TRENDS IN THE INCIDENCE OF CORONARY HEART DISEASE AND CHANGES IN DIET AND LIFESTYLE IN WOMEN

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ABSTRACT

Background Previous studies have found concurrent declines in blood pressure, serum cholesterol levels, and the incidence of and mortality from coronary disease. However, the effects of changes in diet and lifestyle on trends in coronary disease are largely unknown.

Methods We followed 85,941 women who were 34 to 59 years old and had no previously diagnosed cardiovascular disease or cancer from 1980 to 1994 in the Nurses' Health Study. Diet and lifestyle variables were assessed at base line and updated during follow-up.

Results After adjustment for the effect of age, the incidence of coronary disease declined by 31 percent from the two-year period 1980–1982 to the two-year period 1992–1994. From 1980 to 1992, the proportion of participants currently smoking declined by 41 percent, the proportion of postmenopausal women using hormone therapy increased by 175 percent, and the prevalence of overweight, defined as a body-mass index (the weight in kilograms divided by the square of the height in meters) of 25 or more, increased by 38 percent. During the study period, diet improved substantially. Statistically, changes in these variables — when considered simultaneously — explained a 21 percent decline in the incidence of coronary disease, representing 68 percent of the overall decline from 1980–1982 to 1992–1994. Taken individually, the reduction in smoking explained a 13 percent decline in the incidence of coronary disease; improvement in diet explained a 16 percent decline; and increase in postmenopausal hormone use explained a 9 percent decline. On the other hand, the increase in body-mass index explained an 8 percent increase in the incidence of coronary disease.

Conclusions Reduction in smoking, improvement in diet, and an increase in postmenopausal hormone use accounted for much of the decline in the incidence of coronary disease in this group of women. An increasing prevalence of obesity, however, appears to have slowed the decline in the incidence of coronary disease. (N Engl J Med 2000;343:530-7.)

MORTALITY from coronary heart disease in the United States has declined substantially in the past three decades.[1] It is unclear, however, how much of the decline is due to a reduction in the incidence of disease and how much is due to improved survival.[2,3] Although most studies show improvement in survival among patients with myocardial infarction, trends in incidence are uncertain.[2-5] In the Atherosclerosis Risk in Communities Study,[5] a stable or slightly increasing incidence of hospitalization for acute myocardial infarction was observed from 1987 to 1994, despite a decrease in mortality from coronary disease. The recent lack of decline in the incidence of coronary disease suggests that the change attributable to prevention may have stagnated, but the lack of data on changes in particular risk factors precludes detailed analyses.

In this study, we examined trends in the incidence of coronary disease from 1980 to 1994 among women in the Nurses' Health Study cohort. The large sample, high rate of follow-up, and detailed data on dietary and other lifestyle factors provided an opportunity to examine trends over time in the incidence of coronary disease and the degree to which changes in diet and lifestyle might account for these trends.

METHODS

The Nurses' Health Study Cohort

The Nurses' Health Study was established in 1976, when 121,700 female nurses 30 to 55 years old completed a mailed questionnaire on their medical history and lifestyle. Every two years, follow-up questionnaires are sent to obtain updated information on risk factors and to identify newly diagnosed diseases. In 1980 a 61-item food-frequency questionnaire was included to assess the intake of specific fats and other nutrients. In 1984 the dietary questionnaire included 116 items. Similar questionnaires were used to update dietary information in 1986 and 1990.

After up to four mailings, 98,462 women returned the 1980 diet questionnaire. We excluded questionnaires with 10 or more items blank, those reporting implausibly high or low values for total food or energy intake (less than 500 or more than 3500 kcal per day), and those from women with previously diagnosed can-

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cer or cardiovascular disease (including those who had undergone coronary-artery bypass surgery or angioplasty). We obtained data on the incidence of coronary disease among the remaining 85,941 women during the subsequent 14 years of follow-up. The follow-up rate for nonfatal events was 98 percent of the total potential person-years.

End Points

The end point for this study was nonfatal myocardial infarction or fatal coronary disease occurring after the return of the 1980 questionnaire but before June 1, 1994. We sought to review medical records for all myocardial infarctions reported by the women. The records were reviewed by physicians who had no knowledge of the self-reported risk factors. Myocardial infarction was considered confirmed when the criteria of the World Health Organization were met: symptoms plus either diagnostic electrocardiographic changes or elevated cardiac-enzyme levels.[6] Infarctions that required hospital admission and for which confirmatory information was obtained by interview or letter, but for which no medical records were available, were designated as probable (17 percent of the total).

Deaths were identified from state vital records and the National Death Index or were reported by next of kin and the postal system. Follow-up for the deaths was over 98 percent complete.[7] Fatal coronary disease was considered to have been present if fatal myocardial infarction was confirmed by hospital records or autopsy or if coronary disease was listed as the cause of death on the certificate, coronary disease was the underlying and most plausible cause, and evidence of previous coronary disease was available. We designated as deaths due to presumed myocardial infarction (15 percent of the cases of fatal coronary disease) deaths for which coronary disease was listed on the death certificate as the underlying cause but for which no records were available. We also included sudden death within one hour after the onset of symptoms if there was no plausible cause other than coronary disease (12 percent of the cases of fatal coronary disease).

Assessment of Diet

A detailed description of the semiquantitative food-frequency questionnaires has been published elsewhere.[8] A common unit or portion size for each food (e.g., one egg or one slice of bread) was specified, and the participants were asked how often, on average, they had consumed that amount during the previous year. The nine responses ranged from "never or less than once per month" to "six or more times per day." Nutrient intake was computed by multiplying the frequency of consumption of each food by the nutrient content of the specified portions, taking into account the type of fat used in preparation.[9] In validation studies in subsamples of the Nurses' Health Study participants, the correlations between the intake of specific fatty acids as calculated from the questionnaire and the proportions of the same fatty acids in adipose tissue were 0.34 for linolenic acid, 0.37 for linoleic acid,[10] and 0.51 for trans fatty acids.[11] Among men in the Health Professionals' Follow-up Study who were given the same questionnaire, the correlation was 0.47 for eicosapentaenoic acid intake as assessed with the questionnaire and values measured in adipose tissue.[12] In addition, the correlation between folate intake as calculated from the questionnaire and plasma folate levels was 0.56.[13]

Assessment of Nondietary Factors

Every two years, we update the participants' smoking status (never smoked, smoked in the past, or smoke currently, with the number of cigarettes per day), menopausal status and postmenopausal hormone use, and body weight. In validation studies, self-reported weights were highly correlated with measured weights ($r=0.96$).[14] Although increasing levels of physical activity were clearly associated with a lower risk of coronary disease in this cohort,[15] we could not examine the effects of trends over time because of the different measurements used. During the period when physical activity was assessed with the same questionnaire (from 1986 to 1994), there was no appreciable change in levels of physical activity. We also did not include alcohol use in these analyses, because consumption was stable over time. Additional analyses that included physical activity and alcohol consumption had little effect on the estimates of trends in coronary disease.

Statistical Analysis

The person-time for each participant was calculated from the date of return of the 1980 questionnaire to the date of the first coronary disease event, death, or June 1, 1994. We did not exclude women who had undergone coronary-artery bypass surgery or angioplasty during follow-up, because exclusion of these women might artificially lower the calculated incidence of coronary disease. Moreover, it is not certain that these procedures reduce rates of reinfarction or mortality.[16,17]

Trends in diet and lifestyle variables over time were standardized according to the age distribution of the total number of person-years of follow-up in the cohort. We computed the age-specific incidence of coronary disease in different periods to examine trends. The incidence was calculated by dividing the number of coronary disease events by person-time of follow-up in each two-year period. The relative risk was computed as the rate in a specific period divided by that in the period from 1980 to 1982. Tests for trend were conducted by assigning an ordinal value (from 1 to 7) to each of the periods. A multivariate pooled logistic model,[18] which allows the exposure variables to change over the different periods, was used to estimate the effects of time. The basic model included only period and age; updated information on cigarette smoking, diet, postmenopausal hormone use, and body-mass index (the weight in kilograms divided by the square of the height in meters) was then added separately to the model. The changes in estimates of trends in the incidence of coronary disease were used to indicate the degree to which the trends could be explained statistically by changes in each of the exposure variables. Specifically, we calculated the decline in the rate of coronary disease that was explained statistically by changes in a risk factor as the difference between the estimated percent decline in incidence from the two-year period 1980–1982 to the two-year period 1992–1994 from the age-adjusted analysis and the decline derived from a model including age and the updated risk factor. Further adjustment, in a secondary analysis, for base-line values of each exposure variable had no appreciable effect on the estimated percentage of the declines that were explained by the variables.

To reflect trends in overall dietary pattern over time, we calculated a priori a single composite dietary score based on six dietary components: a low intake of trans fat; a low glycemic load (a measure of the ability of a diet to raise the blood glucose level)[19,20]; a high intake of cereal fiber, marine n−3 fatty acids, and folate; and a high ratio of polyunsaturated to saturated fat. For each of these six dietary factors, we calculated the distribution according to quintile within the cohort and assigned each woman the score corresponding to the quintile of intake. For each participant, the quintile value for each nutrient (a higher quintile score represents a lower risk) was summed and the totals were used to recategorize the participants according to quintiles. Previous analyses have documented the importance of trans fat,[21,22] cereal fiber,[23] glycemic load,[24] marine n−3 fatty acids (unpublished data), folate,[25] and the ratio of polyunsaturated to saturated fat[26] in relation to the risk of coronary disease in the Nurses' Health Study.

RESULTS

Trends in the Incidence of Coronary Disease

During 14 years of follow-up, from 1980 to 1994, we documented 1304 newly diagnosed cases of coronary disease: 946 nonfatal myocardial infarctions and 358 cases of fatal coronary disease. The age-specific incidence rates of coronary disease (Fig. 1) indicate an

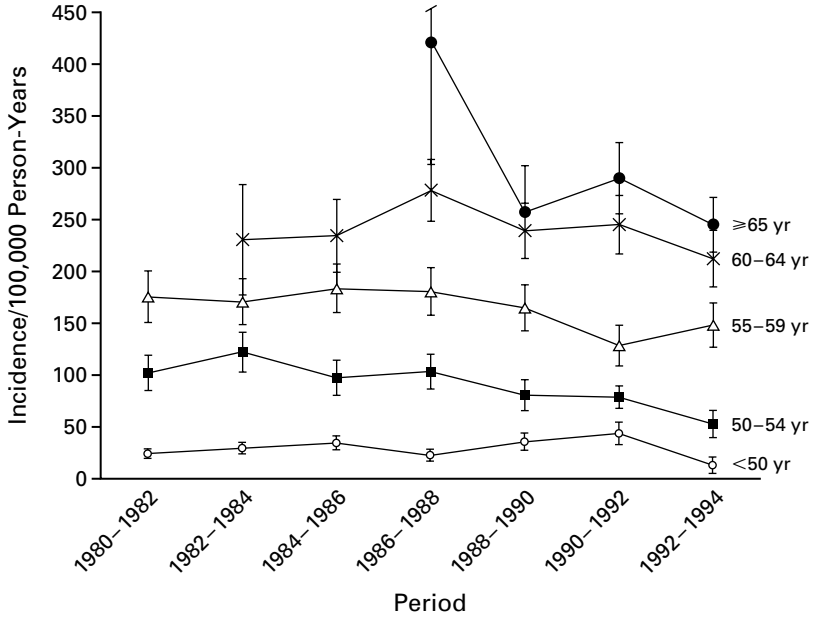

Figure 1. Trends in the Incidence of Coronary Disease According to Age Group in the Nurses' Health Study, 1980 to 1994.

The I bars indicate the standard errors.

overall decline in the incidence of coronary disease over time for all age groups; most of the change appears to have occurred in the second half of the 14-year follow-up period. Between 1980–1982 and 1992–1994, the annual rate declined from 25 to 13 cases per 100,000 person-years for women 49 years of age or younger, from 103 to 53 per 100,000 for women 50 to 54 years of age, and from 177 to 149 per 100,000 for women 55 to 59 years of age. Among older women, the follow-up was slightly shorter, since none of the women in the cohort reached 60 years of age until 1982; the annual rate declined from 242 to 214 per 100,000 between 1982–1984 and 1992–1994 for women 60 to 64 years of age and from 422 to 244 per 100,000 between 1986–1988 and 1992–1994 for women 65 years of age or older.

Trends in Lifestyle and Diet

Figure 2 shows the age-adjusted trends in current smoking, overweight (defined as a body-mass index of at least 25), and current postmenopausal hormone use. The percentage of women who were currently smoking declined from 27 percent in 1980 to 16 percent in 1992 (a decline of 41 percent), whereas the percentage of women who were overweight increased from 37 percent in 1980 to 51 percent in 1992 (an increase of 38 percent). The average age-adjusted body-mass index increased from 24.5 in 1980 to 26.1 in 1992. The percentage of postmenopausal women who were currently using hormone therapy increased from 16 percent in 1980 to 44 percent in 1992 (an increase of 175 percent).

The composite dietary score increased steadily over time (Table 1). Among the six components of the dietary score, the average daily intake of trans fat decreased by 31 percent from 1980 to 1990, the ratio of polyunsaturated to saturated fat increased by 69 percent, the average daily intake of cereal fiber increased by 90 percent, the average daily intake of marine n−3 fatty acids increased by 180 percent, and the average daily intake of folate increased by 12 percent. Of the six dietary factors considered, only one, glycemic load, showed an adverse trend; it increased over time by 22 percent.

From 1980 to 1990, the average consumption of red meat (beef, pork, and lamb) declined from 1.11 to 0.69 serving per day, whereas the consumption of poultry and fish increased from 0.43 to 0.69 serving per day (Fig. 3). The consumption of high-fat dairy products decreased from 1.42 to 0.81 serving per day, whereas the consumption of low-fat dairy products increased from 0.94 to 1.11 servings per day.

Analyses of Diet and Lifestyle in Relation to Trends in the Incidence of Coronary Disease

In age-adjusted analyses, there was a significant trend toward a lower risk of coronary disease over time (Table 2). The relative risk of all coronary disease in 1992–1994 as compared with 1980–1982 was 0.69 (95 percent confidence interval, 0.54 to 0.88; P for

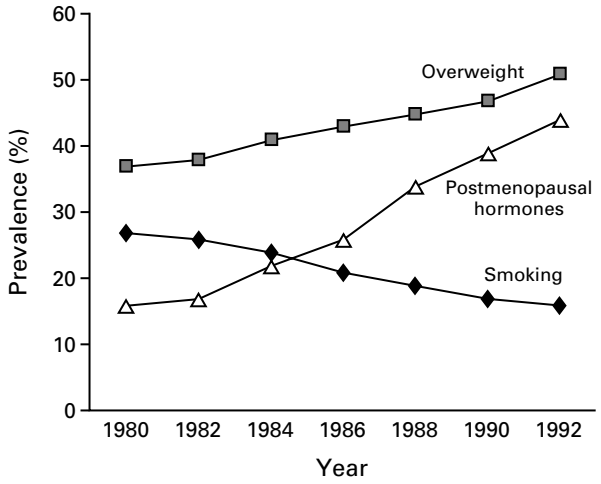

Figure 2. Age-Adjusted Trends in the Prevalence of Smoking, Overweight (Body-Mass Index ≥25), and Postmenopausal-Hormone Use.

Prevalences are standardized according to age distribution for the entire number of person-years of follow-up. The prevalence of postmenopausal hormone use was calculated for postmenopausal women only. All standard errors were less than 0.25 percent and thus would not be visible on the graph.

TABLE 1. AGE-ADJUSTED VALUES FOR DIETARY FACTORS OVER TIME IN THE NURSES' HEALTH STUDY.*

DIETARY FACTOR	1980	1984	1986	1990	P VALUE FOR TREND
Trans fat (% of total energy)	2.20	1.90	1.68	1.52	<0.001
Ratio of polyunsaturated to saturated fat	0.29	0.48	0.47	0.49	<0.001
Cereal fiber (g/day)	2.63	4.21	4.45	4.99	<0.001
Glycemic load†	120.4	138.6	138.0	147.0	<0.001
Marine n−3 fatty acids (% of total energy)	0.05	0.11	0.12	0.14	<0.001
Folate (μg/day)	377	387	403	421	<0.001
Dietary score‡	9.30	13.0	14.0	14.7	<0.001

*Means were standardized according to age distribution for the entire number of person-years of follow-up.

†Glycemic load was calculated by multiplying the carbohydrate content of each food by its glycemic-index value and the frequency of consumption and summing the results for all food items. Each unit of glycemic load represents the equivalent glycemic effect of 1 g of carbohydrate from white bread. Dietary glycemic load represents a diet's overall ability to raise the blood glucose level.

‡Intakes of trans fat, cereal fiber, marine n−3 fatty acids, and folate, the glycemic load, and the ratio of polyunsaturated to saturated fat were categorized into quintiles, and for each participant, the quintile values for the nutrients were summed to generate the composite dietary score (a higher quintile score represents a better diet).

trend <0.001), indicating a 31 percent overall decline in the incidence of coronary disease. In this analysis, we excluded women with previously diagnosed cardiovascular disease or cancer, since the development of these conditions might have led to changes in diet and lifestyle. An analysis including these women did not materially alter the results (age-adjusted relative risk of coronary disease in 1992–1994 as compared with 1980–1982, 0.64).

To address whether trends over time in diet and lifestyle explained the coronary-disease trend, we added updated information on cigarette smoking, dietary score, postmenopausal hormone use, and body-mass index to the age-adjusted model. After simultaneous adjustment for these variables, the relative risk was 0.90 (95 percent confidence interval, 0.70 to 1.16); the similarity of this relative risk to that calculated with diet and lifestyle variables included in the model suggests that these factors can explain much of the observed decline in the incidence of coronary disease. Together, these variables statistically explained a 21 percent decline (31 percent minus 10 percent) in the incidence of coronary disease; this amounts to 68 percent of the total decline.

To examine the contribution of these variables individually to the change in the incidence of coronary disease, we added them one at a time to the age-adjusted model. After adjustment for age and smoking, the relative risk of coronary disease in 1992–1994 as compared with 1980–1982 was 0.82 (95 percent confidence interval, 0.64 to 1.04), indicating an 18 percent decline after the effect of the reduction in smoking was taken into account. Thus, we estimated that reduction in smoking statistically explained a 13 percent decline in the age-adjusted incidence of coronary disease (31 percent minus 18 percent). Similarly, we estimated that improvement in diet explained a 16 percent decline and increase in postmenopausal hormone use explained a 9 percent decline. On the other hand, the increase in body-mass index explained an 8 percent increase in the incidence of coronary disease. Because the risk factors are correlated, the sum of the individual percentages does not equal the percentage from the analysis that included all of the risk factors.

To examine further the relation of change in diet and lifestyle to the risk of coronary disease, we fitted models that included base-line or updated values for these variables and an additional model that included both base-line and updated values (Table 3). Base-line values for smoking, body-mass index, postmenopausal hormone use, and dietary score were all significantly associated with the risk of coronary disease (model 1). In the model using updated values for these variables (model 2), the associations with dietary score and postmenopausal hormone use became stronger. When both base-line and updated variables were modeled simultaneously (model 3), the fit was significantly

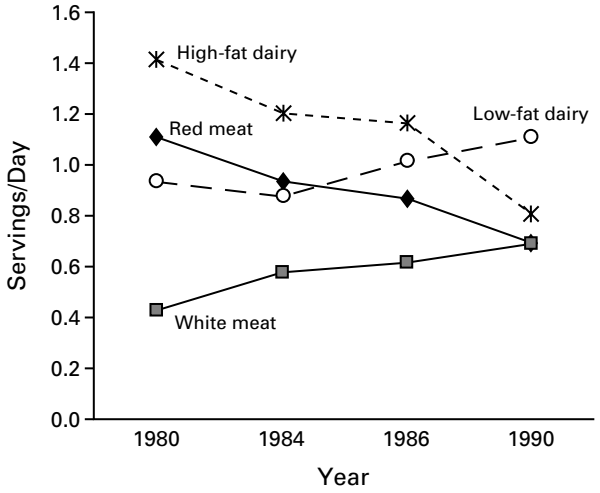

Figure 3. Age-Adjusted Trends in Intake of Major Food Groups. Intake has been standardized according to age distribution for the entire number of person-years of follow-up. The score for red meat is the composite score for the following foods: beef, pork, or lamb as main dish; beef as sandwich or mixed dish; hamburger; hot dog; processed meat; and bacon. White meat includes fish and poultry. High-fat dairy includes whole milk, hard cheese or cream cheese, ice cream, and butter. Low-fat dairy includes skim or low-fat milk, yogurt, and cottage cheese. All standard errors were less than 0.005 serving per day and thus would not be visible on the graph.

better than with model 1 ($P<0.001$). In that model, the association with updated variables can be interpreted as the effects of individual changes in these variables on the risk of coronary disease. Individual changes in diet and postmenopausal hormone use were significantly associated with lower risk of coronary disease. The associations with change in smoking independent of base-line values were consistent with the expected direction, although the confidence intervals were wide. For body-mass index, the association was slightly inverse but not significant.

DISCUSSION

We found that the age-standardized incidence of coronary disease declined by 31 percent from 1980 to 1994 among women in the Nurses' Health Study; the decline was evident in all age groups. From 1980 to 1992, the prevalence of current smoking declined by 41 percent, the proportion of women with postmenopausal hormone use increased by 175 percent, and the prevalence of overweight increased by 38 percent. Meanwhile, diet improved substantially. Multivariate analyses suggest that changes in cigarette smoking, diet, and postmenopausal hormone use statistically explain much of the reduction in the incidence of coronary disease. In contrast, the increase in obesity adversely affected the trend.

Over the past three decades, mortality from coronary disease in the United States has declined substantially.[27] It is unclear, however, how much of the decline in mortality is due to a decline in incidence and how much is due to improved survival.[5,28] Although several studies have suggested a decline in the case fatality rate for coronary disease,[4,5,29,30] the trends in incidence in these studies have been inconsistent.[3,4,29,30] Recently, the Atherosclerosis Risk in Communities Study[5] found a stable or slightly increasing incidence of hospitalization for acute myocardial infarction from 1987 to 1994 in four U.S. communities. We observed an overall decline in the incidence of coronary disease, primarily in nonfatal myocardial infarction. This discrepancy may be due to a greater adoption of health-promoting forms of behavior by women in the Nurses' Health Study. In addition, the power of the study to examine the trend in mortality from coronary disease is limited.

In our cohort, a decline in cigarette smoking contributed substantially to the reduction in the incidence of coronary disease, as might be expected.[31,32] Also associated with the decline in coronary disease was the increase in postmenopausal hormone use. Such hormone use has been related to a lower risk of coronary disease in numerous prospective studies,[33] although a recent secondary-prevention trial failed to find an overall benefit during four years of follow-up.[34]

Few studies have systematically monitored trends in diet concurrently with trends in cardiovascular disease.[35] In our cohort, the intake of saturated and trans fats declined over time, whereas the intake of polyunsaturated fat (in relation to saturated fat), cereal fiber, marine n−3 fatty acids, and folate increased. However, the dietary glycemic load also increased because of high intake of refined carbohydrates, which may have adverse effects on type 2 diabetes,[19,20] coronary disease,[24] and perhaps obesity.[36] Nevertheless, the overall diet score improved substantially, and this appeared to contribute markedly to the decline in the incidence of coronary disease in our cohort.

In a finding that was consistent with national data,[37] obesity increased substantially in our cohort. Because obesity is a strong risk factor for type 2 diabetes and cardiovascular disease,[38] its increasing prevalence slowed the decline in coronary disease. The incidence of coronary disease would probably have declined even more if body-mass index had not increased over time.

Overall, trends in diet and lifestyle explained much of the decline in the incidence of coronary disease. These results, however, do not imply that other factors, such as levels of blood pressure and serum cholesterol, are unimportant or do not contribute to this decline, because the effects of diet and lifestyle are partially mediated by their effects on blood pressure and serum cholesterol. Previous studies[4,29] have observed concurrent declines in blood pressure, serum cholesterol levels, the incidence of coronary disease, and mortality from coronary disease. In the Framingham Study,[39] the increasing use of antihypertensive

TABLE 2. RELATIVE RISK OF CORONARY DISEASE ACCORDING TO PERIOD, FROM 1980 TO 1994, IN THE NURSES' HEALTH STUDY.

PERIOD	ADJUSTED FOR AGE*	ADJUSTED FOR AGE AND SMOKING†	ADJUSTED FOR AGE AND DIET SCORE‡	ADJUSTED FOR AGE AND POSTMENOPAUSAL HORMONE USE§	ADJUSTED FOR AGE, SMOKING, DIET SCORE, AND POSTMENOPAUSAL HORMONE USE§	ADJUSTED FOR AGE AND BODY-MASS INDEX¶	ADJUSTED FOR AGE, SMOKING, DIET, POSTMENOPAUSAL HORMONE USE, AND BODY-MASS INDEX
				relative risk (95% confidence interval)			
Total coronary disease							
1980–1982	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1982–1984	1.02 (0.80–1.31)	1.05 (0.82–1.34)	1.02 (0.80–1.30)	1.02 (0.80–1.31)	1.04 (0.82–1.33)	0.97 (0.76–1.24)	1.01 (0.79–1.29)
1984–1986	0.98 (0.77–1.25)	1.02 (0.80–1.30)	1.11 (0.87–1.42)	0.99 (0.78–1.26)	1.14 (0.90–1.46)	0.89 (0.70–1.14)	1.07 (0.83–1.36)
1986–1988	1.06 (0.84–1.34)	1.14 (0.90–1.45)	1.26 (1.00–1.60)	1.09 (0.86–1.38)	1.34 (1.06–1.70)	0.95 (0.75–1.20)	1.22 (0.96–1.55)
1988–1990	0.90 (0.71–1.14)	1.00 (0.79–1.27)	1.07 (0.84–1.36)	0.96 (0.76–1.22)	1.19 (0.94–1.52)	0.79 (0.62–1.01)	1.07 (0.84–1.37)
1990–1992	0.85 (0.67–1.08)	0.97 (0.76–1.23)	1.04 (0.82–1.32)	0.93 (0.73–1.18)	1.21 (0.95–1.54)	0.78 (0.61–0.99)	1.08 (0.85–1.38)
1992–1994	0.69 (0.54–0.88)	0.82 (0.64–1.04)	0.85 (0.66–1.08)	0.78 (0.61–0.99)	1.03 (0.80–1.32)	0.61 (0.48–0.79)	0.90 (0.70–1.16)
P value for trend	<0.001	0.04	0.11	0.02	0.65	<0.001	0.46
Fatal coronary disease							
1980–1982	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1982–1984	1.08 (0.61–1.92)	1.11 (0.63–1.95)	1.08 (0.61–1.91)	1.07 (0.60–1.88)	1.08 (0.61–1.91)	0.87 (0.49–1.54)	0.91 (0.51–1.61)
1984–1986	1.32 (0.77–2.25)	1.37 (0.80–2.34)	1.51 (0.89–2.59)	1.29 (0.75–2.20)	1.48 (0.87–2.54)	0.96 (0.56–1.65)	1.12 (0.65–1.93)
1986–1988	1.16 (0.68–1.97)	1.23 (0.72–2.10)	1.39 (0.82–2.38)	1.16 (0.68–1.98)	1.42 (0.83–2.42)	0.80 (0.46–1.37)	1.00 (0.58–1.73)
1988–1990	1.14 (0.67–1.93)	1.25 (0.74–2.12)	1.37 (0.81–2.33)	1.20 (0.71–2.04)	1.48 (0.87–2.51)	0.75 (0.44–1.29)	1.00 (0.58–1.72)
1990–1992	1.09 (0.65–1.84)	1.23 (0.72–2.08)	1.35 (0.80–2.29)	1.19 (0.71–2.02)	1.52 (0.90–2.59)	0.91 (0.54–1.53)	1.23 (0.72–2.09)
1992–1994	0.81 (0.47–1.38)	0.93 (0.54–1.60)	1.00 (0.58–1.72)	0.91 (0.53–1.57)	1.18 (0.68–2.04)	0.62 (0.36–1.07)	0.89 (0.51–1.54)
P value for trend	0.14	0.47	0.67	0.52	0.54	0.08	0.96
Nonfatal myocardial infarctions							
1980–1982	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1982–1984	1.01 (0.77–1.33)	1.04 (0.79–1.36)	1.01 (0.77–1.33)	1.02 (0.78–1.34)	1.04 (0.79–1.37)	1.01 (0.77–1.33)	1.06 (0.80–1.39)
1984–1986	0.90 (0.68–1.18)	0.94 (0.72–1.24)	1.02 (0.77–1.34)	0.92 (0.70–1.21)	1.07 (0.81–1.40)	0.89 (0.67–1.16)	1.07 (0.81–1.41)
1986–1988	1.05 (0.81–1.36)	1.14 (0.87–1.48)	1.25 (0.96–1.62)	1.09 (0.84–1.42)	1.34 (1.03–1.75)	1.03 (0.79–1.34)	1.34 (1.02–1.75)
1988–1990	0.84 (0.64–1.10)	0.94 (0.72–1.23)	1.00 (0.76–1.31)	0.90 (0.69–1.18)	1.13 (0.86–1.48)	0.82 (0.63–1.08)	1.12 (0.85–1.47)
1990–1992	0.79 (0.60–1.03)	0.91 (0.69–1.19)	0.96 (0.73–1.26)	0.86 (0.66–1.13)	1.13 (0.85–1.48)	0.75 (0.57–0.98)	1.05 (0.79–1.38)
1992–1994	0.67 (0.51–0.89)	0.80 (0.60–1.06)	0.82 (0.62–1.09)	0.75 (0.57–0.99)	1.00 (0.75–1.33)	0.63 (0.47–0.83)	0.92 (0.69–1.22)
P value for trend	<0.001	0.05	0.11	0.02	0.87	<0.001	0.48

*Age was entered into the model in five-year categories.

†The smoking categories were never smoked, smoked in past, and currently smoking 1 to 14, 15 to 24, or ≥25 cigarettes per day. Information on cigarette smoking was updated every two years.

‡The intakes of trans fat, cereal fiber, marine n−3 fatty acids, and folate, the glycemic load, and the ratio of polyunsaturated to saturated fat were categorized into quintiles, and for each participant, the quintile values for the nutrients (a higher quintile score represents a better diet) were summed to generate the composite dietary score. Dietary scores were updated in 1984, 1986, and 1990.

§The categories of postmenopausal hormone use were premenopausal, postmenopausal without hormone use, and postmenopausal with hormone use. Information was updated every two years.

¶Body-mass index was divided into four categories: <23, 23 to 24.9, 25 to 29.9, and ≥30. Information was updated every two years.

TABLE 3. MULTIVARIATE RELATIVE RISK OF CORONARY DISEASE ACCORDING TO BASE-LINE AND UPDATED RISK FACTORS IN THE NURSES' HEALTH STUDY, 1980 TO 1994.*

RISK FACTOR	MODEL 1: BASE-LINE VALUES	MODEL 2: UPDATED VALUES†	MODEL 3: UPDATED VALUES ADJUSTED FOR BASE-LINE VALUES‡
	relative risk (95% confidence interval)		
Cigarette smoking			
Never	1.0	1.0	1.0
Past	1.24 (1.06–1.47)	1.47 (1.27–1.70)	1.10 (0.27–4.47)
Current			
1–14 cigarettes/day	1.99 (1.59–2.48)	2.56 (2.08–3.16)	1.43 (0.35–5.87)
15–24 cigarettes/day	4.10 (3.52–4.79)	4.51 (3.84–5.31)	1.90 (0.46–7.81)
≥25 cigarettes/day	4.66 (3.96–5.47)	4.64 (3.86–5.57)	1.75 (0.42–7.22)
Body-mass index			
<23	1.0	1.0	1.0
23–24.9	1.49 (1.27–1.76)	1.22 (1.01–1.47)	0.92 (0.75–1.15)
25–29.9	2.04 (1.76–2.36)	1.62 (1.38–1.91)	0.88 (0.71–1.09)
≥30	3.86 (3.30–4.51)	2.57 (2.16–3.06)	0.83 (0.64–1.08)
Postmenopausal hormone use			
Premenopausal	0.72 (0.61–0.83)	0.67 (0.54–0.83)	0.78 (0.62–0.99)
Postmenopausal			
Never used or used in past	1.0	1.0	1.0
Currently using	0.81 (0.66–1.00)	0.68 (0.58–0.91)	0.73 (0.60–0.88)
Composite diet score§			
Lowest quintile	1.0	1.0	1.0
Second quintile	0.89 (0.76–1.04)	0.79 (0.67–0.94)	0.79 (0.66–0.95)
Third quintile	0.80 (0.65–0.98)	0.78 (0.67–0.90)	0.77 (0.64–0.93)
Fourth quintile	0.76 (0.64–0.90)	0.59 (0.49–0.71)	0.57 (0.45–0.71)
Fifth quintile	0.64 (0.53–0.78)	0.43 (0.35–0.52)	0.40 (0.31–0.53)

*Variables were entered into the model simultaneously. Age was adjusted for in five-year categories.

†Data on smoking, body-mass index, and postmenopausal hormone use were obtained in 1980, 1982, 1984, 1986, 1988, 1990, and 1992. Data on diet were obtained in 1980, 1984, 1986, and 1990.

‡The associations for the updated variables can be interpreted as the effects of changes in these variables over time on the risk of coronary disease.

§The intakes of trans fat, cereal fiber, marine n−3 fatty acids, and folate, the glycemic load, and the ratio of polyunsaturated to saturated fat were categorized into quintiles, and for each participant, the quintile values for the nutrients (a higher quintile score represents a better diet) were summed to generate the composite dietary score.

medication from 1950 to 1989 was associated with a downward trend in the prevalence of hypertension and a concomitant decline in left ventricular hypertrophy. In the Nurses' Health Study cohort, much of the benefit of pharmacologic treatment of hypertension was probably realized before 1980.

One strength of our study is the use of regularly collected, detailed data on dietary and other lifestyle factors; this data base permits us to estimate the degree to which trends in coronary disease are explained by changes in diet and lifestyle. However, assessing the effects of individual changes in body-mass index and smoking is difficult, because these variables are highly correlated over time. In addition, our analyses did not take into account the potential effect of a time lag between the change in a risk factor (e.g., an improvement in diet) and the resulting reduction in the risk of coronary disease.

Furthermore, the observed dietary change between 1980 and 1984 may in part reflect changes in the dietary questionnaires. This may be especially true for the calculated intakes of marine n−3 fatty acids and cereal fiber, because more food items containing these nutrients were included in the later questionnaire. However, most of the observed changes are generally consistent with dietary-records data from two validation studies conducted in 1980 and 1986 in the Nurses' Health Study (Sampson L: personal communication). For example, during this period, according to the dietary records, intake of saturated fat decreased by 12 percent and intake of polyunsaturated fat increased by 13 percent.

Finally, because our participants were all registered nurses, the trends over time cannot be extrapolated to women in the general population. However, the observed associations between diet and lifestyle variables and changes in the incidence of coronary disease should apply broadly.

In conclusion, we observed a substantial decline in the incidence of coronary disease from 1980 to 1994 among women in the Nurses' Health Study. Reduction in smoking, improvement in diet, and an increase in postmenopausal hormone use accounted for much of the decline in coronary disease. The increase in obesity, however, appears to have prevented a further decline in the incidence of coronary disease. These findings underscore the importance of diet and lifestyle in the primary prevention of coronary disease.

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