ORIGINAL INVESTIGATION

Risk Factors for Congestive Heart Failure in US Men and Women

NHANES I Epidemiologic Follow-up Study

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Background: The incidence of congestive heart failure (CHF) has been increasing steadily in the United States during the past 2 decades. We studied risk factors for CHF and their corresponding attributable risk in the First National Health and Nutrition Examination Survey Epidemiologic Follow-up Study.

Participants and Methods: A total of 13643 men and women without a history of CHF at baseline examination were included in this prospective cohort study. Risk factors were measured using standard methods between 1971 and 1975. Incidence of CHF was assessed using medical records and death certificates obtained between 1982 and 1984 and in 1986, 1987, and 1992.

Results: During average follow-up of 19 years, 1382 CHF cases were documented. Incidence of CHF was positively and significantly associated with male sex (relative risk [RR], 1.24; 95% confidence interval [CI], 1.10-1.39; $P<.001$; population attributable risk [PAR], 8.9%), less than a high school education (RR, 1.22; 95% CI, 1.04-1.42; $P=.01$; PAR, 8.9%), low physical activity (RR, 1.23; 95% CI, 1.09-1.38; $P<.001$; PAR, 9.2%), cigarette smoking (RR, 1.59; 95% CI, 1.39-1.83; $P<.001$; PAR, 17.1%), overweight (RR, 1.30; 95% CI, 1.12-1.52; $P=.001$; PAR, 8.0%), hypertension (RR, 1.40; 95% CI, 1.24-1.59; $P<.001$; PAR, 10.1%), diabetes (RR, 1.85; 95% CI, 1.51-2.28; $P<.001$; PAR, 3.1%), valvular heart disease (RR, 1.46; 95% CI, 1.17-1.82; $P=.001$; PAR, 2.2%), and coronary heart disease (RR, 8.11; 95% CI, 6.95-9.46; $P<.001$; PAR, 61.6%).

Conclusions: Male sex, less education, physical inactivity, cigarette smoking, overweight, diabetes, hypertension, valvular heart disease, and coronary heart disease are all independent risk factors for CHF. More than 60% of the CHF that occurs in the US general population might be attributable to coronary heart disease.

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DURING THE past several decades, the incidence of and mortality from coronary heart disease (CHD) and stroke have been continuously declining. In contrast, the incidence of and mortality from congestive heart failure (CHF) have been increasing and have become important public health and clinical problems.[1,2] Approximately 4.6 million Americans have a diagnosis of CHF, about 400000 new cases occur annually, and more than 43000 individuals die of CHF in the United States each year.[1] The number of hospitalizations for CHF increased from 377000 in 1979 to 870000 in 1996 (a 131% increase), and deaths from CHF increased by approximately 120% during the same period.[1]

Few population-based epidemiologic studies[3-6] have examined the risk factors for CHF. In the Framingham Heart Study, CHD, hypertension, left ventricular hypertrophy, valvular heart disease, and diabetes were associated with an increased risk of CHF.[3,4] Diabetes, CHD, elevated pulse pressure, and obesity were associated with an increased risk of CHF in the New Haven, Conn, cohort of the Established Population for Epidemiologic Studies of the Elderly program.[5] In the East Boston Senior Health Project, elevated pulse pressure, diabetes, valvular heart disease, atrial fibrillation, and use of antihypertensive medication, but not CHD, were associated with an increased risk of CHF.[6] The effect of socioeconomic status and lifestyle risk factors on the risk of CHF has not been well studied. Furthermore, the contribution of each individual risk factor to the overall incidence of CHF in the US general population has not been established. This information is important in developing strategies for the prevention of CHF in the US general population.

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PARTICIPANTS AND METHODS

STUDY POPULATION

In NHANES I, a multistage, stratified, probability sampling design was used to select a representative sample of the US civilian noninstitutionalized population aged 1 to 74 years. Details of the study design, sampling methods, response rate, and data collection have been published elsewhere.[7,8] Certain population subgroups, including those with a low income, women of childbearing age (25-44 years), and elderly persons (≥65 years), were oversampled.

The NHANES I Epidemiologic Follow-up Study is a prospective cohort study of NHANES I participants aged 25 to 74 years when the survey was conducted in 1971 to 1975.[9-12] Of 14407 NHANES I Epidemiologic Follow-up Study participants in this age range, 219 with a positive history of CHF at baseline, defined as ever having been told by a physician that they have had heart failure or having used any medication for a "weak heart" during the 6 months before the baseline interview, and 545 lost to follow-up (there was no subject or proxy interview at any follow-up wave and no death certificate) were excluded from the analysis. After these exclusions, the experience from 5545 men and 8098 women was available for analysis.

MEASUREMENTS

Baseline data collection included demographic information, a medical history, standardized medical examination, laboratory tests, and anthropometric measurements.[7,8] Frozen serum samples were sent to the Centers for Disease Control and Prevention for measurement of serum total cholesterol levels. Blood pressure, body weight, and height were obtained using standard protocols. The baseline questionnaire detailing medical history included queries about selected health conditions and medications used for these conditions during the preceding 6 months. Data pertaining to education, physical activity, and alcohol consumption were based on responses to interviewer-administered questionnaires. Baseline information on smoking status was obtained in a random subsample of 6913 participants who underwent a more detailed evaluation at the time of their examination.[7,8] For the remaining study participants, information on smoking status at baseline was derived from responses to questions regarding lifetime smoking history administered at follow-up interviews conducted between 1982 and 1984 or later.[13,14] The validity of information on smoking status obtained using this approach has been documented elsewhere.[13,14]

Hypertension at baseline was defined as a systolic blood pressure of 160 mm Hg or greater and/or a diastolic blood pressure of 95 mm Hg or greater and/or use of antihypertensive medication. Hypercholesterolemia was defined as a total serum cholesterol value of 6.21 mmol/L or greater (≥240 mg/dL). Overweight was defined as a body mass index (calculated as weight in kilograms divided by the square of height in meters) of 27.8 or greater for men and 27.3 or greater for women. Baseline diabetes was defined as the participant ever having been told by a physician that he or she had this condition. Coronary heart disease was defined as the participant ever having been told by a physician that he or she had a heart attack or having a diagnosis with an *International Classification of Diseases, Ninth Revision (ICD-9),* code of 410 to 414. Valvular heart disease was defined as having a diagnosis with an *ICD-9* code of 394 to 397 or 424 at the baseline medical examination.

FOLLOW-UP PROCEDURES

Follow-up data were collected between 1982 and 1984 and in 1986, 1987, and 1992.[9-12] Each follow-up examination included tracking a participant or his or her proxy to a current address; performing an in-depth interview; obtaining hospital and nursing home records, including pathology reports and electrocardiograms; and, for decedents, acquiring a death certificate. Incident cardiovascular disease was based on documentation of an event that met prespecified study criteria and occurred between the participant's baseline examination and last follow-up interview. Mortality from cardiovascular disease was based on death certificate reports. Validity of study outcome data from both sources has been documented elsewhere.[15]

Incident CHF was based on 1 or more hospital or nursing home stays in which the participant had a discharge diagnosis with an *ICD-9* code of 428.0 to 428.9 or a death certificate report in which the underlying cause of death was recorded using an *ICD-9* code of 428.0 to 428.9. Incident CHD was based on 1 or more hospital or nursing home stays in which the participant had a discharge diagnosis with an *ICD-9* code of 410 to 414 or a death certificate report in which the underlying cause of death was coded as *ICD-9* 410 to 414. The date of record for incident events was identified as the date of the participant's first hospital admission with an established study event or the date of death from a study event in the absence of hospital or nursing home documentation of such an event.

STATISTICAL ANALYSIS

The cumulative incidence of CHF by status was calculated for each risk factor using the Kaplan-Meier method,[16] and differences in cumulative rates were examined using the log-rank test for trend.[17] Cox proportional hazards models were used to explore the relation between baseline risk factors and CHF incidence.[18] History of CHD was modeled as a time-dependent variable in Cox proportional hazards models. Age was used as the time scale for all time-to-event analyses.[19] Cox proportional hazards models were stratified by birth cohort using 10-year intervals to control for calendar period and cohort effects.[19] Methods to estimate variance that take into account sample clustering and stratification of the NHANES I sample were used in Cox proportional hazards models.[19]

Population attributable risk (PAR) was calculated by standard methods as follows[20]:

$$\text{PAR} = \frac{(\text{RR} - 1) \times P}{[(\text{RR} - 1) \times P] + 1} \times 100\%$$

where P is the proportion of the population with a risk factor at baseline or the cumulative proportion exposed during follow-up and RR is the relative risk of CHF in persons with vs without the risk factor from the Cox proportional hazards model. The PAR estimates the proportion of cases that could be prevented if the risk factor could be eliminated from the total population.

Table 1. Baseline Characterisitics of 13 643 Participants in the NHANES I Epidemiologic Follow-up Study*

	Men (n = 5545)	Women (n = 8098)
Black, %	13.6	15.6
Age, mean ± SD, y	52.2 ± 15.2	48.1 ± 15.4
<High school education, %	47.9	42.1
Current cigarette smoking, %	40.7	31.1
Regular alcohol consumption, %†	37.5	16.0
Low physical activity, %	37.0	49.0
Systolic blood pressure, mean ± SD, mm Hg	136.7 ± 22.5	132.8 ± 25.5
Hypertension, %‡	30.1	26.9
Serum cholesterol level, mean ± SD, mmol/L (mg/dL)	5.72 ± 1.19 (221 ± 46)	5.74 ± 1.29 (222 ± 50)
Hypercholesterolemia,%§	30.6	32.8
Body mass index, kg/m², mean ± SD	25.7 ± 4.1	25.6 ± 5.7
Overweight, %‖	25.7	31.2
Self-reported diabetes, %	3.7	3.9
Valvular heart disease, %	4.5	5.2
Coronary heart disease, %	7.3	3.3

*NHANES I indicates the First National Health and Nutrition Examination Survey.
†Consumes alcohol 2 or more times per week.
‡Blood pressure of 160/95 mm Hg or greater and/or taking antihypertensive medication.
§Serum cholesterol level of 6.21 mmol/L or greater (≥240 mg/dL).
‖Body mass index of 27.3 or greater for women and 27.8 or greater for men.

The First National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Follow-up Study provides an opportunity to examine the risk factors for CHF in a representative sample of the US general population for which relevant long-term outcome information has been obtained. It also permits estimation of the population attributable risk (PAR) of CHF due to each risk factor of interest.

RESULTS

BASELINE RISK FACTORS

The mean age of study participants was 52.2 years in men and 48.1 years in women (**Table 1**). Approximately 13.6% of men and 15.6% of women were black. Among men, 47.9% had less than a high school education, 40.7% smoked cigarettes, 37.5% drank alcohol at least twice per week, and 37.0% did not participate in regular physical activity; the corresponding percentages for women were 42.1%, 31.1%, 16.0%, and 49.0%. The prevalence of hypertension, hypercholesterolemia, overweight, diabetes, valvular heart disease, and CHD was 30.1%, 30.6%, 25.7%, 3.7%, 4.5%, and 7.3%, respectively, in men and 26.9%, 32.8%, 31.2%, 3.9%, 5.2%, and 3.3%, respectively, in women.

CUMULATIVE INCIDENCE OF CHF

During average follow-up of 19 years, 1382 participants developed CHF (741 men and 641 women). The sex-specific cumulative incidence at age 85 years was significantly higher in men (38.1%) than in women (31.0%) ($P<.001$). In men and women, the cumulative incidence of CHF at age 85 years was significantly greater in those who were less educated, less physically active, currently smoking cigarettes, overweight, or hypertensive or had a history of diabetes, valvular heart disease, or CHD (**Table 2**). In addition, black women had a higher incidence of CHF than white women. Hypercholesterolemia was associated with an increased incidence of CHF in men but not in women, and regular alcohol consumption was associated with a significantly lower incidence of CHF in women but not in men.

RELATIVE RISKS

After adjustment for age, race, and time-dependent history of CHD, there was a positive and significant association between less than a high school education, lower level of physical activity, current cigarette smoking, overweight, hypertension, and a history of diabetes or valvular heart disease and increased risk of subsequently developing CHF in men and women (**Table 3**). Regular alcohol consumption was associated with a lower risk of CHF in women only. In a combined analysis, less than a high school education (RR, 1.35; 95% CI, 1.16-1.57; $P<.001$), lower level of physical activity (RR, 1.33; 95% CI, 1.19-1.49; $P<.001$), current cigarette smoking (RR, 1.49; 95% CI, 1.30-1.70; $P<.001$), overweight (RR, 1.35; 95% CI, 1.17–1.55; $P<.001$), history of hypertension (RR, 1.50; 95% CI, 1.34-1.68; $P<.001$), history of diabetes (RR, 1.98; 95% CI, 1.63-2.41; $P<.001$), and history of valvular heart disease (RR, 1.47; 95% CI, 1.17-1.84; $P=.001$) at the baseline examination were positively and significantly associated with an increased risk of CHF.

In a multivariate model that simultaneously included all the significant risk factors identified in the previous model, current cigarette smoking, overweight, hypertension, history of diabetes, history of valvular heart disease, and history of CHD were significantly associated with an increased risk of CHF in men and women (**Table 4**). There was a borderline significant association between less than a high school education and increased risk of CHF in men and women. Lower physical activity was positively associated, whereas regular alcohol consumption was inversely associated with risk of CHF in women but not in men (Table 4). In the com-

Table 2. Cumulative Incidence of Congestive Heart Failure at Age 85 Years in 13 643 Participants in the NHANES I Epidemiologic Follow-up Study*

	Men (n = 5545)		Women (n = 8098)	
	Incidence	*P*†	Incidence	*P*†
Race				
Black	38.2	.63	37.4	.003
Others	38.1		29.9	
Education				
<High school	41.0	.003	36.3	<.001
≥High school	34.0		24.4	
Recreational physical activity				
Low	45.4	<.001	36.6	<.001
Medium and high	33.4		24.6	
Current cigarette smoking				
Yes	45.3	<.001	39.3	<.001
No	35.0		28.4	
Regular alcohol consumption				
Yes	35.7	.09	20.6	<.001
No	39.2		32.5	
Overweight				
Yes	45.0	<.001	38.9	<.001
No	35.6		26.0	
Hypercholesterolemia				
Yes	43.1	.002	31.2	.68
No	35.6		31.2	
Hypertension				
Yes	46.9	<.001	41.0	<.001
No	32.7		24.5	
Diabetes				
Yes	65.5	<.001	61.8	<.001
No	36.9		28.9	
Valvular heart disease				
Yes	61.6	<.001	45.0	<.001
No	36.6		29.9	
Coronary heart disease				
Yes	84.7	<.001	83.9	<.001
No	19.9		16.2	

**NHANES I indicates the First National Health and Nutrition Examination Survey. Risk factor and disease definitions are described in Table 1.*
†By log-rank test.

Table 3. Relative Risk of Congestive Heart Failure in 13 643 Partcipants in the NHANES I Epidemiologic Follow-up Study by Socioeconomic and Health Characteristics*

	Men (n = 5545)		Women (n = 8098)		Total (N = 13 643)	
	RR (95% CI)†	*P*	RR (95% CI)†	*P*	RR (95% CI)†	*P*
<High school education	1.28 (1.06-1.53)	.01	1.41 (1.13-1.77)	.003	1.35 (1.16-1.57)	<.001
Low physical activity	1.30 (1.08-1.57)	.007	1.34 (1.15-1.58)	<.001	1.33 (1.19-1.49)	<.001
Current cigarette smoking	1.40 (1.20-1.65)	<.001	1.60 (1.33-1.92)	<.001	1.49 (1.30-1.70)	<.001
Regular alcohol consumption	0.99 (0.82-1.20)	.95	0.71 (0.52-0.96)	.03	0.89 (0.76-1.03)	.12
Overweight	1.24 (1.01-1.51)	.04	1.43 (1.19-1.72)	<.001	1.35 (1.17-1.55)	<.001
Hypercholesterolemia	1.01 (0.86-1.19)	.89	1.06 (0.92-1.22)	.45	1.03 (0.92-1.15)	.61
Hypertension	1.44 (1.25-1.67)	<.001	1.58 (1.36-1.82)	<.001	1.50 (1.34-1.68)	<.001
Diabetes	1.94 (1.35-2.77)	<.001	1.97 (1.50-2.57)	<.001	1.98 (1.63-2.41)	<.001
Valvular heart disease	1.72 (1.29-2.31)	<.001	1.34 (0.99-1.80)	.05	1.47 (1.17-1.84)	.001

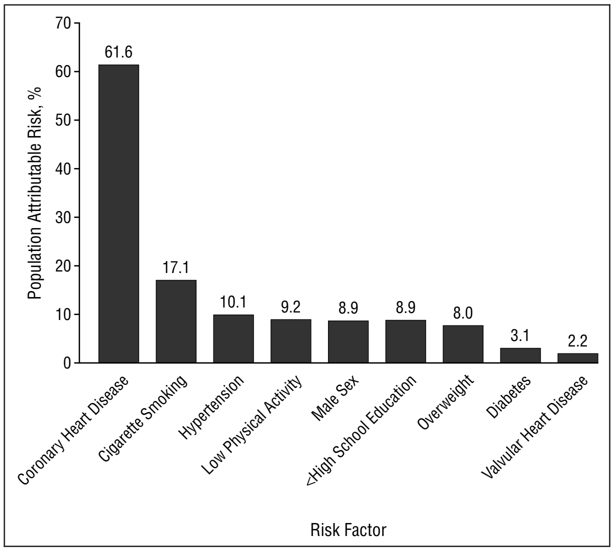
**NHANES I indicates the First National Health and Nutrition Examination Survey; RR, relative risk; and CI, confidence interval. Risk factor and disease definitions are described in Table 1.*
†Adjusted for age, race, and time-dependent history of coronary heart disease in sex-stratified analysis. In addition, sex was adjusted for analysis in the total sample.

bined analysis, male sex (RR, 1.24; 95% CI, 1.10-1.39; *P*<.001), less than a high school education (RR, 1.22; 95% CI, 1.04-1.42; *P*=.01), lower physical activity (RR, 1.23; 95% CI, 1.09-1.38; *P*<.001), cigarette smoking (RR, 1.59; 95% CI, 1.39-1.83; *P*<.001), overweight (RR, 1.30; 95% CI, 1.12-1.52; *P*=.001), hypertension (RR, 1.40; 95% CI, 1.24-1.59; *P*<.001), diabetes (RR,1.85; 95% CI, 1.51-2.28; *P*<.001), valvular heart disease (RR, 1.46; 95% CI,

Table 4. Multivariate Relative Risk of Congestive Heart Failure in 13 643 Participants in the NHANES I Epidemiologic Follow-up Study by Socioeconomic and Health Characteristics*

	Men (n = 5545)		Women (n = 8098)		Total (N = 13 643)	
	RR (95% CI)†	*P*	RR (95% CI)†	*P*	RR (95% CI)†	*P*
Male sex	. . .	. . .	. . .	. . .	1.24 (1.10-1.39)	<.001
Black race	0.95 (0.72-1.26)	.73	1.20 (0.90-1.62)	.21	1.11 (0.89-1.38)	.37
<High school education	1.20 (0.99-1.45)	.06	1.25 (0.99-1.57)	.06	1.22 (1.04-1.42)	.01
Low physical activity	1.14 (0.94-1.38)	.19	1.31 (1.11-1.54)	.002	1.23 (1.09-1.38)	<.001
Current cigarette smoking	1.45 (1.24-1.70)	<.001	1.88 (1.53-2.30)	<.001	1.59 (1.39-1.83)	<.001
Regular alcohol consumption	. . .	. . .	0.70 (0.51-0.97)	.03	0.88 (0.75-1.03)	.12
Overweight	1.23 (1.00-1.52)	.05	1.34 (1.10-1.64)	.005	1.30 (1.12-1.52)	.001
Hypertension	1.33 (1.14-1.57)	<.001	1.51 (1.29-1.77)	<.001	1.40 (1.24-1.59)	<.001
Diabetes	1.83 (1.27-2.63)	.002	1.83 (1.38-2.41)	<.001	1.85 (1.51-2.28)	<.001
Valvular heart disease	1.74 (1.31-2.31)	<.001	1.36 (1.00-1.84)	.05	1.46 (1.17-1.82)	.001
Coronary heart disease‡	8.12 (6.68-9.88)	<.001	8.16 (6.79-9.80)	<.001	8.11 (6.95-9.46)	<.001

**NHANES I indicates the First National Health and Nutrition Examination Survey; RR, relative risk; and CI, confidence interval. Risk factor and disease definitions are described in Table 1.*
†Adjusted for all covariables listed in Table 1.
‡Cumulative prevalence of coronary heart disease during follow-up was 29.7% in men and 17.7% in women.



Population attributable risk of congestive heart failure due to various risk factors in 5545 men and 8098 women participating in the First National Health and Nutrition Examination Survey Epidemiologic Follow-up Study.

1.17-1.82; *P*=.001), and CHD (RR, 8.11; 95% CI, 6.95-9.46; *P*<.001) were all positively and significantly associated with an increased risk of CHF.

POPULATION ATTRIBUTABLE RISKS

The **Figure** shows estimates of the PAR of CHF due to various risk factors based on experience in the present study. Coronary heart disease was the major cause of CHF in the general population, accounting for approximately 61.6% of all the cases, followed by cigarette smoking (PAR, 17.1%) and hypertension (PAR, 10.1%). The contribution of lower physical activity (PAR, 9.2%), male sex (PAR, 8.9%), less than a high school education (PAR, 8.9%), and overweight (PAR, 8.0%) was similar. Diabetes and valvular heart disease accounted for only 3.1% and 2.2% of CHF cases, respectively, because of their low prevalence at the baseline examination. In the sex-stratified analysis, PARs of CHF in men for CHD, current cigarette smoking, hypertension, less than a high school education, overweight, valvular heart disease, and diabetes were 67.9%, 15.5%, 9.0%, 8.7%, 5.6%, 3.2%, and 3.0%, respectively. The corresponding estimates for women were 55.9%, 21.5%, 12.1%, 9.5%, 9.6%, 1.8%, and 3.1%. In addition, physical inactivity was associated with a PAR of 13.2% in women.

COMMENT

Congestive heart failure is not only a personal tragedy for patients and their families but a serious public health burden for society. Patients with CHF have a poorer quality of life and shorter life expectancy compared with those of the same age in the general population.[21] With an increasingly older population and progressive improvements in survival after acute myocardial infarction, it is almost inevitable that CHF will continue to be an important public health challenge in the foreseeable future. Because of the high mortality rate associated with CHF, it is important to identify modifiable risk factors and develop effective strategies for the prevention of CHF in the general population. Results of prospective cohort studies[3-6] have indicated that old age, male sex, hypertension, diabetes, obesity, valvular heart disease, and CHD are important risk factors for CHF. The present study extends our understanding of risk factors for CHF in several important ways.

First, our analysis demonstrates that cigarette smoking is a strong and independent risk factor for CHF. Few prospective cohort studies have examined the relation between cigarette smoking and risk of CHF. Eriksson and colleagues[22] followed 973 men born in 1913 in Gothenburg, Sweden, for 17 years to examine risk factors for CHF. Smoking at age 50 years was associated with a 60% higher risk of CHF (RR, 1.6; 95% CI, 1.2-3.2) in their study. This relation was independent of hypertension, body weight, and other important risk factors for CHF. Other prospective cohort studies[3-6] have not examined the association between cigarette smoking and risk of CHF. In our study, cigarette smoking was associated with a 45% higher risk of CHF in men and an 88% higher risk of CHF in women after adjustment for CHD and other known risk factors for CHF. This finding implies that cigarette smoking might directly increase the risk of CHF in addition to its effect on increasing the risk of CHD, a major cause of CHF. Results of our study also suggest that cigarette smoking might cause about 17% of the incident CHF cases in the US general population. As such, smoking cessation should be an important component of any strategy to prevent CHF in the general population.

The results of our study also indicate that physical inactivity is an important risk factor for development of CHF. The relation between physical activity and risk of developing CHF has not been studied in previous prospective cohort studies.[3-6,22] Many studies[23-26] have indicated that a higher level of physical activity is associated with a lower risk of CHD, hypertension, obesity, and diabetes. The increased risk of CHF associated with physical inactivity in our study was partially explained by these risk factors. However, after adjustment for these risk factors, physical inactivity was still associated with a significantly higher risk of CHF. Our PAR estimates suggest that physical inactivity might account for approximately 9.2% of CHF cases in the US general population. Increasing physical activity could substantially reduce the risk of CHF in the US general population.

In addition, our findings suggest that less than a high school education (an index of lower socioeconomic status) is associated with an increased risk of CHF. Many studies[27,28] have indicated that lower educational levels are related to limited access to higher-quality health care and poor adherence to treatment of hypertension, diabetes, and other risk factors for CHF. Hypertension and diabetes were important risk factors for CHF in the NHANES I Epidemiologic Follow-up Study cohort and in other study populations.[3-6,22] These findings indicate that improving health care, including better control of hypertension and diabetes in the general population, especially in socioeconomically disadvantaged groups, should be an important part of attempts to reduce the incidence of and mortality from CHF in the general population.

Finally, our study was conducted in a representative sample of the US general population, which we took advantage of to estimate the PAR of CHF due to various risk factors. Coronary heart disease was associated with the largest PAR for CHF, accounting for 61.6% of CHF incident cases (67.9% in men and 55.9% in women), followed by cigarette smoking (17.1%), hypertension (10.1%), physical inactivity (9.2%), lower educational levels (8.9%), and overweight (8.0%). Diabetes and valvular heart disease accounted for only 3.1% and 2.2% of CHF cases, respectively, because of their low prevalence in the sample studied. The fact that only self-reported information was available for diagnosis of diabetes almost certainly resulted in an underestimation of the burden of diabetes-related CHF.[29]

An additional limitation of the present investigation was that study participants were followed up in a passive rather than an active fashion. Congestive heart failure was identified by means of information obtained from hospital discharge diagnoses or death certificates. Therefore, the cumulative incidence of CHF might be underestimated. However, there is no reason to believe that these outcome measurements would differ by risk factor status. Because of the nature of passive follow-up, echocardiographic or electrocardiographic data were not available and left ventricular dysfunction could not be studied.

Coronary heart disease has become the single most important cause of CHF in Western populations.[30,31] Among 20 190 participants in 13 major multicenter heart failure clinical trials, CHD was the underlying cause of CHF in 68% of patients.[31] The cumulative proportion of CHD during follow-up in our study was 29.7% in men and 17.7% in women. More than 60% of the CHF cases in our study population were attributed to CHD. Based on these results and those from other studies, primary prevention of CHD should play a central role in any attempts to achieve a meaningful reduction in the burden of illness from CHF in the US general population.

Our findings are consistent with previous studies[3-6] that have reported overweight as a risk factor for CHF. In addition, our study findings indicate that the increased risk associated with overweight is independent of the presence or absence of CHD, diabetes, and hypertension. Thus, weight loss should reduce the risk of CHF over and above any indirect effects that result from lowering of the risk of CHD, diabetes, and hypertension. During the past several decades, the prevalence of overweight has increased steadily in the US general population for every age, sex, and race group.[32] Our findings support recommendations for weight loss as a means to reduce overall cardiovascular risk and total mortality.

In conclusion, our study results suggest that male sex, lower educational levels, physical inactivity, cigarette smoking, overweight, diabetes, hypertension, valvular heart disease, and CHD are all independent risk factors for CHF. These findings indicate that attention to improvement of the overall cardiovascular risk profile, including physical activity, weight loss, smoking cessation, and control of hypertension and diabetes, should play an important role in the prevention of CHF in the US general population.

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