

## Special Article

BENEFIT OF A FAVORABLE CARDIOVASCULAR RISK-FACTOR PROFILE  
IN MIDDLE AGE WITH RESPECT TO MEDICARE COSTS

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**ABSTRACT**

**Background** People without major risk factors for cardiovascular disease in middle age live longer than those with unfavorable risk-factor profiles. It is not known whether such low-risk status also results in lower expenditures for medical care at older ages. We used data from the Chicago Heart Association Detection Project in Industry to assess the relation of a low risk of cardiovascular disease in middle age to Medicare expenditures later in life.

**Methods** We studied 7039 men and 6757 women who were 40 to 64 years of age when surveyed between 1967 and 1973 and who survived to have at least two years of Medicare coverage in 1984 through 1994. Men and women classified as being at low risk for cardiovascular disease were those who had the following characteristics at the time they were initially surveyed: serum cholesterol level, <200 mg per deciliter (5.2 mmol per liter); blood pressure, ≤120/80 mm Hg; no current smoking; an absence of electrocardiographic abnormalities; no history of diabetes; and no history of myocardial infarction. We compared Medicare costs for the 279 men (4.0 percent) and 298 women (4.4 percent) who had this low-risk profile with those for the rest of the study group, who were not at low risk. Health Care Financing Administration charges for services to Medicare beneficiaries were used to estimate average annual health care costs (total costs, those for cardiovascular diseases, and those for cancer).

**Results** Average annual health care charges were much lower for persons at low risk — the total charges for the men at low risk were less than two thirds of the charges for the men not at low risk (\$1,615 less); for the women at low risk, the charges were less than one half of those for the women not at low risk (\$1,885 less). Charges related to cardiovascular disease were lower for the low-risk groups of men and women than for those not at low risk (by \$979 and \$556, respectively), and charges related to cancer were also lower (by \$134 and \$189).

**Conclusions** People with favorable cardiovascular risk profiles in middle age had lower average annual Medicare charges in older age. Having optimal status with respect to major cardiovascular risk factors may result not only in greater longevity but also in lower health care costs. (N Engl J Med 1998;339:1122-9.)

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PEOPLE without major risk factors for cardiovascular disease in young adulthood and middle age are at lower age-specific risk for death from cardiovascular causes, noncardiovascular causes, and all causes<sup>1-3</sup> and consequently have greater life expectancy than others in the population. The merits of having a favorable risk-factor profile may extend even further. Thus, it is reasonable to assume that low-risk status earlier in adulthood relates to lower health care costs in older age. As the population ages, this is an increasingly important issue with respect to expenditures for health care under Medicare, the largest single source of health care spending in the United States.

We explored this hypothesis by evaluating data obtained on cohorts of middle-aged men and women surveyed from 1967 to 1973 as part of the Chicago Heart Association Detection Project in Industry. These cohorts were followed through 1994; 7039 men and 6757 women survived to be eligible for Medicare coverage for at least two years. The average annual charges (adjusted for age and inflation) over a period of 11 years for health care for all conditions, cardiovascular conditions, and cancer were compared between men and women with favorable base-line risk-factor profiles and those with unfavorable profiles.

**METHODS****Participants**

Between November 1967 and January 1973, the Chicago Heart Association Detection Project in Industry screened 39,573 women and men 18 years of age or older who were employed by 84 Chicago-area organizations. All employees (approximately 75,000) were invited to participate; about 55 percent volunteered for the study. Standardized methods were used and have been re-

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ported elsewhere.<sup>2</sup> In brief, trained staff members measured each participant's height, weight, blood pressure in the supine position, and serum cholesterol.<sup>4</sup> The participants completed a questionnaire about their demographic characteristics, smoking history, and medical diagnoses and treatment. Electrocardiograms, recorded while the participants were at rest, were classified as showing major abnormalities, minor abnormalities, or no abnormalities on the basis of the criteria of the Hypertension Detection and Follow-up Program.<sup>5,6</sup>

### Eligibility

Among the men and women who participated in the Chicago Heart Association study, those who were 40 to 64 years old at base line (1967 to 1973) and who were eligible to receive Medicare benefits between 1984 and 1994 were eligible for the current study. To increase the likelihood that the participants would have used services paid for by Medicare, persons with fewer than two years of eligibility for Medicare coverage were excluded (i.e., those who were less than 67 years of age in 1994 or those who died before the age of 67). Of the 16,669 participants who were 40 to 64 years of age at base line (8989 men and 7680 women), 2763 had died (1906 men and 857 women) before 1984 or before they had been eligible for Medicare benefits for two years. Another 44 men and 66 women were excluded because of missing data on blood pressure (13 participants), serum cholesterol levels (56), smoking status (16), or diabetes (25). Thus, 7039 men and 6757 women were eligible for Medicare benefits between 1984 and 1994, had had at least two years of Medicare coverage, and had a complete set of data on the risk factors we studied.

### Subgroups

Men and women were classified separately. Participants were stratified according to six risk factors. Those with all the following characteristics were considered to be at low risk for cardiovascular disease: blood pressure,  $\leq 120/80$  mm Hg; serum cholesterol level,  $< 200$  mg per deciliter (5.2 mmol per liter);<sup>7</sup> no current smoking; no electrocardiographic abnormalities; no history of diabetes; and no history of myocardial infarction.<sup>1-3</sup>

### Data on Costs

Medicare inpatient and outpatient claims data were obtained from the Health Care Financing Administration (HCFA) for surviving participants who were 65 years of age or older and who were thus eligible for Medicare benefits during the period from 1984 — the first year HCFA data were available for public use — through 1994. HCFA data for a patient were cross-referenced according to Social Security number, sex, and birth date. Records include, for each medical service billed to Medicare, the date of service, the total charges, the diagnosis-related group, the primary diagnosis, and up to eight other diagnoses coded according to the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM).<sup>8</sup> These files contain charges related to acute inpatient and outpatient care but do not include charges for skilled-nursing and hospice care or prescription drugs. Outpatient charges are for visits to an emergency room, clinic and ambulatory surgery, laboratory tests, radiography, rehabilitation therapy, radiation therapy, and renal dialysis. Physicians' fees, visits to doctors' offices, and other non-hospital-related ambulatory care services are not included.

Medicare claims for inpatient and outpatient care were used to estimate health care costs. For each beneficiary, all charges were totaled and then annualized by dividing the total by the number of years of Medicare coverage. For annual costs related to cardiovascular disease, charges were averaged for health care services with primary diagnoses with ICD-9-CM discharge codes 390 through 459; for costs related to cancer, charges were averaged for services coded 140 through 172, 174 through 184, and 186 through 208. Charges may overstate costs, but the two are

highly correlated, and the relations of risk factors to costs and charges are likely to be consistent.<sup>9</sup> It is reasonable to assume that the cost-to-charges ratio does not differ systematically according to risk.

### Statistical Analysis

Descriptive statistics were calculated separately for the base-line characteristics of men and women in the low-risk group and for those not classified as at low risk. The percentage of each group with Medicare costs was determined by dividing the number of persons with at least one Medicare claim during their period of coverage by the total number of persons in the group. Average annual charges, numbers of hospital visits, and numbers of days of hospital use (inpatient and outpatient combined) were determined separately for each person. Services that began and ended on the same date were counted as one hospital day. Sex-specific analyses also compared the low-risk subgroups with those not at low risk after persons with diabetes, a history of myocardial infarction, or electrocardiographic abnormalities at base line had been excluded from the subgroups that were not at low risk.

Charges adjusted for age and the number of years of Medicare coverage and hospital use for both subgroups of men and women were compared by analysis of variance. Since the distribution of charges was very skewed, we used log-transformed data — assigning a value of \$1 for services with no charges — to test hypotheses. Adjusted comparisons between groups were also performed with the use of Cox regression.<sup>10</sup> In these comparisons, each person's average annual charge was subtracted from the maximal average annual charge in each cohort of men or women, and this value was treated as "survival time." Data on persons with no charges were censored at the maximal charge. In essence, this approach involves the inversion of the data (i.e., people with no charges were considered to have the longest survival time).

To assess whether higher charges were associated with a higher number of risk factors at base line, we considered only three major risk factors — blood pressure  $> 120/80$  mm Hg, serum cholesterol levels  $\geq 200$  mg per deciliter, and current smoking. The participants were classified according to whether they had none of these unfavorable characteristics, any one, any two, or all three. Multiple linear regression was then used to compute the adjusted mean value for each subgroup. Tests were based on log-transformed charges as well as on Cox regression. To account for inflation, all charges were adjusted to 1994 dollars on the basis of the hospital-room component of the Consumer Price Index.<sup>11</sup>

## RESULTS

### Characteristics at Base Line

Only 279 men (4.0 percent) and 298 women (4.4 percent) met the criteria for low risk (Table 1). For the men at low risk, as compared with all the other men, the mean serum cholesterol level was lower by 36 mg per deciliter (0.9 mmol per liter); systolic and diastolic blood pressures were lower by 28 and 13 mm Hg, respectively. For the women at low risk, the mean serum cholesterol level was lower by 48 mg per deciliter (1.2 mmol per liter) and systolic and diastolic blood pressures were lower by 24 and 11 mm Hg, respectively, than in all the other women. The average serum cholesterol and blood-pressure values were also markedly lower for the low-risk subgroups than for those not at low risk, after those with electrocardiographic abnormalities, a history of diabetes, or evidence of myocardial infarction had been excluded (Table 1). Other base-line characteristics were also more favorable for the low-risk sub-

TABLE 1. BASE-LINE CHARACTERISTICS OF THE STUDY PARTICIPANTS.\*

CHARACTERISTIC	MEN WITH LOW-RISK STATUS (N=279)†	MEN WITH ≥1 OF 6 RISK FACTORS (N=6760)‡	MEN WITH ≥1 OF 3 MAJOR RISK FACTORS (N=5346)§	WOMEN WITH LOW-RISK STATUS (N=298)†	WOMEN WITH ≥1 OF 6 RISK FACTORS (N=6459)‡	WOMEN WITH ≥1 OF 3 MAJOR RISK FACTORS (N=5109)§
Age (yr)	49.8±5.5	51.4±5.9	51.1±5.8	48.9±4.9	52.1±5.6	52.0±5.6
Serum cholesterol (mg/dl)¶	177.2±17.1	213.6±36.0	213.5±34.9	177.2±16.0	225.1±40.1	225.1±39.9
Systolic blood pressure (mm Hg)	115.5±5.6	143.0±19.3	141.7±18.3	114.7±6.6	139.2±20.2	137.7±19.3
Diastolic blood pressure (mm Hg)	72.0±6.3	84.6±11.4	84.0±11.0	70.4±6.9	81.2±11.4	80.4±11.1
Current smoker (%)	0	37.3	37.3	0	33.6	34.4
No. of cigarettes per day	0	22.7±11.2	23.0±11.2	0	17.3±9.0	17.3±8.9
Body-mass index	25.5±2.9	27.2±3.5	27.2±3.5	23.5±3.2	25.4±4.4	25.3±4.3
Electrocardiographic abnormalities (%)						
Major	0	8.9	0	0	13.5	0
Minor only	0	7.8	0	0	5.1	0
History of diabetes (%)	0	3.5	0	0	2.4	0
History of myocardial infarction (%)	0	2.4	0	0	0.8	0
Education (yr)	13.8±2.7	12.7±2.8	12.8±2.8	12.4±2.5	11.8±2.2	11.8±2.2
Black race (%)	4.3	4.4	4.1	3.4	4.2	3.9

\*Plus-minus values are means ±SD.

†Low-risk status was defined as having all of the following at base line: serum total cholesterol level of <200 mg per deciliter, systolic blood pressure ≤120 mm Hg and diastolic blood pressure ≤80 mm Hg, no current smoking, no electrocardiographic abnormalities, no history of diabetes, and no history of myocardial infarction.

‡This category includes all others; these persons were classified as being not at low risk.

§Persons with a history of diagnosed diabetes, myocardial infarction, or any electrocardiographic abnormality at base line were excluded. The major risk factors were a serum cholesterol level of ≥200 mg per deciliter, blood pressure of >120/80 mm Hg, and cigarette smoking.

¶To convert values for serum cholesterol to millimoles per liter, multiply by 0.02586.

||The body-mass index is the weight in kilograms divided by the square of the height in meters.

groups (e.g., education level and body-mass index). The numbers of years of Medicare coverage were similar for men at low risk and for the men not at low risk (7.9 and 7.9, respectively); the women at low risk had 1.2 fewer years of Medicare coverage than the women not at low risk (7.4 and 8.6).

**Health Care Costs and Use of Services**

The follow-up period after the base-line survey averaged 23 years. On the basis of the HCFA data on inpatient and outpatient services, the average annual Medicare charges for cardiovascular care and for all care were significantly lower for the men at low risk than for those not at low risk; charges were also significantly lower for the women at low risk than for those not at low risk (Table 2). This finding was consistent regardless of whether persons with base-line electrocardiographic abnormalities or a history of diabetes or myocardial infarction were included in the analysis. The average annual differences in charges were considerable, although the proportion of persons using services for which Medicare claims were submitted was uniformly high (77 to 84 percent) for all subgroups. Thus, when persons with electrocardiographic abnormalities, diabetes, or a pri-

or myocardial infarction were excluded, the total average charges were lower for the men at low risk than for the men not at low risk by \$1,294 per year (29 percent) and lower for the women at low risk than for the women not at low risk by \$1,634 per year (49 percent) (Table 2). For the men and women who had no evidence of electrocardiographic abnormalities, clinical diabetes, or heart disease in middle age, the absence of all three major risk factors for cardiovascular disease (i.e., a serum cholesterol level of <200 mg per deciliter, blood pressure of no more than 120/80 mm Hg, and no cigarette smoking) was associated with substantially lower Medicare charges in older age than those incurred for people with one or more of these risk factors.

Differences in charges were accentuated by the stratification of the subgroup not at low risk according to whether the participants had only one of the three major risk factors, had any two only, or had all three (Table 3). For example, total annual charges were lower by \$878 (21 percent) for the men at low risk and \$966 (35 percent) for the women at low risk than for those with only a serum cholesterol level of ≥200 mg per deciliter; total annual charges were lower by \$2,626 (44 percent) and \$2,437 (57

**TABLE 2.** ADJUSTED AVERAGE ANNUAL MEDICARE CHARGES FOR INPATIENT AND OUTPATIENT CARE AND MEASURES OF USE.\*

VARIABLE	LOW-RISK STATUS†	≥1 OF 6 RISK FACTORS‡	≥1 OF 3 MAJOR RISK FACTORS§
<b>Men</b>			
No.	279	6760	5346
Use of services (%)	84.1	79.9	80.1
Charges related to cardiovascular disease (\$)¶	751	1,730	1,549
Charges related to cancer (\$)***	408	542	537
Total charges (\$)	3,165	4,780	4,459
Hospital visits (no.)	1.3	1.4	1.4
Hospital days (no.)	2.6	3.3††	3.2††
<b>Women</b>			
No.	298	6459	5109
Use of services (%)	76.8	79.9	79.4
Charges related to cardiovascular disease (\$)¶	350	906	788
Charges related to cancer (\$)***	190	379	346
Total charges (\$)	1,700	3,585	3,334
Hospital visits (no.)	1.3	1.4	1.3
Hospital days (no.)	1.9	2.9††	2.7††

\*Data were adjusted for age and the number of years of Medicare coverage. Reported means are nontransformed data derived from the least-squares means of the general linear model. Charges were adjusted for inflation to 1994 dollars.

†Low-risk status was defined as having all of the following at base line: serum total cholesterol level of <200 mg per deciliter, blood pressure ≤120/80 mm Hg, no current smoking, no electrocardiographic abnormalities, no history of diabetes, and no history of myocardial infarction.

‡This category includes all others; these persons were classified as being not at low risk.

§Persons with a history of diagnosed diabetes, myocardial infarction, or electrocardiographic abnormalities at base line were excluded.

¶These charges were related to diseases assigned ICD-9-CM codes 390 through 459.

||P<0.05 for the comparison with the persons with no risk factors, by regression analysis.

\*\*\*These charges were related to diseases assigned ICD-9-CM codes 140 through 172, 174 through 184, and 186 through 208.

††P<0.05 for the comparison with the persons with no risk factors, by regression analysis of log-transformed values.

percent), respectively, than for smokers with serum cholesterol levels ≥200 mg per deciliter. Total annual charges were significantly lower — by \$2,779 (46 percent) — for the men at low risk than for the men with all three major risk factors and by \$2,670 (60 percent) for the women at low risk than for the women with all three risk factors. Total charges increased with the number of risk factors. Charges for cardiovascular care showed similar patterns. The average numbers of hospital admissions and hospital days were significantly higher when the number of risk factors was greater (data not shown).

In addition, the mean and median total charges for the stratified subgroups were compared for consistency of findings. Median charges were much lower than mean charges. However, the pattern of charges across risk-factor subgroups was similar — i.e., the subgroups with higher mean total charges also had higher median total charges (data not shown).

The findings from the Cox regression (data not shown) were also consistent with those of the log-transformed analyses (Tables 2 and 3). Thus, all the

methods used in this study, including the statistical procedures used to deal with the skewness of the charge data, yielded results that were consistent with each other.

For every risk-factor subgroup, cause-specific and total charges were consistently lower for the women than for the men (Tables 2 and 3).

### DISCUSSION

On the basis of an average follow-up period of 23 years, our main finding is that a favorable cardiovascular risk-factor profile in middle age is associated with substantially lower Medicare costs in older age for both women and men. Over the period between 1984 and 1994, average annual health care charges — both total charges and those related to cardiovascular care — were much lower for the men and women identified as being at low risk for cardiovascular disease at base line than for the men and women at higher risk. The charges attributable to cancer as the primary diagnosis were also lower for the men and women at low risk than for those not

**TABLE 3.** ADJUSTED AVERAGE ANNUAL CHARGES FOR INPATIENT AND OUTPATIENT CARE ACCORDING TO THE NUMBER OF RISK FACTORS.\*

No. of Risk Factors	No. of Persons	Charges Related to Cardiovascular Disease†	Charges Related to Cancer‡	Total Charges
				dollars
<b>Men</b>				
No risk factors§	279	760	447	3,289
1 major risk factor only				
Any one	1560	1,327¶	446	3,899
Serum total cholesterol ≥200 mg/dl	320	1,471	473	4,167
Blood pressure >120/80 mm Hg	1095	1,326¶	427	3,816
Smoking ≥1 cigarette/day	145	1,213	672	4,710
2 major risk factors only				
Any two	2729	1,543¶	518	4,430
Serum total cholesterol ≥200 mg/dl and blood pressure >120/80 mm Hg	1938	1,569¶	466	4,230
Serum total cholesterol ≥200 mg/dl and smoking ≥1 cigarette/day	197	2,099¶	496¶	5,915
Blood pressure >120/80 mm Hg and smoking ≥1 cigarette/day	594	1,361¶	755	4,907
3 major risk factors				
Serum total cholesterol ≥200 mg/dl, blood pressure >120/80 mm Hg, and smoking ≥1 cigarette/day	1057	2,080¶	888¶	6,068¶
<b>Women</b>				
No risk factors§	298	388	205	1,817
1 major risk factor only				
Any one	1518	597¶	315	3,043¶
Serum total cholesterol ≥200 mg/dl	582	638¶	379	2,783¶
Blood pressure >120/80 mm Hg	753	607¶	297	3,368
Smoking ≥1 cigarette/day	183	606	210	2,993
2 major risk factors only				
Any two	2667	780¶	359	3,244¶
Serum total cholesterol ≥200 mg/dl and blood pressure >120/80 mm Hg	2018	812¶	307	3,002
Serum total cholesterol ≥200 mg/dl and smoking ≥1 cigarette/day	335	887¶	518¶	4,254¶
Blood pressure >120/80 mm Hg and smoking ≥1 cigarette/day	314	658¶	522	3,996¶
3 major risk factors				
Serum total cholesterol ≥200 mg/dl, blood pressure >120/80 mm Hg, and smoking ≥1 cigarette/day	924	1,315¶	395	4,487¶

\*Data were adjusted for age and the number of years of Medicare coverage. Reported means are nontransformed data derived from the least-squares means of the general linear model. Charges were adjusted for inflation to 1994 dollars.

†These charges were related to diseases assigned ICD-9-CM codes 390 through 459.

‡These charges were related to diseases assigned ICD-9-CM codes 140 through 172, 174 through 184, and 186 through 208.

§Persons with no risk factors had all of the following at base line: serum total cholesterol level of <200 mg per deciliter, blood pressure ≤120/80 mm Hg, no current smoking, no electrocardiographic abnormalities, no history of diabetes, and no history of myocardial infarction.

¶P<0.05 for the comparison with the persons with no risk factors, by regression analysis of log-transformed values.

at low risk, although these differences were not significant. Furthermore, Medicare charges were lowest among the low-risk men and women, with charges progressively rising with the number of risk factors for those with one or more of the three major risk factors.

We focused on the three coronary risk factors designated as major since 1970<sup>12</sup> — high serum cholesterol level, high systolic and diastolic blood pressure, and cigarette smoking — not only because of their

substantial influence on risk, but also because of their high prevalence in the adult population and the fact that they can be prevented and controlled with a great effect on risk, longevity, and health care costs.<sup>13</sup> Hence our comparisons between persons having none of these three modifiable and preventable traits and those having one or more, unconfounded by the presence of diabetes, history of myocardial infarction, or electrocardiographic abnormalities, have key importance.

Data from several longitudinal studies demonstrate that risk factors for cardiovascular disease measured in young and middle-aged adults remain strong predictors of the development of cardiovascular diseases during long-term follow-up (20 to 30 years).<sup>2,14,15</sup> The long-term risk of death due to cardiovascular disease and to all causes is also much lower for men and women with a favorable base-line status with respect to all three of the major risk factors.<sup>2</sup> As a result, men and women at low risk have a considerably greater life expectancy. However, the long-term economic consequences (e.g., effects on Medicare expenditures) of either an unfavorable or an optimal risk-factor profile have been unclear.

Most of the available studies on the economic consequences of risk factors are cross-sectional,<sup>16,17</sup> are limited to younger working populations,<sup>16-18</sup> or have only short-term follow-up.<sup>18</sup> Such studies generally have related short-term health care costs to risk factors that had been recently assessed. Our findings are consistent with these data.<sup>16-18</sup> Two cross-sectional studies, one from Control Data<sup>16</sup> and the other from Dupont,<sup>17</sup> reported higher health care expenditures and use of services<sup>16</sup> or excess annual costs for illness (defined as the sum of compensation, health care, and benefits not related to health care)<sup>17</sup> for employees with any one risk factor (smoking, being overweight, having a high cholesterol level, having high blood pressure, or having a sedentary lifestyle), as compared with those without any of these risk factors. In a three-year prospective study of the employees of a large manufacturing company, the average annual medical costs associated with any of 11 health-related variables (including risk factors related to cardiovascular disease) were higher for workers classified as being at high risk than for those considered to be at low risk.<sup>18</sup> The number of risk factors was also significantly associated with higher costs for medical care.

Research on the economic effect of preventable and modifiable risk factors for cardiovascular disease in older populations is also limited. Two studies linked health habits and risk factors for cardiovascular disease to health care costs. Risks were measured a year or two before the costs were incurred<sup>19,20</sup>; the results were consistent with ours. In a sample of retirees from the Bank of America who were followed for 12 months, health habits associated with higher subsequent medical costs included smoking and not exercising at base line.<sup>19</sup> A report from the Framingham Study also showed that higher levels and greater numbers of major risk factors — cigarette smoking, high systolic blood pressure, and high serum cholesterol — in older men and women were associated with higher subsequent annual Medicare costs over a two-year period.<sup>20</sup> None of these studies reported the costs of care for specific diagnoses.

We found no significant difference in the rate of

use of services covered by Medicare (i.e., the percentage of persons with at least one Medicare claim) among the subgroups at low risk and those not at low risk. However, the average number of hospital days per year was lower for persons at low risk, possibly because they had less severe illness, different types of illness, fewer medical problems, or fewer complications requiring hospitalization than those not at low risk.

Contrary to some expectations,<sup>21</sup> our findings also indicate that men, regardless of risk status, spend more days in the hospital than women and have higher Medicare charges, for reasons not yet elucidated. It has been suggested that women receive less comprehensive care and treatment for diseases or disorders,<sup>22,23</sup> that their illnesses are detected earlier (because women use more services provided by physicians, including those for preventive care),<sup>24</sup> that they have better health than their male counterparts, or all three.

Since there have been few deaths thus far in the low-risk subgroups (18 men and 17 women), it is not yet possible to assess whether the observed cost benefits reflect an as-yet-undetected shift in the incidence of chronic diseases to older persons (i.e., the “compression of morbidity” phenomenon proposed by Fries<sup>25</sup>). Meaningful comparisons of Medicare costs in the last year of life and cumulative Medicare costs before death based on longer follow-up and more mortality data have not yet been made.

A limitation of this study is the possible misclassification of persons as being low risk due to the fact that base-line cardiovascular risk was assessed only once (regression-dilution bias).<sup>26,27</sup> This problem produces an underestimation of the true effect of risk status. Moreover, the positive effect of low-risk status on Medicare costs may also be underestimated because of a lack of data on an important risk factor (i.e., habitual diet).<sup>28</sup> A further limitation is the lack of data on the use of other health services covered by Medicare, including home care, nursing home care, hospice care, and visits to physicians. However, several studies indicate that the chief risk factor for placement in a nursing home is poor health status<sup>29,30</sup> and that hypertension and diabetes are important predictors of the level of use of physicians’ services.<sup>31</sup> Therefore, it is likely that the use of health care services other than those that were hospital-related was substantially lower for the men and women at low risk than for those not at low risk. Furthermore, the costs of hospitalization represent the largest proportion of Medicare expenditures.<sup>32</sup>

Another issue associated with the use of Medicare data is the appropriateness of the primary diagnosis for estimating costs for specific diseases. Several studies have focused on the reliability of diagnoses obtained from HCFA records.<sup>33-35</sup> Fisher et al. reported that measures of coding accuracy (sensitivity

and positive predictive value) in HCFA data varied widely, depending on the condition.<sup>35</sup> For cardiovascular diseases, the sensitivity of the discharge-diagnosis codes ranged from 0.82 to 0.94, and the positive predictive value from 0.63 to 0.92; for cancer, values for both measures ranged from 0.84 to 0.96.<sup>35</sup> Thus, the actual charges related to care for cardiovascular diseases and cancer are probably higher than those we calculated.

In summary, data from the Chicago Heart Association study indicate that with favorable status with respect to all major risk factors for cardiovascular disease in middle age, the costs of health care in older age are markedly lower. The benefit of being at low risk during middle age not only encompasses greater longevity, as demonstrated for our participants and other cohorts, but also has a positive effect on Medicare costs. These findings imply improved quality of life — the prolongation of independent and productive living, with a decreased burden on family and society. These data underscore the soundness of national public health policy, with its emphasis on the primary prevention and control of all three major risk factors for cardiovascular disease — high serum cholesterol levels, high blood pressure, and cigarette smoking — as the key not only to mitigating the epidemic of coronary heart disease and cardiovascular diseases and ameliorating chronic non-cardiovascular disease,<sup>13,36,37</sup> but also to containing health care expenditures and possibly improving the quality of life in the later years.

Supported by grants from the American Heart Association and its Chicago and Illinois affiliates, the Illinois Regional Medical Program, the National Heart, Lung, and Blood Institute (HL21010 and HL03387), the Chicago Health Research Foundation, and private donors.

*We are indebted to the officers and employees of the Chicago companies and organizations whose invaluable cooperation and assistance made this study possible; to the staff members and volunteers involved in the Chicago Heart Association Detection Project in Industry; and to our colleagues who contributed to this important endeavor.<sup>2</sup>*

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