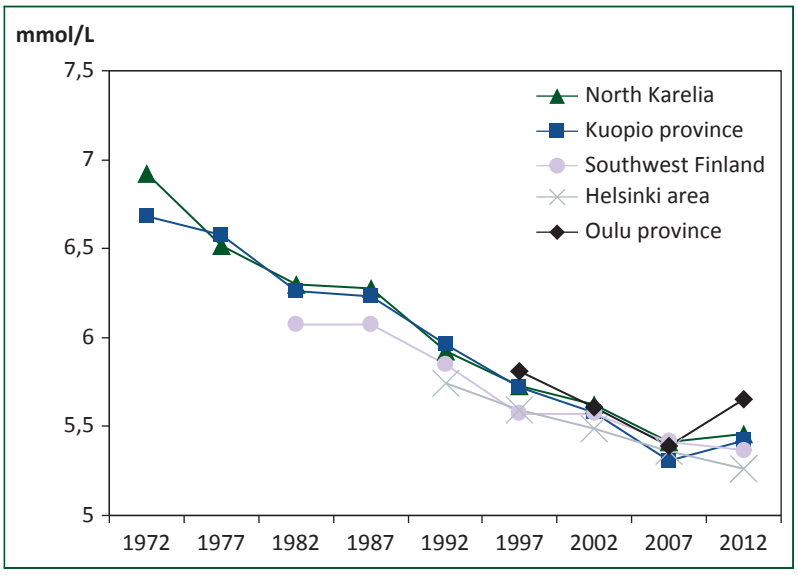

FIGURE 1. Serum cholesterol levels in men 30 to 59 years old.

- Restrict the use of eggs (egg yolk) to only a couple per week;
- Increase intake of whole-grain cereals; and
- Increase consumption of vegetables, roots, berries, and fruits.

These nutrition messages were spread through different channels and in connection with different activities in the community. During the original project period (1972 to 1977) a total of 342 newspaper articles were published in addition to 769 articles dealing also other risk factors, and >100,000 leaflets were distributed. Hundreds of training seminars were organized for health care workers, mass catering personnel, and the general public.

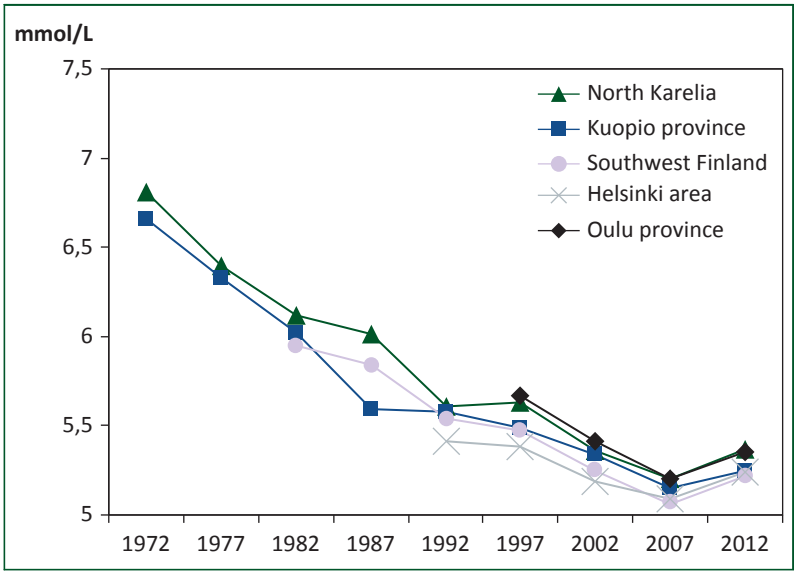

FIGURE 2. Serum cholesterol levels in women 30 to 59 years old.

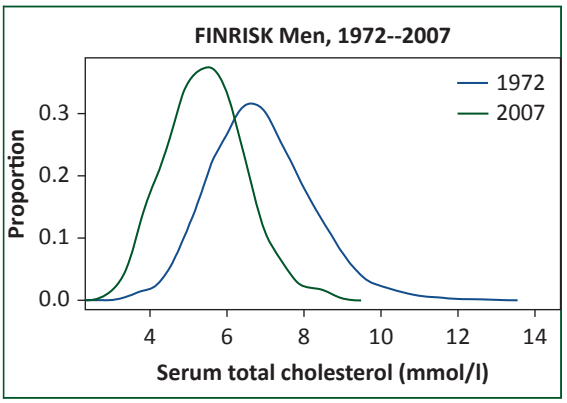

FIGURE 3. Cholesterol distribution in North Karelia in 1972 and 2007 in men.

Diet was discussed in 167 health education meetings attended by 12,100 participants. Local housewives' associations (the Martha Association) organized 344 special "parties of long life" in local villages where healthy food was cooked and served to village members. More than 1,500 people participated in these meetings. Special training meetings were organized to change the diet in mass catering at work places, schools, hospitals, and restaurants.

On the national level, since 1980s several sectors became involved. National dietary guidelines were published for the first time in 1981 by the National Nutrition Council. A national cholesterol consensus meeting was hold in 1989. Guidelines on the prevention of coronary heart disease in Finland were published in 1987, together with national health authorities and voluntary organizations. Since that time, these documents have been updated regularly.

The government became more involved and put forth a health policy statement in 1985, recognizing the role of healthy nutrition as an important goal. The law on dietary fats in 1987 allowed mixing dietary fats and oils to make new type of products available. The Finnish food industry has, with increasing health consciousness of consumers, been very active in developing new low-fat products. In addition to low-fat milks and spreads, low-fat cheese, ice cream, sausages, and other products have appeared in the markets. Later, margarine with plant sterols was developed [3]. A new variety of rapeseed oil was developed and it became widely used in homes and the margarine industry. Many voluntary organizations have also been very active, especially the Finnish Heart Association. Large-scale public health campaigns were organized in mass media. Health issues became an important topic also in magazines, newspapers, and TV and radio programs.

EVALUATION OF SERUM CHOLESTEROL AND DIETARY CHANGES

The National Institute for Health and Welfare (formerly the National Public Health Institute) has carried out risk factor

surveys in 5-year intervals since 1972. Methods have been described in more detail elsewhere [4]. The first and second surveys in 1972 and 1977 were carried out in eastern Finland in North Karelia and Kuopio province to evaluate the North Karelia Project. In subsequent survey years, new areas were added to improve national representativeness of the monitoring, namely, Turku and Loimaa regions in southwestern Finland in 1982, the capital area including cities of Helsinki and Vantaa in 1992, and the provinces of Northern Ostrobothnia and Kainuu (former Oulu province) in north western Finland in 1997.

For each survey, an independent random sample was drawn from the national population register. For the surveys in 1972 and 1977, a random sample of 6.6% of the population born between 1913 and 1947 was drawn in both survey areas. Later a random sample stratified by sex and 10-year age group was drawn from the population aged 25 to 64 years separately for each survey area. For the 2007 and 2012 surveys, the age group was 25 to 74 years. Because the sampling has differed slightly between the surveys, a common age range for all these surveys, also used in the current analyses, is 30 to 59 years.

Venous blood samples were centrifuged at field survey sites and transferred daily for cholesterol measurements to the National Institute for Health and Welfare laboratory. In 2007 and 2012, the sera were frozen immediately after separation and transferred weekly in dry ice to the laboratory for analyses. In 1972 and 1977, serum total cholesterol was determined from fresh samples using the Liebermann–Burchard method. In the other surveys, the analyses have been carried out using an enzymatic method. As the enzymatic method gave 2.3% lower values than the Liebermann–Burchard method, the serum total cholesterol values in 1972 and 1977 have been corrected by the same amount. In 2007 and 2012, serum total cholesterol was measured by an enzymatic assay (Abbott Laboratories, Abbott Park, IL, USA) with Abbott Architect c8000 clinical chemistry analyzer. The laboratory in the National Institute for Health and Welfare has taken part in both national and international quality assurance systems first with the World Health Organization center in Prague and in the last 3 surveys with the Centers for Disease Control and Prevention in Atlanta. The dietary questions comprised about 20 multiple choice questions on dietary habits in a general health questionnaire. From 1982 to 1997, a 3-day food record was collected; from 1997 to 2002, a 24-hour dietary recall was collected, and since 2002 a 48-hour recall was done for a subsample of surveys [5].

RESULTS

During the first 5 years, serum cholesterol level decreased faster in North Karelia than in the reference area Kuopio province especially in men. Since that time, the change has been similar in all studied areas (Figs. 1 and 2). From 1972 to 2007, cholesterol levels decreased in North Karelia by 22% in men and 23% in women (from 6.92 to 5.41 mmol/l in men and 6.81 to 5.20 mmol/l in women). The cholesterol distribution has shifted to lower level and extreme cholesterol values have almost disappeared (Fig. 3).

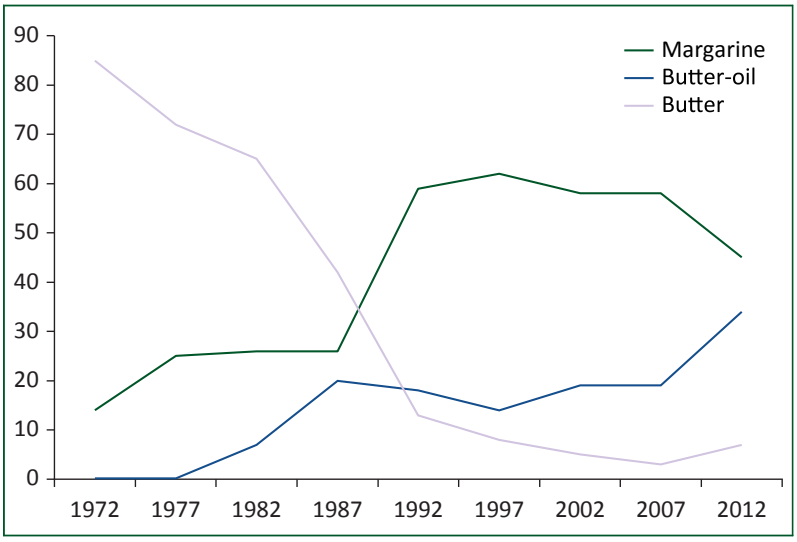

FIGURE 4. Spread used on bread, men 30 to 59 years old.

Between the 2007 and 2012 survey, there was a small increase (1.3% in men and 2.3% in women) in all areas in Finland. The pooled 2012 mean for all areas in cholesterol was 5.43 mmol/l in men and 5.29 mmol/l in women. In North Karelia, the respective means were 5.46 mmol/l in men and 5.37 mmol/l in women.

There have been major behavioral changes in diet. In 1972, almost 90% were using butter on bread and in last surveys in 2007 and 2012 this number was <10%. Butter has been replaced by soft margarines and butter-oil spreads

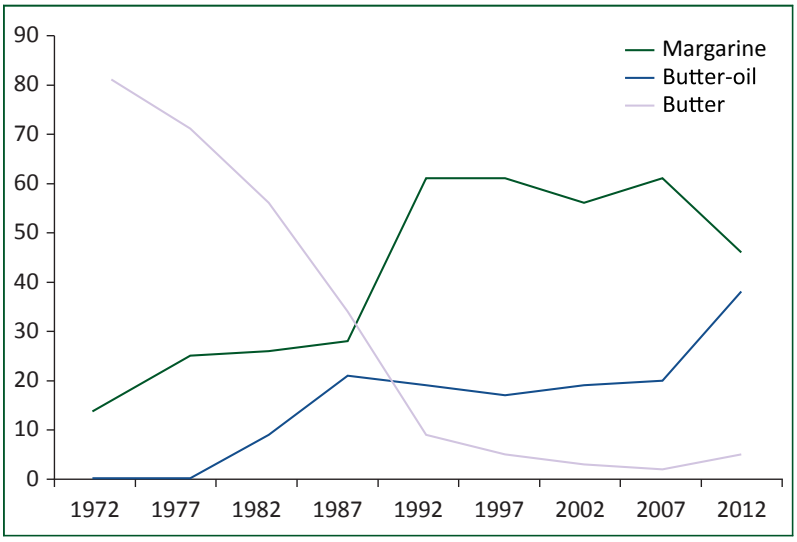

FIGURE 5. Spread used on bread, women 30 to 59 years old.

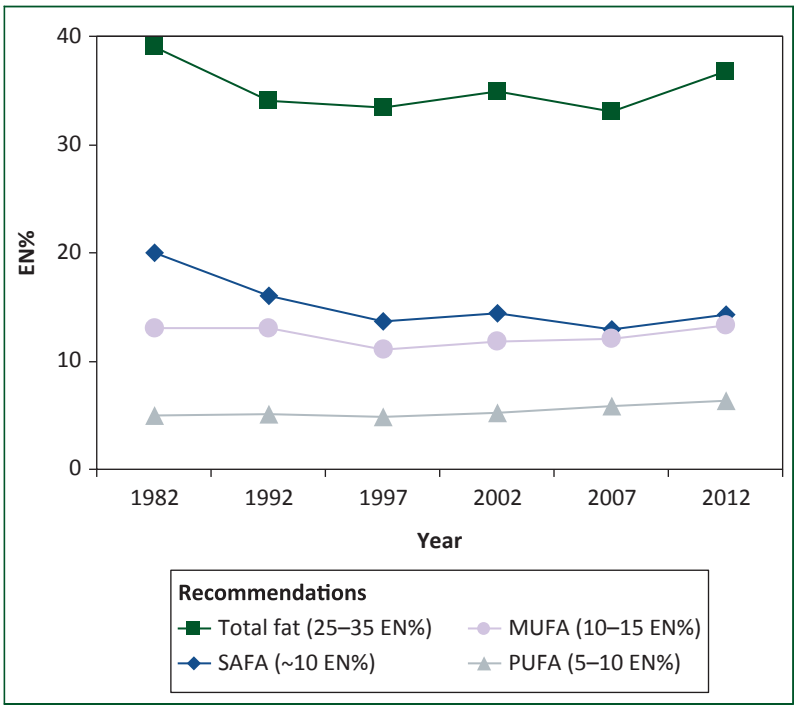

FIGURE 6. Fat intake, men 25 to 64 years old. MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SAFA, saturated fatty acids.

(Figs. 4 and 5). In 1972, almost 70% were using butter for cooking and use of vegetable oils was <10%. In last surveys, use of butter was about 20% and use of vegetable oils about 50%.

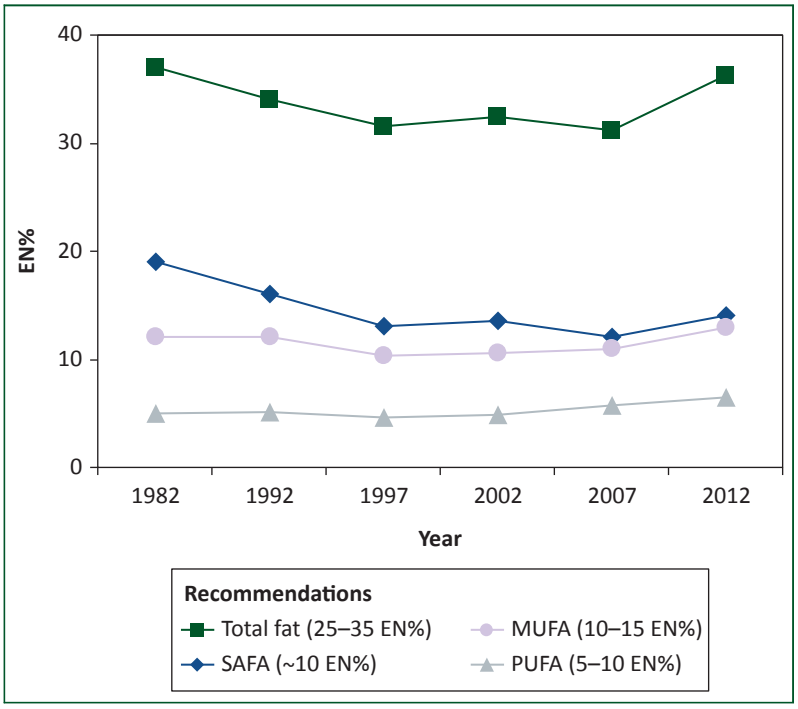

FIGURE 7. Fat intake, women 25 to 64 years old. Abbreviations as in Figure 6.

Three-day food records or 24-hour or 48-hour recalls have been done since 1982. Saturated fat intake as energy percent decreased from 20% being the lowest in 2007 (12%) and increased to 14% in 2012 (Figs 6 and 7).

From 1982 to 2007, the decrease in serum cholesterol level was 0.86 mmol/l among 25- to 64-year-old men and women (Figs 8 and 9). Decreases in the intake of saturated and trans fats, increases in the intake of polyunsaturated fats, and decreases in the intake of dietary cholesterol predicted a 0.56 mmol/l decline in serum cholesterol level. The increase use of statins explains 0.14 mmol/l of the decrease if we assume that statins reduce cholesterol level on the average 25%. Among women, the serum cholesterol decreased by 0.97 mmol/l and dietary changes predicted a 0.58 mmol/l decrease and increase use of statins 0.06 mmol/l. From 2007 to 2012, serum cholesterol increased 0.05 mmol/l and, based on the increase in the intake of saturated fats and dietary cholesterol, the predicted change was 0.11 mmol/l. In women, observed increase was 0.16 mmol/l and predicted 0.15 mmol/l.

DISCUSSION

It was estimated that in North Karelia, the >20% decrease in serum cholesterol level alone could explain about 40% of the decrease in coronary heart disease mortality. Especially in men, the cholesterol decrease was faster during the first 5 years of the program but after the activities were moved to national level the development has been quite similar also in other areas in the country. Dietary changes, decreases in the intake of saturated and trans fatty acids, and increases in the use of polyunsaturated fats can explain most of the serum cholesterol decline. In the 1990s, an increased use of statins explains a small part of the mean serum cholesterol change, especially in the upper end of the distribution.

From cultural point of view, the possibilities to change the diet in all populations was not very promising in 1972. North Karelia was a poor, rural area where dairy farming was one of the main sources of income, milk fat was the main fat used, and it was highly valued among the population. However, people recognized that young men died from coronary heart disease and the project was originally started after petition of people in North Karelia. Gradually, people started to accept the needed dietary changes and the diet started to change. The main messages on cardiovascular disease prevention started to spread also to all country. After the first 5 years, the messages were distributed systematically through different channels and through various activities, such as national television services.

The major change in diet was not only a behavioral change. It required deep changes in agricultural policy, food industry, marketing, recommendations, and laws and regulations in Finland. It took >10 years before the

government adopted the changes in the health policy statement, which included the healthy diet. In addition, in the Finnish scientific community, there was much controversy on the interplay of diet, cholesterol, and coronary heart disease. The first population-wide dietary recommendation to all population was released in 1981 to reduce the intake of saturated fats. However, it took until 1989 when there was a consensus meeting on blood cholesterol and great majority of the medical community approved that lowering cholesterol would reduce coronary heart disease.

During the past few decades, there has been a lot of cooperation with the food industry; many debates have ensued. In general, because of growing national awareness, the food industry took the national dietary guidelines quite seriously in their product development. Soft margarines were developed, trans fats were eliminated from margarines and other products, rapeseed growing and production of domestic vegetable oil was started, low-fat cheese was developed, and special margarine with plant stanols or sterols were developed. The meat industry reduced saturated fats in processed meat products and replaced it with unsaturated fats. In the beginning, the dairy industry was strongly against the dietary changes, but gradually they also started to develop low-fat products.

Most of the original dietary recommendations of the North Karelia Project are still valid in the Finnish society and are in line with the current national nutrition recommendations. Hard margarines almost disappeared after the role of trans fats was elucidated in the 1980s and soft margarines, vegetable oil margarines, and rapeseed oil have become popular. A substantial source of butter is "soft butter," which contains mainly butter and very little oil.

In last few years, there has been a small rebound in serum cholesterol levels, which can be explained by emerging unfavorable dietary changes. In Nordic countries, there has been a debate mainly related to low carbohydrate diet and milk fat as a "natural product." A lot of different kinds of "healthy" diets were introduced by individuals who regarded themselves as experts in health nutrition. Media excitement ignited this controversy and people were left confused. The monitoring system made it possible to detect the recent small unfavorable change and draw much national attention to the need to continue with evidence-based dietary changes. Thus, health behavior changes are not guaranteed once they have started but require continuing efforts in all sectors in the society and continuous monitoring is essential for good development.

SUMMARY

The experiences from North Karelia and later all Finland show that serum cholesterol reduction by dietary changes is feasible on population level, but require many activities and large-scale cooperation between all the meaningful

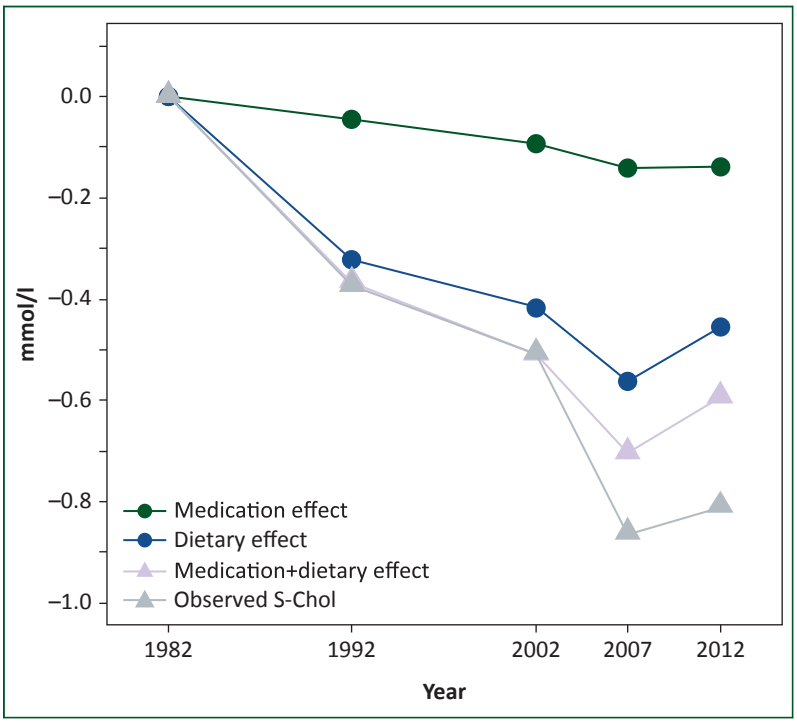

FIGURE 8. Estimated effects on serum cholesterol (S-Chol) in men.

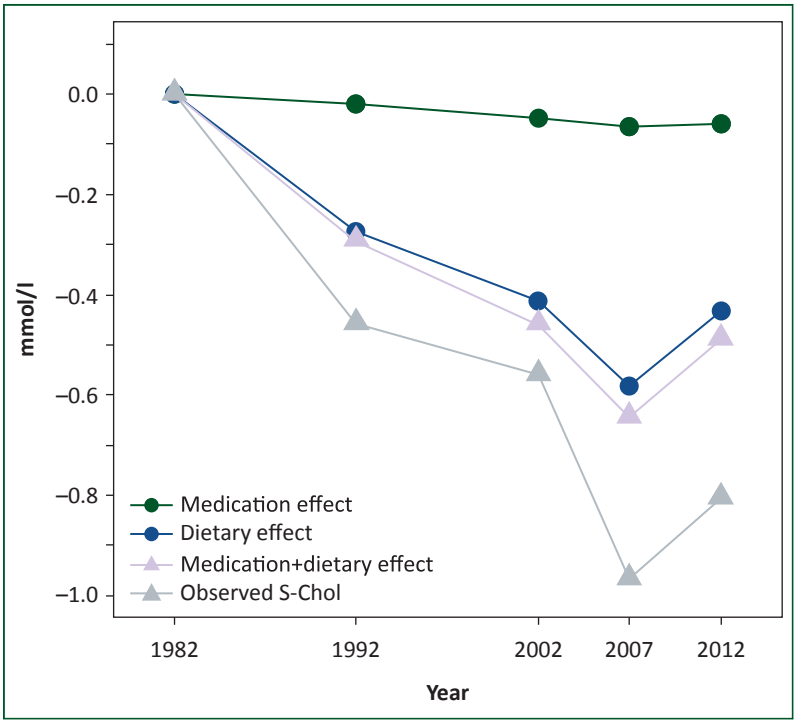

FIGURE 9. Estimated effects on serum cholesterol (S-Chol) in women.

sectors in the society. These dietary changes have had meaningful contribution to an 83% decrease in coronary heart disease mortality among the middle-aged population in Finland.

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