

## CARDIOVASCULAR DISEASE

# Thirty-five-year trends in cardiovascular risk factors in Finland

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**Background** In the late 1960s, coronary heart disease (CHD) mortality among Finnish men was the highest in the world. From 1972 to 2007, risk factor surveys have been carried out to monitor risk factor trends and assess their contribution to declining mortality in Finland.

**Methods** The first risk factor survey was carried out in the North Karelia and Kuopio provinces in 1972 as the basis for the evaluation of the North Karelia Project. Since then, up to five geographical areas have been included in the surveys. The target population has been persons aged 25–74 years, except in the first two surveys where the sample was drawn from a population aged 30–59 years. Risk factor contribution on mortality change was assessed by a logistic regression model.

**Results** A remarkable decline in serum cholesterol levels was observed between 1972 and 2007. Blood pressure declined among both men and women until 2002 but levelled off during the last 5 years. Prevalence of smoking decreased among men. Among women, smoking increased throughout the survey years until 2002 but did not increase between 2002 and 2007. Body mass index (BMI) has continuously increased among men. Among women, BMI decreased until 1982, but since then an increasing trend has been observed. Risk factor changes explained a 60% reduction in coronary mortality in middle-aged men while the observed reduction was 80%.

**Conclusions** The 80% decline in coronary mortality in Finland mainly reflects a great reduction of the risk factor levels; these in turn have been associated with long-term comprehensive chronic disease prevention and health promotion interventions.

**Keywords** Blood pressure, cholesterol, smoking, body mass index, cardiovascular diseases

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## Introduction

At the end of the 1960s, Finnish men, especially men in North Karelia, had the highest international records in coronary heart disease (CHD) mortality.<sup>1</sup>

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In 1972, a comprehensive community-based intervention programme, as a national pilot, was launched in North Karelia to reduce the burden of exceptionally high CHD morbidity and mortality.<sup>2</sup> A comprehensive evaluation including carefully standardized population surveys of risk factors and health behaviours was an important part of the programme. After the initial 5-year period of the North Karelia Project (1972–1977), national preventive activities were gradually implemented, building on many of the principles

and experiences of the North Karelia project. The population risk factor surveys have been carried out at 5-year intervals, at first for the evaluation of the North Karelia project.<sup>3</sup> Later, the surveys have been conducted in connection with the WHO MONICA (Multinational monitoring of trends and determinants in cardiovascular disease) project (1982–1992) and as the National FINRISK Study to monitor the national risk factor trends (1997–2002).<sup>4–8</sup> Since the 1970s, cardiovascular disease (CVD) mortality rates have decreased considerably, first especially in North Karelia and later throughout Finland.<sup>9</sup>

This risk factor monitoring system has been a very important tool in the prevention of chronic diseases in Finland over the years. The information obtained from these surveys has been utilized for prevention planning and policy, and for health communication in the media.<sup>10–13</sup> The aim of this paper is to describe trends in main CVD risk factors and their contribution to the CHD mortality trend in Finland over 35 years.

## Materials and methods

The first and second risk factor surveys in 1972 and 1977 were carried out in eastern Finland in North Karelia and Northern Savo (former Kuopio province). Over the years new survey areas have been added: in 1982 the Turku and Loimaa regions in southwestern Finland, in 1992 the capital area including the cities of Helsinki and Vantaa, and in 1997 Oulu province in northwestern Finland.

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. In the later surveys, a sex and 10-year age group stratified random sample was drawn from the population aged 25–64 years separately for each survey area. The number of subjects in each sex and 10-year age group was 500 in 1982, 500 in North Karelia and 250 in other areas in 1987, and between 1992 and 2002, 250 subjects and 200 in 2007 in all areas. As the sampling in the first and second surveys differed slightly from the later surveys, the common age group for all these surveys is 30–59 years. The samples and participation rates for the common age group are presented in Table 1.

To obtain comparable data on risk factor trends, the methodology of the surveys has been kept as similar as possible. The methods used in the 1972 and 1977 surveys were highly comparable. Since 1982 the survey methodology has closely followed the WHO MONICA protocol.<sup>14</sup> In the 2002 survey, some more detailed recommendations of the European Health Risk Monitoring project were adopted.<sup>15</sup> The surveys included a self-administered questionnaire, physical measurements and blood tests.

The questionnaire, together with the invitation to the health examination, was sent by mail to all the selected subjects. Physical measurements and blood sampling were carried out in local health centres or other survey sites by specially trained nurses.

Blood pressure has been measured by the mercury sphygmomanometer in all surveys. In 1972 and 1977, the cuff length was 23 cm and in the later surveys it was 40 cm. Measurements were made from the right arm of the subject in sitting position. Before the measurements,  $\geq 5$  min rest was requested. The first phase of Korotkoff sounds was recorded as systolic blood pressure and the fifth phase as diastolic blood pressure.

The venous blood samples were centrifuged in the field survey sites and the sera were mailed daily for cholesterol measurements to the laboratory of the National Public Health Institute. In 2007, the sera were frozen immediately after separating serum and transferred in dry ice to the laboratory once a week 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. The methods, instruments and reagents for cholesterol measurement between 1972 and 2002 have been described previously.<sup>16</sup> In 2007, serum total cholesterol was measured by an enzymatic assay (Abbott Diagnostics Europe, Wiesbaden, Germany) using Abbott Architect c8000 clinical chemistry analyzer. The laboratory in the National Public Health Institute has taken part in both national and international quality assurance systems first with WHO centre in Prague and last two surveys with Center for Disease Control in Atlanta.<sup>16</sup>

Smoking was assessed by structured questions in the self-administered questionnaire. Based on their responses, the participants were classified into three categories. Smokers were classified as those who had smoked regularly for  $\geq 1$  year and had smoked during the previous month. Ex-smokers were those who had smoked regularly but had quit  $\geq 1$  month before the survey, and never smokers were those who had never smoked regularly.

For continuous variables the analysis of variance was used to determine the significance of the risk factor changes for each 5-year interval. Proportions were tested using logistic regression. Survey year, area and age were used as covariates. Only those areas where the survey had been carried out in both years were included in the analyses. When interpreting the results, Bonferroni correction was used to adjust *P*-values to eliminate the effect of multiple statistical testing. Also, the age-standardized means for risk factors were calculated, but as the age adjustment

**Table 1** Samples and participation rates for population aged 30–59 years by area and gender in the National FINRISK Study in 1972–2007

	Men		Women	
	Sample <i>N</i>	Participation rate %	Sample <i>N</i>	Participation rate %
<b>North Karelia</b>				
1972	1959	94	2056	96
1977	2063	87	2020	91
1982	1599	77	1511	84
1987	1521	79	1485	87
1992	759	69	750	81
1997	747	72	761	76
2002	779	67 (63 <sup>a</sup> )	769	76 (72 <sup>a</sup> )
2007	616	62 (58 <sup>a</sup> )	611	70 (65 <sup>a</sup> )
<b>Northern Savo (Kuopio)</b>				
1972	2918	91	2949	94
1977	2933	89	2996	92
1982	1459	83	1143	88
1987	762	82	745	87
1992	767	76	734	85
1997	766	70	753	81
2002	754	66 (60 <sup>a</sup> )	754	78 (74 <sup>a</sup> )
2007	615	65 (59 <sup>a</sup> )	617	71 (66 <sup>a</sup> )
<b>Southwestern Finland</b>				
1982	1506	82	1487	87
1987	756	77	761	83
1992	747	75	720	85
1997	770	69	758	75
2002	766	66 (58 <sup>a</sup> )	761	75 (68 <sup>a</sup> )
2007	592	58 (54 <sup>a</sup> )	585	73 (70 <sup>a</sup> )
<b>Helsinki and Vantaa</b>				
1992	751	70	734	74
1997	769	63	777	72
2002	767	62 (56 <sup>a</sup> )	761	71 (65 <sup>a</sup> )
2007	602	57 (52)	601	69 (64 <sup>a</sup> )
<b>Oulu province</b>				
1997	766	66	752	76
2002	748	65 (59 <sup>a</sup> )	744	77 (72 <sup>a</sup> )
2007	603	64 (61 <sup>a</sup> )	611	69 (65 <sup>a</sup> )

<sup>a</sup>Participation rate for those who both returned the questionnaire and went through the health check.

did not change the interpretation of the results, the raw means are reported, keeping the results comparable with earlier reports.<sup>8</sup>

To assess how much the risk factor changes could have contributed to the observed 80% decline in coronary mortality, a logistic regression model developed from the 1972 survey in North Karelia and Northern Savo was used.<sup>6</sup> The mean risk factor levels in each survey were used to estimate the percent change in

risk caused by diastolic blood pressure, cholesterol and smoking changes in men.

## Results

### Serum cholesterol

Serum total cholesterol levels have declined significantly in eastern Finland since 1972 (Table 2).

**Table 2** The mean and categories of total serum cholesterol by area, year and sex

		Total serum cholesterol												
		Men					Women							
	N	Mean	SD	<5.0 mmol/l (%)	5.0-6.49 mmol/l (%)	6.5-7.99 mmol/l (%)	>8.0 mmol/l (%)	N	Mean	SD	<5.0 mmol/l (%)	5.0-6.49 mmol/l (%)	6.5-7.99 mmol/l (%)	>8.0 mmol/l (%)
<b>North Karelia county</b>														
1972	1742	6.92	1.32	6	34	41	20	1880	6.81	1.37	7	36	38	18
1977	1762	6.52	1.22	11	41	37	11	1817	6.40	1.35	13	44	31	11
1982	1229	6.30	1.18	12	47	32	8	1268	6.11	1.32	20	46	25	9
1987	1138	6.25	1.19	14	49	30	8	1246	5.98	1.24	22	48	24	6
1992	519	5.88	1.09	21	52	25	3	600	5.56	1.09	33	50	14	3
1997	537	5.65	1.08	28	50	20	2	573	5.55	1.10	32	49	16	3
2002	492	5.74	1.12	24	55	18	3	551	5.47	0.98	35	52	11	1
2007	357	5.45	1.0	36	54	9	2	397	5.24	1.01	46	47	6	1
<b>Northern Savo county</b>														
1972	2513	6.68	1.21	7	40	41	13	2607	6.66	1.29	9	39	37	14
1977	2601	6.58	1.23	8	42	38	11	2731	6.33	1.28	14	45	31	10
1982	1206	6.26	1.21	13	51	28	8	1001	6.01	1.28	21	48	24	7
1987	599	6.20	1.24	16	47	29	9	629	5.86	1.17	22	53	20	5
1992	581	5.91	1.08	20	52	24	4	619	5.53	1.03	32	50	17	1
1997	539	5.65	1.00	25	58	16	2	611	5.41	0.98	37	47	14	1
2002	449	5.69	1.17	25	55	18	2	555	5.45	0.95	33	53	12	1
2007	365	5.34	1.03	41	52	6	2	409	5.19	0.97	47	47	5	1
<b>Southwestern Finland</b>														
1982	1233	6.06	1.11	16	52	26	5	1291	5.93	1.19	21	50	23	6
1987	566	6.03	1.19	18	50	27	6	612	5.80	1.21	27	47	21	5
1992	562	5.80	1.08	23	55	19	3	609	5.49	1.09	36	47	15	2
1997	530	5.49	1.01	31	54	14	1	568	5.39	0.95	36	52	11	1
2002	488	5.68	1.07	27	51	21	2	518	5.36	0.99	38	49	11	2
2007	317	5.35	0.98	35	59	5	1	403	5.09	0.93	49	48	3	0
<b>Helsinki and Vantaa cities</b>														
1992	527	5.69	1.08	28	50	20	2	542	5.36	1.04	39	48	11	2
1997	481	5.51	1.10	31	53	13	2	557	5.31	0.96	40	48	12	0
2002	428	5.60	1.14	29	54	15	2	489	5.29	0.99	42	48	9	2
2007	314	5.40	0.90	33	59	8	1	383	5.13	0.91	48	48	4	0

(continued)

Table 2 Continued

		Total serum cholesterol													
		Men					Women								
N	Mean	SD	<5.0 mmol/l (%)	5.0-6.49 mmol/l (%)	6.5-7.99 mmol/l (%)	>8.0 mmol/l (%)	N	Mean	SD	<5.0 mmol/l (%)	5.0-6.49 mmol/l (%)	6.5-7.99 mmol/l (%)	>8.0 mmol/l (%)		
<b>Oulu province</b>															
1997	5.73	1.02	24	54	21	1	565	5.59	1.03	29	54	15	2		
2002	5.72	1.07	24	56	19	2	534	5.52	0.95	30	56	13	1		
2007	5.43	1.00	38	53	9	1	397	5.24	0.91	42	54	4	0		
<b>ANOVA</b>															
	72-77	77-82	82-87	87-92	92-97	97-02	02-07	ANOVA	72-77	77-82	82-87	87-92	92-97	97-02	02-07
<b>Area</b>	0.001	0.182	<0.001	0.005	<0.001	0.002	0.278	<b>Area</b>	<0.001	0.007	<0.001	0.019	<0.001	<0.001	<0.001
<b>Year</b>	<0.001	<0.001	0.044	<0.001	<0.001	0.017	<0.001	<b>Year</b>	<0.001	<0.001	<0.001	<0.001	0.001	0.063	<0.001
<b>Area × year</b>	<0.001	0.553	0.357	0.376	0.536	0.463	0.647	<b>Area × year</b>	0.160	0.570	0.977	0.246	0.278	0.489	0.483

With Bonferroni correction the highest accepted individual P-value at error rate of 0.05 would be 0.0071 (0.05/7). SD = Standard deviation.

In North Karelia, cholesterol declined 21% in men and 23% in women. A remarkable decline in cholesterol levels was also observed in southwestern Finland after 1982. There was a levelling off in the decline between 1997 and 2002, but in the past 5 years cholesterol levels have again declined ~5%. The observed trend in serum total cholesterol was very similar among both men and women. However, throughout the years, the mean serum total cholesterol was lower among women than among men. In the last 2007 survey, the pooled mean cholesterol level in men was 5.39 mmol/l and in women 5.18 mmol/l. In men there were no differences in the cholesterol level among the areas, but in women the highest levels were in the northern Oulu province and lowest in southwestern Finland. Overall, the population cholesterol distribution has shifted to the left.

**Blood pressure**

In men, systolic blood pressure levels declined remarkably until 2002 (Table 3). In the past 5 years the decline has stopped. In women, systolic blood pressure declined until 1997 but not between 1997 and 2002, but again a small decline (1.8 mmHg) from 2002 to 2007 was statistically significant. The pooled mean for five survey areas in 2007 for systolic blood pressure was 137.7 mmHg in men and 129.9 mmHg in women.

In both men and women, diastolic blood pressure declined until 2002 but not in the last 5 years from 2002 to 2007 (Table 4). The mean diastolic blood pressure in the pooled areas was 83.1 mmHg in men and 77.3 mmHg in women.

**Smoking**

Until 1997 the prevalence of smoking among men declined significantly in all survey areas (Table 5). During the first 10 years the proportion of smokers decreased more in North Karelia than in the neighbouring Northern Savo area. This was mainly due to the increasing proportion of ex-smokers in North Karelia. Later on, the differences in smoking prevalence between areas diminished, slightly >30% of men in all areas were smokers in 1997. During the 5-year period from 1997 to 2002, the smoking prevalence among men increased somewhat but declined again by 2007. The pooled smoking prevalence for the five survey areas was 30% in 2007.

Among women, the smoking prevalence increased slowly until 2002, especially in the North Karelia and Northern Savo areas. In the last 5 years from 2002 to 2007, smoking did not increase further and the differences between the areas diminished. The pooled prevalence for the five survey areas was 21% in 2007. Until 1997, the prevalence of ex-smokers increased continuously, but in the latest survey the proportion of ex-smokers did not increase anymore. Instead, the proportion of never smokers decreased.

**Table 3** The mean and categories of systolic blood pressure by area, year and sex

		Systolic blood pressure												
		Men				Women								
	N	Mean	SD	<129 mmHg (%)	130–139 mmHg (%)	140–159 mmHg (%)	>160 mmHg (%)							
<b>North Karelia county</b>														
1972	1744	148.6	21.0	16	19	39	26	1887	152.6	26.0	18	17	29	36
1977	1765	142.9	17.7	21	22	41	16	1834	141.2	21.1	31	19	33	17
1982	1227	144.7	19.2	21	21	36	22	1267	141.1	19.7	31	19	31	19
1987	1139	143.9	18.9	22	21	38	19	1249	138.7	20.6	36	19	28	17
1992	521	141.5	19.2	28	23	31	17	611	135.3	20.9	45	16	25	14
1997	539	139.7	19.6	32	22	30	17	576	132.8	19.1	48	18	23	11
2002	493	137.1	17.8	36	22	30	12	550	132.0	21.1	52	17	19	12
2007	356	138.5	17.5	31	23	34	12	395	134.0	20.4	46	17	27	11
<b>Northern Savo county</b>														
1972	2520	146.0	21.0	20	22	36	23	2621	147.2	25.5	25	18	29	28
1977	2607	145.7	19.2	19	21	39	22	2747	142.9	22.1	29	19	32	20
1982	1207	146.5	18.3	17	19	42	23	999	143.3	22.3	29	19	32	20
1987	599	144.4	18.5	20	20	39	21	631	138.9	20.5	36	19	29	17
1992	582	140.1	18.2	29	24	30	17	622	135.5	21.7	45	17	25	13
1997	539	138.9	17.4	30	27	32	11	610	133.2	18.0	46	20	26	9
2002	449	137.5	18.0	36	23	29	12	554	132.3	20.3	50	19	21	10
2007	365	138.0	17.8	34	23	32	12	409	130.9	18.4	51	19	22	8
<b>Southwestern Finland</b>														
1982	1231	143.6	19.0	22	23	36	20	1293	135.7	20.0	42	20	24	14
1987	566	139.2	16.7	27	26	34	13	614	135.7	21.1	41	22	25	13
1992	562	139.2	16.7	25	28	35	11	612	133.5	19.4	48	21	21	10
1997	530	136.0	16.4	35	25	32	8	569	129.3	18.9	55	17	20	8
2002	448	136.8	17.4	38	23	29	10	519	131.6	18.9	53	16	21	10
2007	321	135.5	17.4	40	22	29	9	407	125.9	16.1	61	19	17	3
<b>Helsinki and Vantaa cities</b>														
1992	527	137.0	17.4	34	26	29	11	545	132.4	19.1	48	23	20	9
1997	482	136.9	18.7	38	20	29	13	560	129.4	18.1	55	19	20	6
2002	429	134.1	16.7	40	22	30	8	493	127.9	18.3	58	20	15	7
2007	316	134.4	17.0	40	25	27	8	383	126.9	17.7	57	21	17	5

(continued)

Table 3 Continued

		Systolic blood pressure																		
		Men					Women													
		N	Mean	SD	<129 mmHg (%)	130-139 mmHg (%)	140-159 mmHg (%)	>160 mmHg (%)	N	Mean	SD	<129 mmHg (%)	130-139 mmHg (%)	140-159 mmHg (%)	>160 mmHg (%)					
<b>Oulu province</b>																				
1997	507	138.2	18.7	31	27	29	13	573	131.5	18.8	51	18	21	9						
2002	439	138.1	17.7	33	24	32	11	534	132.7	19.0	48	19	24	9						
2007	365	137.0	17.3	35	23	32	10	399	131.8	19.0	50	20	22	8						
<b>ANOVA</b>		<b>72-77</b>	<b>77-82</b>	<b>82-87</b>	<b>87-92</b>	<b>92-97</b>	<b>97-02</b>	<b>02-07</b>	<b>ANOVA</b>	<b>72-77</b>	<b>77-82</b>	<b>82-87</b>	<b>87-92</b>	<b>92-97</b>	<b>97-02</b>	<b>02-07</b>				
<b>Area</b>		0.543	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>Area</b>	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				
<b>Year</b>		<0.001	0.013	<0.001	<0.001	0.001	0.839	<b>Year</b>	<0.001	0.777	<0.001	<0.001	<0.001	<0.001	0.610	0.005				
<b>Area × year</b>		<0.001	0.934	0.009	0.023	0.155	<0.487	<b>Area × year</b>	<0.001	0.793	0.005	0.686	0.408	0.101	<0.001	<0.001				

With Bonferroni correction the highest accepted individual P-value at error rate of 0.05 would be 0.0071 (0.05/7).

**Body mass index**

Among men, the mean body mass index (BMI) has increased continuously since 1972 (Table 6). Between the surveys in 1987 and 1992, some levelling off was observed, but after that the increase continued until 2002. No increase in BMI was observed between 2002 and 2007. The pooled mean BMI was 27.2 kg/m<sup>2</sup> in men in 2007. The prevalence of obesity (BMI 30) has increased constantly among men since 1972.

Among women, the BMI decreased significantly in eastern Finland between 1972 and 1982. After that, there was a slightly increasing trend in BMI. During the last 5 years the pooled mean for the five survey areas increased from 26.3 kg/m<sup>2</sup> in 2002 to 26.5 kg/m<sup>2</sup> in 2007, but this increase was not statistically significant. Among women, there was a greater fluctuation in mean BMI among the survey years and areas than among men. In eastern Finland, the prevalence of obesity first declined slightly in the 1970s, but started to increase again in the 1990s. The prevalence of obesity was significantly lower in southwestern Finland and in the capital area compared with eastern Finland and northern Finland. The pooled prevalence of obesity for the five survey areas both among men and women was 21% in 2007.

**Risk factor changes and CHD mortality**

The combined risk change was estimated by using a logistic regression model and it was compared with coronary mortality changes in the North Karelia and Northern Savo areas where the risk factor trends are available over 35 years. Based on the decreases in diastolic blood pressure (8.7 mmHg), cholesterol level (1.54 mmol/l) and smoking (15 percentage-points) the combined risk declined by 60%. The coronary mortality declined 80% in the same areas (Figure 1).

**Discussion**

Finnish men had the highest numbers of CHD mortality at the end of the 1960s,<sup>1</sup> but the decline in coronary mortality among Finnish men since the 1970s has also been the most rapid in the world.<sup>17-20</sup> About 75% of the observed decline in coronary mortality in middle-aged men can be explained by decline in blood pressure, cholesterol and smoking. Until the mid-1980s, the observed decline in CHD mortality can be almost totally explained by the decline in risk factors. Since the mid-1980s, many new treatments and invasive procedures for coronary patients have become more common and can probably explain most of the remaining decline in observed CHD mortality.<sup>21</sup> In Finland, the change of risk factors seems to be more important than in many other countries. Based on different models, the impact of risk factors on mortality varied from 60% in New Zealand to 44% in the USA, and the impact of treatment varied from 23% in Finland to 47% in the USA.<sup>22</sup> However, the

**Table 4** The mean and categories of diastolic blood pressure by area, year and sex

		Diastolic blood pressure													
		Men					Women								
		N	Mean	SD	<79 mmHg (%)	80-89 mmHg (%)	90-99 mmHg (%)	>100 mmHg (%)	N	Mean	SD	<79 mmHg (%)	80-89 mmHg (%)	90-99 mmHg (%)	>100 mmHg (%)
<b>North Karelia county</b>															
1972		1742	92.0	12.2	13	27	34	26	1886	92.4	13.5	15	27	29	29
1977		1764	88.6	11.0	19	32	33	17	1834	86.3	10.9	24	36	28	11
1982		1227	86.7	12.7	27	30	26	17	1267	84.5	12.0	33	33	22	11
1987		1139	88.1	11.8	22	31	30	17	1249	83.2	11.5	36	3	19	9
1992		521	84.6	12.4	33	36	21	11	610	79.5	11.3	49	32	14	5
1997		539	84.3	11.7	35	33	22	10	576	80.2	11.3	47	32	15	5
2002		493	83.0	11.6	36	33	22	8	550	77.6	11.6	56	28	12	4
2007		356	83.2	12.1	34	36	21	9	395	77.9	11.7	55	27	15	3
<b>Northern Savo county</b>															
1972		2520	93.3	11.8	9	27	38	27	2620	91.3	12.1	14	29	34	23
1977		2607	92.6	11.9	11	31	30	28	2747	88.4	11.9	22	33	27	18
1982		1207	88.9	13.3	22	28	29	21	999	84.8	11.9	33	32	23	11
1987		599	89.1	11.1	19	31	31	19	631	83.9	11.3	33	36	22	10
1992		582	83.8	11.9	33	36	20	11	622	79.7	11.9	49	29	15	7
1997		539	86.0	11.8	27	32	27	14	611	80.9	11.0	44	34	17	5
2002		449	81.7	11.6	40	35	18	6	554	76.5	11.4	59	27	12	3
2007		365	84.5	11.6	31	36	22	11	409	78.5	10.9	50	33	14	2
<b>Southwestern Finland</b>															
1982		1231	86.7	12.3	26	32	26	16	1293	81.0	11.7	45	31	18	7
1987		566	85.9	85.1	27	35	25	12	614	81.9	11.1	41	35	17	8
1992		562	85.1	12.3	30	33	25	12	612	81.2	11.0	43	33	18	6
1997		530	86.1	10.7	25	37	28	10	569	81.0	10.2	42	36	17	4
2002		448	84.0	10.7	33	37	22	7	519	79.3	11.0	51	30	16	3
2007		321	82.1	12.3	38	33	21	9	407	76.0	11.1	60	28	10	3
<b>Helsinki and Vantaa cities</b>															
1992		527	85.3	12.0	31	31	25	13	545	81.3	11.9	44	32	17	7
1997		482	85.0	12.1	29	35	24	12	560	80.4	10.8	47	33	14	6
2002		429	80.2	11.7	49	28	16	7	493	75.5	10.9	63	26	10	2
2007		316	82.8	11.2	36	36	21	7	383	76.4	10.4	61	26	12	1

(continued)



Table 4 Continued

		Diastolic blood pressure														
		Men					Women									
	N	Mean	SD	mmHg (%)	<79	80-89	90-99	>100	mmHg (%)	SD	mmHg (%)	<79	80-89	90-99	>100	
					mmHg (%)	mmHg (%)	mmHg (%)	mmHg (%)		mmHg (%)	mmHg (%)	mmHg (%)	mmHg (%)	mmHg (%)	mmHg (%)	
<b>Oulu province</b>																
	507	85.0	11.7	30	34	26	10	573	80.3	11.0	46	33	15	6		
	439	82.7	12.0	36	35	20	9	534	77.6	11.5	55	28	13	3		
	365	83.0	11.1	36	34	23	7	397	77.7	10.8	55	30	12	3		
<b>ANOVA</b>																
		72-77	77-82	82-87	87-92	92-97	97-02	02-07	ANOVA	72-77	77-82	82-87	87-92	92-97	97-02	02-07
<b>Area</b>		<0.001	<0.001	<0.001	0.176	0.096	<0.001	0.026	<b>Area</b>	0.007	<0.001	<0.001	0.260	0.037	<0.001	0.002
<b>Year</b>		<0.001	<0.001	0.804	<0.001	0.139	<0.001	0.035	<b>Year</b>	<0.001	<0.001	0.119	<0.001	0.847	<0.001	0.984
<b>Area × year</b>		<0.001	0.045	0.010	<0.001	0.025	0.003	0.001	<b>Area × year</b>	<0.001	<0.001	0.007	<0.001	0.085	0.002	<0.001

With Bonferroni correction the highest accepted individual P-value at error rate of 0.05 would be 0.0071 (0.05/7).

exact comparison between the countries is difficult because of different time periods, different baseline levels of mortality and risk factors and different changes in risk factors and treatments.

The community-based disease prevention and health promotion activities have been remarkably successful in Finland in reducing the cardiovascular risk factors at the population level. The North Karelia project, which was a comprehensive intervention based on community organization and supportive environmental changes, was launched in 1972.<sup>2</sup> The main aim of the project was CVD prevention by reduction of the cholesterol and blood pressure levels and smoking in the population of North Karelia. Several interventions, involving collaboration with health services, non-governmental organizations, industry, employers, decision makers and media, were carried out in North Karelia. Successful results can be shown in both mortality and morbidity rates as well as in risk factor reduction.<sup>3,9</sup> Since the first period of the North Karelia project, the disease prevention strategies have been applied in all Finland as part of national activities. Work in North Karelia continued as a national demonstration. In the first 5–10 years most risk factors declined faster in North Karelia than in the original reference area Northern Savo (former Kuopio Province). After that the development was very similar in different parts of the country, mainly because of adapting many national policies and programmes to fight against CVDs. The National Public Health Institute (KTL) under the Ministry of Social Affairs and Health has been centrally involved not only in the health monitoring, but also in promoting the preventive work.

The 2007 survey results showed that the decline in population blood cholesterol level continues. There was a levelling-off period in serum cholesterol level between 1997 and 2002. This was parallel with the changes in saturated and polyunsaturated fat intake. The total intake of saturated fat has declined in Finland from 22% of energy intake to 13% between 1972 and 2007.<sup>23,24</sup> No change in saturated fats was observed between 1997 and 2002, when also no changes in serum cholesterol occurred. Saturated fatty acids play the key role in the regulation of serum cholesterol. Also, the intake of dietary cholesterol and *trans*-fatty acids increases serum cholesterol levels. In Finland, the role of *trans*-fatty acids is marginal, as the proportional intake of *trans*-fatty acids is only 0.5 energy percent compared with the 12 energy percent of saturated fat intake.<sup>24</sup>

During the past 30 years, the greatest change in health behaviour in Finland has indisputably been the changes in diet, especially in the type and amount of fat and intake of fresh vegetables and fruit.<sup>12</sup> In the early 1970s, Finland was a country with much dairy farming. Butter and milk production was subsidized and all vegetable oil was imported. The domestic vegetable oil industry was developed

**Table 5** Smoking by area, year and sex

Survey areas	Men				Women			
	N	Smoker (%)	Ex-smoker (%)	Never smoker (%)	N	Smoker (%)	Ex-smoker (%)	Never smoker (%)
<b>North Karelia county</b>								
1972	1802	52	20	28	1955	10	2	88
1977	1733	44	27	29	1824	10	5	85
1982	1185	36	30	34	1238	15	8	77
1987	1157	36	28	36	1274	15	12	73
1992	517	32	25	43	610	17	13	70
1997	535	31	26	43	573	16	16	68
2002	523	33	25	42	586	22	14	63
2007	384	31	27	42	428	18	22	60
<b>Northern Savo county</b>								
1972	2566	50	22	29	2693	11	3	86
1977	2557	44	27	28	2729	12	6	82
1982	1181	42	24	34	986	15	8	77
1987	606	41	24	35	636	15	11	74
1992	582	37	26	37	620	19	14	67
1997	538	31	30	39	610	17	16	67
2002	499	38	24	38	591	20	18	62
2007	395	30	26	45	438	22	24	54
<b>Southwestern Finland</b>								
1982	1198	39	28	32	1275	22	11	67
1987	576	38	27	34	25	23	13	64
1992	561	39	28	33	612	23	15	62
1997	529	34	26	41	569	22	16	62
2002	508	34	22	43	569	25	15	60
2007	341	31	25	45	426	20	17	63
<b>Helsinki and Vantaa cities</b>								
1992	527	36	27	37	543	30	15	55
1997	483	33	28	39	561	26	19	54
2002	473	40	20	40	537	27	21	53
2007	346	31	25	44	415	25	23	52

(continued)

Table 5 Continued

Survey areas	Men				Women			
	N	Smoker (%)	Ex-smoker (%)	Never smoker (%)	N	Smoker (%)	Ex-smoker (%)	Never smoker (%)
<b>Oulu province</b>								
1997	499	32	23	45	564	20	18	62
2002	487	34	26	40	567	21	19	61
2007	386	26	29	45	422	21	21	58

	Men				Women			
	72-77	77-82	82-87	87-92	92-97	97-02	02-07	07-12
<b>LOGISTIC</b>	0.275	0.008	0.001	0.008	0.181	0.297	0.612	0.177
<b>Area</b>	<0.001	<0.001	0.661	0.191	0.012	0.006	0.021	<0.001
<b>Year</b>	0.188	0.013	0.964	0.414	0.563	0.443	0.495	0.980
<b>Area × year</b>	0.188	0.013	0.964	0.414	0.563	0.443	0.495	0.980

Logistic regression analyses for smoking prevalence. Both never smokers and ex-smokers regarded as non-smokers. With Bonferroni correction the highest accepted individual P-value at error rate of 0.05 would be 0.0071 (0.05/7).

in the late 1970s and the popularity of vegetable oil grew remarkably in the 1980s. People were 'educated' in the effects of the types of fat and so could avoid fatty milk products and spreads with high saturated fat content as well as food products high in cholesterol.

The sources of saturated fats have changed during the past 30 years. Earlier, when the choice of food products used was smaller than nowadays, the main sources of saturated fats were butter, other milk products and meat, whereas today the main sources are meat dishes, cheese and spreads. Also, different pastries, both salty and sweet, are more important sources of saturated fats in the diet.<sup>24</sup> The role of milk itself has decreased and been replaced by other milk products such as ice cream, yoghurt and puddings. As the variety of foodstuffs has increased and people are increasingly consuming highly processed food, it is more difficult for them to be fully aware of the nutritional contents of the products they use.

Both systolic and diastolic blood pressure levels decreased between 1972 and 2002, but from 2002 to 2007 the decline has levelled off although salt intake has still declined. Obesity and alcohol consumption have increased, which is likely to explain much of the levelling off. The accurate measurement of diastolic blood pressure is very difficult and might explain the fluctuation seen in diastolic blood pressure trends.<sup>25</sup> The change of cuff length may have had some effect on blood pressure measurement results between the 1977 and 1982 surveys, but it cannot explain the overall major decline in other time periods.

The reduction in salt intake and the more effective screening and treatment of hypertension and the new drugs have most likely affected the blood pressure levels among the Finnish population.<sup>26,27</sup> However, it is obvious that the coverage of antihypertensive drugs cannot explain the continued decline in blood pressure on the population level 'because whole blood pressure distribution had lowered and not only those who were in drug treatment'.<sup>26</sup> Also, the significant increase in the use of polyunsaturated fats might have had an effect on blood pressure levels.<sup>28</sup>

In Finland, many tobacco control initiatives have been carried out since the beginning of the 1970s. The national tobacco legislation was initially passed in 1977. The legislation has been amended in 1995 and again in 2000. At present, the Finnish tobacco legislation is rather strict, prohibiting all forms of tobacco advertising, smoking in public indoor places and workplaces, the sale of tobacco products to people <18 years of age and the sale of smokeless tobacco. Also, warnings on tobacco packages are obligatory and 0.5% of the tobacco tax is designated for tobacco control. Smoking among men has declined remarkably since 1972. In women there has been an increase in smoking from ~10 to 20%. However, in the past 5 years there has been a levelling off in the smoking

**Table 6** The mean and categories of BMI by area, year and sex

Survey areas	N	BMI										
		Men			Women							
		Mean	SD	<24.9 kg/m <sup>2</sup> (%)	25.0–29.9 kg/m <sup>2</sup> (%)	>30.0 kg/m <sup>2</sup> (%)	N	Mean	SD	<24.9 kg/m <sup>2</sup> (%)	25.0–29.9 kg/m <sup>2</sup> (%)	>30.0 kg/m <sup>2</sup> (%)
<b>North Karelia county</b>												
1972	1748	26.0	3.4	43	46	11	1888	26.8	4.7	40	39	22
1977	1767	26.1	4.7	42	46	12	1835	26.5	4.7	43	37	20
1982	1229	26.5	3.6	37	49	15	1270	26.1	4.8	48	34	18
1987	1138	27.1	4.0	32	48	20	1247	26.2	4.8	48	33	19
1992	521	27.0	4.0	35	44	21	611	26.3	4.9	48	34	18
1997	539	27.0	4.1	32	50	18	576	26.4	5.3	49	31	20
2002	497	27.1	4.3	31	48	20	553	26.8	5.3	46	31	23
2007	357	27.4	4.5	30	47	23	396	26.6	5.5	46	33	21
<b>Northern Savo county</b>												
1972	2520	25.9	3.3	43	45	11	2621	26.7	4.6	40	38	22
1977	2604	26.2	3.5	40	47	13	2747	26.1	4.7	47	35	19
1982	1206	26.4	3.8	37	47	16	1001	25.9	4.4	49	36	16
1987	599	26.8	3.5	33	52	16	632	26.4	5.0	47	33	19
1992	582	26.7	4.0	37	44	20	621	26.4	5.0	47	31	22
1997	537	27.3	4.1	31	46	23	609	26.0	4.8	47	36	17
2002	454	27.4	4.0	31	48	22	554	26.7	5.1	44	35	21
2007	365	27.7	4.4	27	47	26	410	26.6	5.2	44	34	22
<b>Southwestern Finland</b>												
1982	1231	26.6	3.8	37	46	17	1293	25.3	4.3	54	33	13
1987	566	26.7	3.5	34	51	15	614	26.1	4.7	47	34	18
1992	562	26.8	3.9	35	45	20	612	25.6	4.8	53	32	16
1997	530	27.1	4.0	29	52	18	569	26.2	5.0	47	36	18
2002	454	27.4	4.4	31	46	23	520	26.0	5.1	51	32	18
2007	322	27.4	4.2	30	49	21	407	26.6	5.4	45	34	21
<b>Helsinki and Vantaa cities</b>												
1992	527	26.2	3.7	41	43	16	545	25.1	4.5	58	28	14
1997	483	26.5	4.1	39	44	17	560	25.6	4.8	53	29	18
2002	432	26.9	4.2	34	44	21	497	25.3	4.3	55	33	13
2007	316	26.7	3.8	35	47	18	383	25.7	5.0	55	30	15

(continued)

Table 6 Continued

Survey areas	BMI											
	Men						Women					
Oulu province	N	Mean	SD	<24.9 kg/m <sup>2</sup> (%)	25.0-29.9 kg/m <sup>2</sup> (%)	>30.0 kg/m <sup>2</sup> (%)	N	Mean	SD	<24.9 kg/m <sup>2</sup> (%)	25.0-29.9 kg/m <sup>2</sup> (%)	>30.0 kg/m <sup>2</sup> (%)
1997	507	26.9	3.7	32	51	18	573	26.2	4.9	50	32	18
2002	442	27.5	4.0	26	52	22	534	26.6	5.0	44	35	21
2007	365	26.7	3.8	35	47	17	399	26.9	5.6	45	31	24

ANOVA	Women													
	72-77	77-82	82-87	87-92	92-97	97-02	02-07	72-77	77-82	82-87	87-92	92-97	97-02	02-07
Area	0.809	0.401	0.551	0.055	<0.001	0.002	0.004	0.081	0.012	0.012	0.008	<0.001	<0.001	<0.001
Year	0.004	<0.001	0.002	0.944	0.015	0.017	0.543	<0.001	0.010	<0.001	0.588	0.213	0.218	0.291
Area × year	0.368	0.891	0.113	0.847	0.217	0.413	0.026	0.170	0.971	0.007	0.084	0.028	0.067	0.254

With Bonferroni correction the highest accepted individual *P*-value at error rate of 0.05 would be 0.0071 (0.05/7).

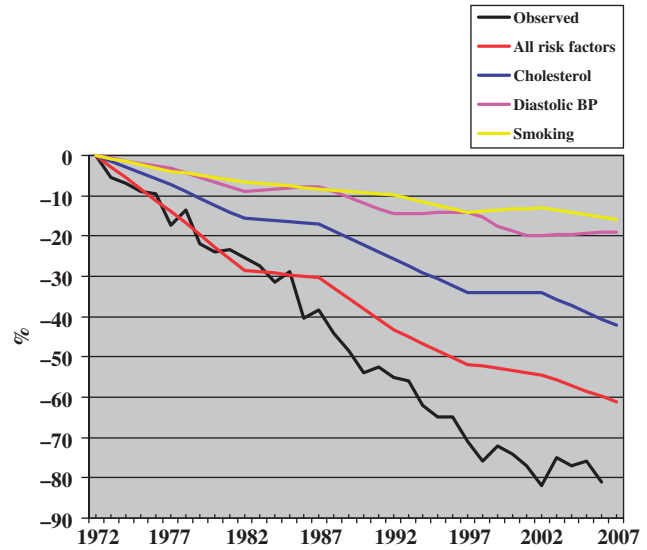


Figure 1 Observed and predicted decline in CHD mortality in men

increase in women. Birth cohort analyses from the Adult Health Behaviour Monitoring data indicated that onset of smoking increased in the birth cohorts born from 1916 to the 1950s.<sup>29</sup> However, this increase was reduced in the later cohorts, who were in the smoking initiation age during and after the first tobacco law. This ‘probably’ explains why smoking in women never increased to a higher level in Finland. It may be that we have now passed the peak of the tobacco epidemic in Finland.

One of the major concerns for public health in Finland is increasing obesity. Especially among men the BMI as well as the prevalence of obesity is continuously increasing. Work-related activity has greatly decreased while health-enhancing leisure time physical activity has increased, but not enough to compensate for the decrease of physical activity at work or other duties.<sup>30</sup> Thus, it seems likely that the main reason for the increasing obesity is the decrease in total physical activity and, as a consequence, the decrease in energy expenditure. Also, the increasing use of alcohol may have contributed to the increasing BMI.<sup>31</sup> Energy intake from food seems not to have increased;<sup>24</sup> however, it is not known if the under-reporting of dietary intake has increased.

One of the main concerns in the study is the lowering participation rate. On the basis of the non-participation phone survey in 1992, we can estimate that the smoking rate could be 1-3% higher than estimated here. This is based on the observation that non-participants had higher smoking rates than those who participated in the survey. For other risk factors, similar estimates are not available. Because participation was lower in the young age groups, the estimated changes in blood pressure and cholesterol may be underestimated. This is based on the fact

that blood pressure and cholesterol increase with increasing age.

In summary, remarkable declines in population risk factor levels have taken place in Finland since 1972. These risk factor changes explain the majority of the observed decline in CHD mortality in the middle-aged population. Risk factor, behaviour and diet monitoring provide hard evidence to assess progress and

guide national policy and actions in national chronic disease prevention and health promotion.

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National Institute for Health and Welfare.

**Conflict of interest:** None declared.

### KEY MESSAGES

- Blood pressure, serum cholesterol and smoking have declined in Finland in past 35 years.
- CHD mortality has declined 80% in middle age and changes in risk factors levels predicted 60% decline in mortality.
- Obesity has increased.

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## Commentary: The Finnish success of cardiovascular risk factor reduction

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More than 20 years ago, I remember being at a cardiovascular scientific meeting where a Finnish scientist told me this 'true' story during the conference dinner:

A group of Finnish and Italian scientists decided jointly to conduct an investigation on the influence of the common daily diet in the two countries on plasma cholesterol levels. Forty families in each country were to record exactly what they ate during a period of 8 weeks. Using a cross-over design, the Finnish families should then for the following 8 weeks eat exactly like the Italians did in the previous 8 weeks, and vice versa for the Italian families. The ethical committee in

Finland had no comments, while the Italian ethical committee refused to approve the protocol. They found it unethical to ask Italian families to eat the Finnish food.

I do not remember who told me this story and it has probably improved over the years, as I have forgotten the exact wording. Nevertheless, the story nicely illustrates the common lifestyle of people in Finland, Scandinavia and most of Northern Europe not so long ago. Food was dominated by saturated fat from dairy products and a high salt intake, and smoking was prevalent. This led to high cholesterol levels and high blood pressure in the population at large and