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PART II: NEW INSIGHTS INTO THE EPIDEMIOLOGY AND PATHOPHYSIOLOGY OF HEART FAILURE

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EPIDEMIOLOGY

The Epidemiology of Heart Failure: The Framingham Study

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Congestive heart failure has become an increasingly frequent reason for hospital admission during the last 2 decades and clearly represents a major health problem. Data from the Framingham Heart Study indicate that the incidence of congestive heart failure increases with age and is higher in men than in women. Hypertension and coronary heart disease are the two most common conditions predating its onset. Diabetes mellitus and electrocardiographic left ventricular hypertrophy are also associated with an increased risk of heart failure. During the 1980s, the annual age-adjusted incidence of congestive heart failure among persons aged ≥45 years was 7.2 cases/1,000 in men and 4.7 cases/1,000 in women, whereas the age-adjusted prevalence of overt heart failure was 24/1,000 in men and 25/1,000 in women. Despite improved treatments for ischemic heart disease and hypertension, the age-adjusted incidence of heart failure has declined by only 11%/calendar decade in men and by 17%/calendar decade in women during a 40-year period of observation. In addition, congestive heart failure remains highly lethal, with a median survival time of 1.7 years in men and 3.2 years in women and a 5-year survival rate of 25% in men and 38% in women.

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Although there is no consensus on the criteria required to establish a diagnosis of congestive heart failure, it is clear that congestive heart failure represents a major health problem. It has been estimated that congestive heart failure afflicts nearly 4 million Americans, with 400,000 new cases each year (1). Congestive heart failure was listed as the principal cause for 37,400 deaths in 1988 and is thought to have been a contributing cause of another 200,000 deaths (2,3). Data from the National Hospital Discharge Survey (4–8) showed a steady increase in the number of hospital admissions for congestive heart failure during the last 2 decades. For example, the rate of hospital discharges with a principal diagnosis of congestive heart failure among Americans ≥65 years increased from 7.5/1,000 in 1968 to 16.3/1,000 in 1989 (4,7).

In 1989, 643,000 hospital discharges (2% of all discharges) carried a principal diagnosis of congestive heart failure (7). An additional 4% (1.2 million) of all discharges carried a secondary diagnosis of congestive heart failure. Among patients ≥65 years, congestive heart failure was the principal diagnosis in 5% of those discharged and a secondary diagnosis in another 10%. The rate of hospital stays with any discharge diagnosis of congestive heart failure increases dramatically with age, rising from 6.2/1,000 in persons aged 45 to 64 years to 47.4/1,000 in persons ≥65 years of age in 1989. Women were more frequently admitted to the hospital for congestive heart failure than were men. In 1989, the rate of hospital admissions with any discharge diagnosis of congestive heart failure was 6.8/1,000 in men and 8/1,000 in women; the rate of hospital admission with a principal diagnosis of congestive heart failure was 2.5/1,000 in men and 2.7/1,000 in women (7).

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Methods

In the Framingham Heart Study, we have had the opportunity to examine the incidence, prevalence and prognosis of congestive heart failure during four decades of observation. Our study group was composed of participants in the Framingham Study and the Framingham Offspring Study. In 1948, 5,209 residents of Framingham, Massachusetts aged 28 to 62 years were enrolled in a prospective epidemiologic study. The selection criteria and study design have been reported elsewhere (9,10). Members of this "original cohort" have subsequently been evaluated at 2-year intervals with medical history, physical examination and laboratory tests. In 1971, children of the original study participants and spouses of these children, aged 6 to 70 years, were entered in the Framingham Offspring Study (11). Serial evaluations were performed on members of the Framingham Offspring Study 8 and 12 years after enrollment. The 5,209 members of the original cohort and the 5,135 members of the offspring cohort were eligible for inclusion in these analyses. To avoid inclusion of overly high risk subjects in the offspring study, 881 members of the offspring cohort with only one natural parent in the original cohort were excluded; such subjects were preferentially enrolled if that parent had a high risk lipid profile or premature cardiovascular disease. Cases of congestive heart failure diagnosed at the first Framingham Heart Study examination were included in estimates of heart failure prevalence but excluded from estimates of heart failure incidence.

At each examination, interim cardiovascular disease events were identified by medical history, physical examination, 12-lead electrocardiogram (ECG) and review of medical records. Hospital and physician records were obtained for participants who did not appear for an examination. All possible cardiovascular events were reviewed by a committee of three physicians, using established Framingham Heart Study protocols and definitions (12,13). Coronary heart disease events included angina pectoris, coronary insufficiency (unstable angina) and myocardial infarction (12). A patient was considered to have preexisting valvular heart disease if the examining physician noted a systolic murmur grade III/VI or louder, a diastolic murmur or a palpable thrill at any examination before the onset of heart failure. Radiographic and echocardiographic data were not used in the diagnosis of coronary or valvular heart disease. Elevated blood pressure was defined as a systolic blood pressure ≥160 mm Hg or a diastolic blood pressure ≥95 mm Hg on each of two successive determinations by a physician during a clinic examination. Hypertension was defined as the presence of either elevated blood pressure or ongoing pharmacologic treatment of a previously elevated blood pressure. Subjects with a fasting blood glucose level ≥7.77 mmol/liter (140 mg/dl) or a random blood glucose level ≥11.10 mmol/liter (200 mg/dl) were considered to be diabetic, as were individuals using insulin or oral hypoglycemic agents. Definite ECG left ventricular hypertrophy was diagnosed if voltage criteria for left ventricular hypertrophy were fulfilled in an ECG exhibiting lateral ST segment depression or T wave flattening or inversion (13).

Table 1. Criteria for Congestive Heart Failure*

Major Criteria
Paroxysmal nocturnal dyspnea
Neck vein distension
Rales
Radiographic cardiomegaly (increasing heart size on chest X-ray film)
Acute pulmonary edema
Third sound gallop
Increased central venous pressure (>16 cm water at the right atrium)
Circulation time ≥25 s
Hepatojugular reflux
Pulmonary edema, visceral congestion or cardiomegaly at autopsy
Weight loss ≥4.5 kg in 5 days in response to treatment of CHF
Minor Criteria
Bilateral ankle edema
Nocturnal cough
Dyspnea on ordinary exertion
Hepatomegaly
Pleural effusion
Decrease in vital capacity by 33% from maximal value recorded
Tachycardia (rate ≥120 beats/min)

*The diagnosis of congestive heart failure (CHF) required that two major or one major and two minor criteria be present concurrently. Minor criteria were acceptable only if they could not be attributed to another medical condition.

Using information obtained at Framingham Heart Study examinations and from hospital and physician records, a diagnosis of congestive heart failure was established by the simultaneous presence of at least two major or one major and two minor criteria for congestive heart failure (Table 1). Minor criteria were acceptable only if they could not be attributed to another medical condition (12–14). The same criteria for congestive heart failure were used throughout the 40-year follow-up period for these analyses.

The incidence of congestive heart failure was estimated using the cross-sectional pooling method, with each 2-year interval between successive examinations treated as an independent observation. Only individuals free of heart failure were included in a 2-year observation pool. Subjects who failed to appear for an examination were assigned "hypothetical" examination dates corresponding to their biennial anniversary dates; only information concerning interval cardiovascular disease events was attributed to these hypothetical examinations. All of the observations were further classified by the calendar year of the examination and the age of the subject at the time of the visit. The relations between disease incidence and calendar year, as well as between dichotomous risk factor measures and calendar year, were estimated using gender-specific logistic regression analyses stratifying by 5-year age groups. A summary regression coefficient over all ages was derived by averaging the age-specific coefficients, using as weights the

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inverse of their variances. The standard error of this summary coefficient was calculated as the square root of the inverse of the sum of the weights. Some extreme age groups (for example, age <40 or ≥90 years) were excluded from certain models because there were too few observations to permit analysis. Age-adjusted differences in the proportion of cases of congestive heart failure with various antecedent conditions were examined by gender, using Cochran-Mantel-Haenszel statistics stratified by 5-year age groups. For analysis of survival, Cox proportional hazards regression models were employed to investigate the relations among survival, gender, age and calendar year at the time of first diagnosis of congestive heart failure. Because the study group was aging during the study period, in those models investigating the effect of calendar year, analyses were stratified by age at diagnosis (in 5-year age groups); similarly, in those models evaluating age at diagnosis, analyses were stratified by calendar year, expressed in half-decades. Except for the model exploring the effect of gender on survival, men and women were analyzed separately. Median survival times and survival rates at 90 days and at 1, 2, 4, 5 and 10 years after the diagnosis of congestive heart failure were estimated using Kaplan-Meier methods. To facilitate comparison with results from heart failure intervention trials, we repeated the survival analyses excluding subjects who died or were lost to follow-up during the 1st 90 days after the diagnosis of heart failure. Except where indicated, age-adjusted rates were obtained by direct adjustment to the United States 1991 population (15). The software package S-PLUS (Statistical Sciences, Inc.) was used for the survival analyses; all other computations were performed utilizing the SAS System (SAS Institute Inc.). A two-sided probability (p) value ≤ 0.05 was required for statistical significance. Numeric values are expressed as mean value ± SD.

Results

Congestive heart failure cases. Among 9,405 Framingham Heart Study participants (47% male) followed up from September 1948 to June 1988, congestive heart failure developed in 652. The mean age at the diagnosis of heart failure was 70.0 ± 10.8 years. These 331 men and 321 women were followed up for a median of 1.8 years after the diagnosis of congestive heart failure (mean 3.9 ± 5.4 years; range 0 days to 35.8 years). There were 17 additional cases of congestive heart failure diagnosed at the first Framingham Heart Study examination.

Incidence of congestive heart failure. The incidence of congestive heart failure increased dramatically with age (Fig. 1). The annual incidence increased from 3 cases/1,000 in men aged 50 to 59 years to 27 cases/1,000 in men aged 80 to 89. In women, the annual incidence increased from 2 cases/1,000 in those 50 to 59 years of age to 22 cases/1,000 in those 80 to 89 years of age. The incidence of congestive heart failure was one-third lower in women than in men after adjustment for age (age-adjusted odds ratio of women/men 0.6; 95% confidence interval [CI] 0.5 to 0.7). During the 1980s, the age-adjusted annual incidence of congestive heart failure was 2.3 cases/1,000 in men. In women, the corresponding age-adjusted annual incidence was 1.4 cases/1,000. Among individuals aged ≥45 years, the age-adjusted annual incidence of congestive heart failure was 7.2 cases/1,000 in men and 4.7 cases/1,000 in women. Analyses using logistic regression models revealed that the age-adjusted incidence of congestive heart failure in men decreased from 1948 to 1988 by 11%/calendar decade ($p < 0.05$); in women, the age-adjusted incidence of congestive heart failure decreased by 17%/calendar decade ($p < 0.05$) (16).

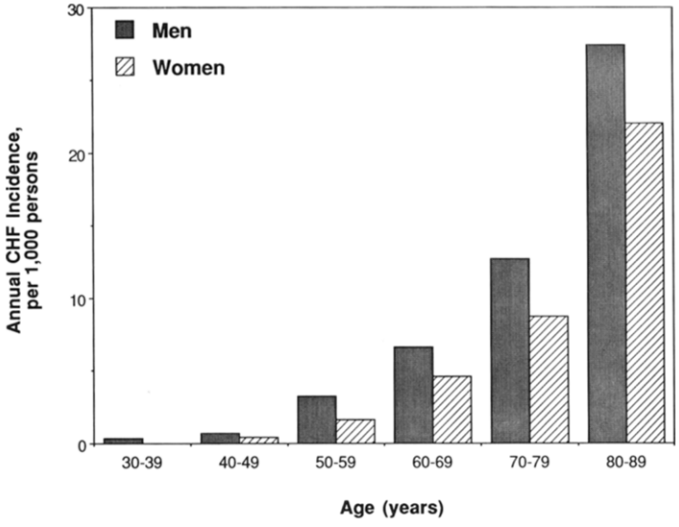
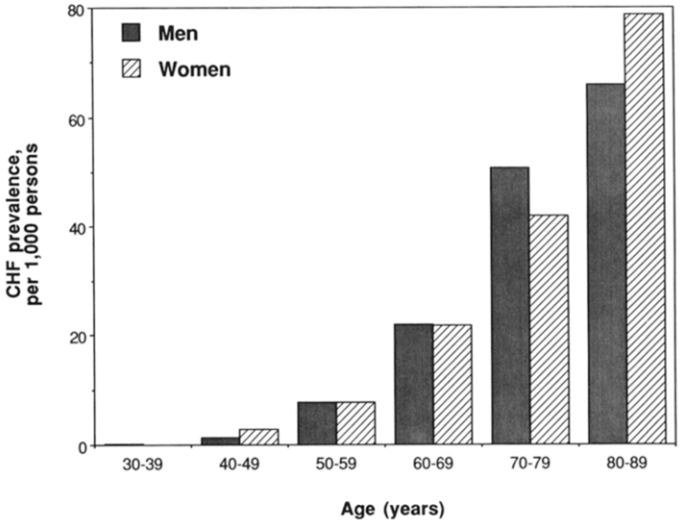


Figure 1. Incidence rates of congestive heart failure (CHF) among Framingham Heart Study subjects, by gender and age.

Prevalence of heart failure. The prevalence of congestive heart failure also increased with age (Fig. 2). Among men, the prevalence of heart failure climbed from 8 cases/1,000 in those 50 to 59 years of age to 66 cases/1,000 in those aged 80

Figure 2. Prevalence rates of congestive heart failure (CHF) among Framingham Heart Study subjects, by gender and age.



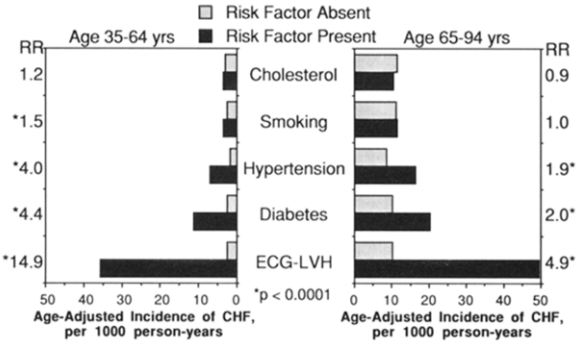


Figure 3. Risk of congestive heart failure (CHF) in men in the Framingham Heart Study by age and risk factor status. Relative risks (RR) for the development of heart failure in the presence of the specified risk factor are displayed at the **margins**; values with **asterisks** are significant at $p < 0.0001$. Cholesterol = serum cholesterol >6.2 mmol/liter (240 mg/dl); ECG-LVH = electrocardiographic left ventricular hypertrophy.

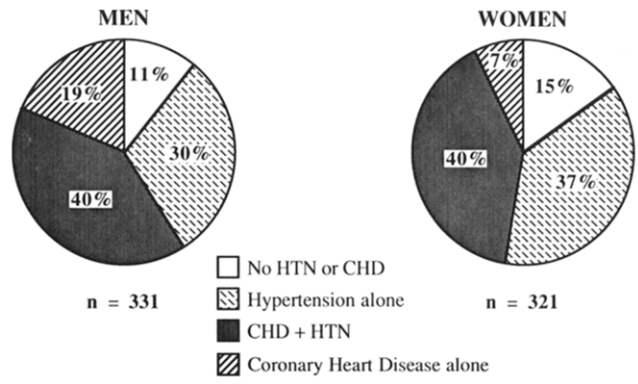
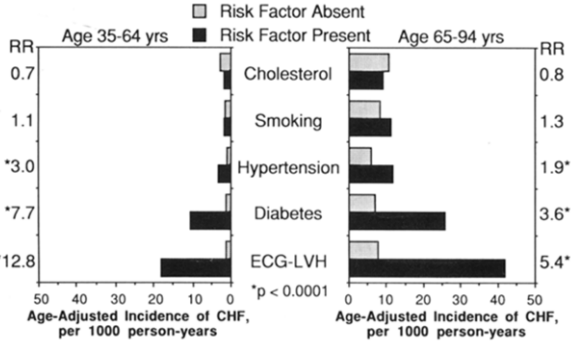


Figure 5. Prevalence of coronary heart disease (CHD) and hypertension (HTN) alone and in combination among Framingham Heart Study subjects with congestive heart failure, by gender.

to 89 years. In women, the prevalence of heart failure increased from 8 cases/1,000 in those aged 50 to 59 years to 79 cases/1,000 in those 80 to 89 years of age. During the 1980s, the age-adjusted prevalence of congestive heart failure was 7.4/1,000 in men and 7.7/1,000 in women. Among individuals aged ≥45 years, the age-adjusted prevalence of congestive heart failure was 24/1,000 (or 2.4%) in men and 25/1,000 (2.5%) in women.

Risk factors for heart failure. Figures 3 and 4 demonstrate the risk of several conditions on the development of congestive heart failure. In men, a serum cholesterol level >6.2 mmol/liter (240 mg/dl) was not associated with an increased risk of heart failure. Cigarette smoking increased the likelihood of heart failure in younger, but not in older men. In younger men, hypertension and diabetes mellitus were associated with a 4-fold increase in the incidence of heart failure and ECG left ventricular hypertrophy with a 15-fold increase. In men older than 65 years of age, the relative risks for heart failure associated with hypertension, diabetes and ECG left ventricular hypertrophy were less than those for younger men, but the excess risks were higher, reflecting greater absolute risk differences. In women, neither an elevated serum cholesterol level nor cigarette smoking resulted in an increased risk of heart failure. In younger women, hypertension was associated with a 3-fold increase in the incidence of heart failure, diabetes with an 8-fold increase and left ventricular hypertrophy with a 13-fold increase. As in men, these three conditions were associated with higher excess risks but lower relative risks in older compared with younger women. Left ventricular hypertrophy was associated with an increased incidence of heart failure, even after controlling for blood pressure. Similarly, the effect of diabetes was independent of concomitant hypertension or coronary heart disease. Other findings associated with an increased incidence of overt congestive heart failure included obesity, a high ratio of total cholesterol to high density lipoprotein cholesterol, proteinuria and ECG intraventricular conduction disturbances or nonspecific repolarization abnormalities.

Figure 4. Risk of congestive heart failure (CHF) in women in the Framingham Heart Study by age and risk factor status. Relative risks (RR) for the development of heart failure in the presence of the specified risk factor are displayed at the **margins**; values with **asterisks** are significant at $p < 0.0001$. Definitions as in Figure 3.



Among the 331 men and 321 women in the Framingham Heart Study who developed congestive heart failure during the follow-up period, hypertension and coronary heart disease were the two most common preexisting conditions (Fig. 5). Seventy percent of men and 78% of women with heart failure had an antecedent diagnosis of hypertension. Forty percent of men and women with heart failure had a prior history of both hypertension and coronary heart disease. Prevalent coronary heart disease was less common in women than in men, with an odds ratio of 0.55 after adjusting for age (95% CI 0.40 to 0.76); it was found in 59% of men and 48% of women with new congestive heart failure. Eleven percent of men and 15% of women with heart failure had no prior history of hypertension or coronary heart disease.

The prevalence of several causes of and risk factors for heart failure are shown in Figure 6. Again, hypertension and coronary heart disease were the two most prevalent conditions in subjects with new heart failure. Recent cigarette smoking was less common in women than in men, with an

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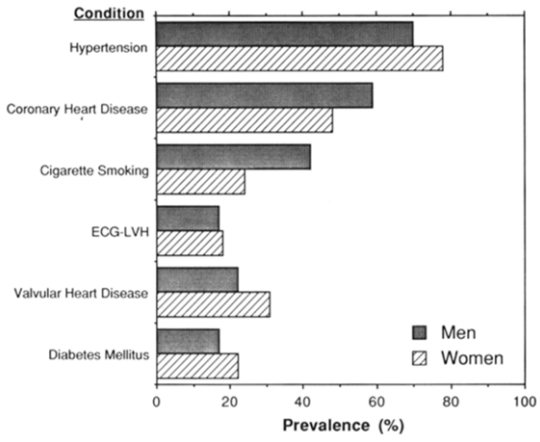

Figure 6. Prevalence of certain conditions among Framingham Heart Study subjects with congestive heart failure, by gender. ECG-LVH = electrocardiographic left ventricular hypertrophy.

odds ratio of 0.51 after adjusting for age (95% CI 0.32 to 0.79); overall, 42% of men and 24% of women smoked cigarettes at the time of the Framingham Heart Study examination immediately before the diagnosis of heart failure. Electrocardiographic left ventricular hypertrophy was noted before the diagnosis of heart failure in 17% of men and 18% of women. After adjusting for age, only coronary heart disease and recent cigarette smoking were significantly less common in women than in men with new congestive heart failure.

From 1948 to 1988, the age-adjusted prevalence of coronary heart disease among men with new congestive heart failure increased by 46%/calendar decade ($p < 0.05$). In contrast, the age-adjusted prevalence of coronary heart disease among all men in the Framingham Heart Study decreased by 8%/calendar decade ($p < 0.05$). The results were similar in women, who had an age-adjusted 46%/calendar decade increase in the prevalence of coronary heart disease among subjects with new heart failure ($p < 0.05$) in association with an age-adjusted 16%/calendar decade decline in the prevalence of coronary heart disease among all women in the Framingham Heart Study ($p < 0.001$).

Survival after diagnosis of heart failure. Among the 652 persons with congestive heart failure, 551 deaths (84.5%) occurred. The median survival time after the diagnosis of congestive heart failure was 1.66 years in men and 3.17 years in women (Table 2) (17). Overall 1-year survival rates in men and women were 57% and 64%, respectively. The overall 5-year survival rate was 25% in men and 38% in women. There was no significant temporal change in overall survival after the diagnosis of congestive heart failure during the 40-year period of observation (age-adjusted male hazards ratio for mortality = 1.08/calendar decade, 95% CI 0.92 to 1.27; age-adjusted female hazards ratio for mortality = 1.02/calendar decade, 95% CI 0.83 to 1.26). After adjusting for age, survival after the development of heart failure was better in women than in men, with a hazards ratio of 0.64 (95% CI 0.54 to 0.77). The mortality rate increased with advancing age at the diagnosis of heart failure. In men, the increase in mortality rate was 27%/decade of age (95% CI 9% to 47%). In women, the mortality rate increased by 61%/decade of age (95% confidence interval 37% to 90%).

Discussion

Data from the Framingham Heart Study indicate that congestive heart failure is more common in older persons and affects approximately 2.5% of the population aged ≥45 years. Hypertension preceded the onset of heart failure in 70% of men and 78% of women and was associated with a two- to four-fold increase in the incidence of heart failure. Coronary heart disease was present in 59% of men and 48% of women with heart failure and has been increasing in prevalence among new cases of heart failure. Diabetes mellitus and ECG left ventricular hypertrophy were also associated with a significantly increased incidence of overt congestive heart failure. Despite the increased use of improved therapies for ischemic heart disease and hypertension, the age-adjusted incidence of heart failure has declined by only 11%/calendar decade in men and by 17% per calendar decade in women during a 40-year period of observation. In addition, congestive heart failure remains highly lethal, with a median survival time of 1.7 years

Table 2. Overall Survival After Congestive Heart Failure as Estimated by Kaplan-Meier Methods

	Subjects (no.)	Median Survival Time (yr)	Survival Rates				
			90 days	1 yr	2 yr	5 yr	10 yr
All subjects with congestive heart failure							
Men	331	1.66	0.73	0.57	0.46	0.25	0.11
Women	321	3.17	0.72	0.64	0.56	0.38	0.21
Subjects with congestive heart failure who survived ≥90 days							
Men	237	3.21	—	0.79	0.63	0.35	0.15
Women	230	5.39	—	0.88	0.78	0.53	0.29

Table 3. Epidemiologic Studies of Congestive Heart Failure

Study Group	Age (yr)	Annual CHF Incidence (per 1,000)	Comparable Annual CHF Incidence in Framingham (per 1,000)	CHF Prevalence (per 1,000)	Comparable CHF Prevalence in Framingham (per 1,000)
Tecumseh, Michigan: 1959–1960 (32)					
Men	40–79			24*	15*
Women	40–79			36*	13*
Evans County, Georgia: 1960–1962 (31)					
Men	45–74			28*	16*
Women	45–74			18*	15*
Rural Vermont and North Carolina: 1962–1963 (27)					
Men and women	All ages	1.4*	1.4*		
Men	All ages			10*	8*
Women	All ages			11*	6*
Göteborg, Sweden: 1963–1980 (28,29)					
Men	50–54	1.5	1.8		
	55–60	4.3	4.5		
	61–67	10.2	6.4		
	50			21	7
	54			24	9
	60			43	16
	67			130	32
Göteborg, Sweden: 1971–1972 (33)					
Men	70			110	48
	75			170	50
Women	70			80	35
	75			110	53
NHANES-I: 1971–1975 (34)					
Men	25–54			8	1
	55–64			45	12
	65–74			48	39
Women	25–54			13	1
	55–64			30	14
	65–74			43	31
Framingham: 1980–1988					
Men	All ages		2.3*		7*
	≥45		7.2*		24*
Women	All ages		1.4*		8*
	≥45		4.7*		25*
Rochester, Minnesota: 1986 (30)					
Men	≥35			12*	16*
Women	≥35			11*	16*
Eastern Finland: 1986–1988 (26)					
Men	45–74	4.0–4.2*	4.6*		
Women	45–74	1.0–1.6*	2.2*		

*Age-adjusted to the United States 1991 population. Numbers in parentheses indicate reference numbers. CHF = congestive heart failure; NHANES-I = First National Health and Nutrition Examination Survey.

in men and 3.2 years in women. With 5-year survival rates of 25% in men and 38% in women, heart failure is associated with a shorter life expectancy than that of many common malignancies.

The Framingham Heart Study provides several unique advantages for the study of the epidemiology of congestive heart failure. A large unselected patient population with nearly equal numbers of men and women was observed for >40 years with uniform ascertainment of events. All persons with congestive heart failure were followed up from the time of diagnosis; in contrast, intervention trials and hospital-based referral series utilize selected patients who survived the acute onset of congestive heart failure to achieve study entry.

Other epidemiologic studies of heart failure. There is no agreement on the precise criteria required to establish a diagnosis of congestive heart failure. Most prior heart failure intervention trials (18–22) required a reduced left ventricular ejection fraction as an entry criterion; therefore, their results may be applicable only to patients with systolic heart failure. Congestive heart failure has always been defined in the Framingham Heart Study on the basis of clinical criteria that have been previously validated (23) and are compatible with

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the presence of either diastolic or systolic dysfunction (24,25). Other epidemiologic studies of heart failure have used different definitions of heart failure; nonetheless, some of their results are similar to those from Framingham (Table 3). For example, from 1986 to 1988 in eastern Finland, the age-adjusted annual incidence of heart failure among persons 45 to 74 years old was 4 to 4.2 cases/1,000 in men and 1.0 to 1.6 cases/1,000 in women using either the Framingham or modified Boston criteria for heart failure (26). The comparable annual incidence of congestive heart failure in Framingham during the 1980s was 4.6 cases/1,000 in men and 2.2 cases/1,000 in women. Using a simple survey, Gibson et al. (27) found that the age-adjusted annual incidence of heart failure in two rural counties in 1962 and 1963 was 1.4 cases/1,000 (adjusted to the U. S. 1991 population); the comparably age-adjusted annual incidence of congestive heart failure in Framingham in the 1960s was also 1.4 cases/1,000. The Swedish study (28,29) of male residents of Göteborg born in 1913 also reported incidence rates for congestive heart failure (using a heart failure score) that are very similar to those from Framingham. The prevalence rates of heart failure in epidemiologic studies are more disparate. The prevalence of heart failure among residents of Rochester, Minnesota ≥35 years of age in 1986 was 1.2% in men and 1.1% in women (30); the comparable prevalence of congestive heart failure in Framingham in the 1980s was 1.6% in both men and women. In Evans County, Georgia in 1960 to 1962, heart failure was found in 2.8% of men and 1.8% of women aged 45 to 74 years (31); the comparable age-adjusted prevalence in Framingham in the 1960s was 1.6% in men and 1.5% in women. In Tecumseh, Michigan among persons aged 40 to 79 years in 1959 and 1960, the age-adjusted prevalence of heart failure was 2.4% in men and 3.6% in women (32); the respective rates in Framingham were 1.5% and 1.3%. Several Swedish studies (28,29,33) have used more liberal definitions of heart failure and consequently documented prevalence rates of heart failure up to four times higher than those in Framingham.

Over a 40-year period of observation, the age-adjusted incidence of congestive heart failure decreased by 11%/calendar decade in men and by 17%/calendar decade in women. Analyses are ongoing to further elucidate the relations between the incidence and prevalence of congestive heart failure and temporal changes in the prevalence of coronary heart disease, valvular heart disease, hypertension, diabetes and other conditions.

Survival after diagnosis of heart failure. We were unable to detect any significant improvement in survival after the diagnosis of congestive heart failure during the 40-year period of observation. However, our observational study did not directly examine the impact of therapy on survival after the onset of heart failure. In addition, most of the follow-up period for our study occurred before the widespread use of vasodilators, angiotensin-converting enzyme inhibitors and heart transplantation. Of note, our population included persons who would have been excluded from many of the recent pharmacologic heart failure trials (for example, those patients with acute pulmonary edema, unstable angina, recent myocardial infarctions or significant valvular heart disease). When the analysis was restricted to subjects who survived ≥90 days after the diagnosis of heart failure, a population more comparable to those included in intervention trials, the median survival time was 3.21 years in men and 5.39 years in women. In men, the 1-year survival rate was 79% and the 5-year survival rate was 35%. In women, the 1- and 5-year survival rates were 88% and 53%, respectively. These results more closely resemble those from heart failure intervention trials. For example, the 1-, 2- and 4-year survival rates for men in the placebo group in the first Veterans Administration Cooperative Vasodilator–Heart Failure Trial (V-HeFT I) were 81%, 66% and 46%, respectively (19). In our study, the corresponding survival rates were 79%, 63% and 45% in men who survived ≥90 days after the diagnosis of heart failure.

Conclusions. Despite advances in our therapies for ischemic heart disease and hypertension, congestive heart failure remains a common and highly lethal condition. There is accumulating evidence that treatment of hypertension and left ventricular systolic dysfunction can decrease the incidence of clinical congestive heart failure (22,35–37) and that use of angiotensin-converting enzyme inhibitors or vasodilators can prolong survival after the onset of heart failure (19–21,38). Clearly, the diagnosis of congestive heart failure encompasses a constellation of symptoms that can result from a variety of pathophysiologic processes reflecting both systolic and diastolic dysfunction. Improved strategies for the prevention and treatment of congestive heart failure must take into account the heterogeneous nature of this clinical syndrome.

References

1. Massie BM, Packer M. Congestive heart failure: current controversies and future prospects. Am J Cardiol 1990;66:429–30.
2. National Center for Health Statistics. Vital Statistics of the United States, 1988. Vol II. Mortality, Part A. Washington, DC: Public Health Service, 1991; DHHS publication no. (PHS) 91-1101.
3. Gillum RF. Heart failure in the United States 1970–1985. Am Heart J 1987;113:1043–5.
4. National Center for Health Statistics. Inpatient Utilization of Short-Stay Hospitals by Diagnosis: United States, 1968–1980. Rockville and Hyattsville, Maryland: National Center for Health Statistics, 1974–1984; DHEW and DHHS publications (Vital and Health Statistics; series 13).
5. Utilization of short-stay hospitals, United States, 1979–1986, Annual Summary. Hyattsville, Maryland: National Center for Health Statistics, 1981–1988; DHHS publications (Vital and Health Statistics; series 13).
6. National Center for Health Statistics. Detailed Diagnoses and Procedures, National Hospital Discharge Survey, 1983–1988. Hyattsville, Maryland: National Center for Health Statistics, 1985–1991; DHHS publications (Vital and Health Statistics; series 13).
7. Graves EJ. Detailed Diagnoses and Procedures, National Hospital Discharge Survey, 1989. Hyattsville, Maryland: National Center for Health Statistics, 1991; DHHS publication no. (PHS) 91-1769, (Vital and Health Statistics; series 13; no. 108).
8. Ghali JK, Cooper R, Ford E. Trends in hospitalization rates for heart

failure in the United States, 1973–1986: evidence for increasing population prevalence. Arch Intern Med 1990;150:769–73.

9. Dawber TR, Meadors GF, Moore FE. Epidemiologic approaches to heart disease: the Framingham study. Am J Public Health 1951;41:279–86.
10. Dawber TR, Kannel WB, Lyell LP. An approach to longitudinal studies in a community. the Framingham study. Ann NY Acad Sci 1963;107:539–56.
11. Kannel WB, Feinleib M, McNamara PM, Garrison RJ, Castelli WP. An investigation of coronary heart disease in families: the Framingham Offspring Study. Am J Epidemiol 1979;110:281–90.
12. Shurtleff D. Some characteristics related to the incidence of cardiovascular disease and death: Framingham study 18-year follow-up. In: Kannel WB, Gordon T, eds. The Framingham study: An Epidemiological Investigation of Cardiovascular Disease. Section 30. DHEW publication no. (NIH) 74-599. Washington DC: U.S. Government Printing Office, 1974: 17–40.
13. Cupples LA, D'Agostino RB. Some risk factors related to the annual incidence of cardiovascular disease and death using pooled repeated biennial measurements: Framingham Heart Study, 30-year followup. In: Kannel WB, Wolf PA, Garrison RJ, eds. The Framingham Study: An Epidemiological Investigation of Cardiovascular Disease. Section 34. DHHS publication no. (NIH) 87-2703. Washington DC: U.S. Government Printing Office, 1987:9–20.
14. McKee PA, Castelli WP, McNamara PM, Kannel WB. The natural history of congestive heart failure: the Framingham study. N Engl J Med 1971;285:1441–6.
15. U.S. Bureau of the Census. Statistical Abstract of the United States: 1992 (112th ed). Washington DC: U.S. Government Printing Office, 1992:15.
16. Kannel WB, Pinsky J. Trends in cardiac failure—incidence and cause over three decades in the Framingham study (abstr). J Am Coll Cardiol 1991;17:87A.
17. Ho KKL, Anderson KM, Kannel WB, Grossman W, Levy D. Survival after the onset of congestive heart failure in Framingham Heart Study subjects. Circulation 1993;88:107–15.
18. Gradman A, Deedwania P, Cody R, et al. Predictors of total mortality and sudden death in mild to moderate heart failure. J Am Coll Cardiol 1989;14:564–70.
19. Cohn JN, Archibald DG, Ziesche S, et al. Effect of vasodilator therapy on mortality in chronic congestive heart failure: results of a Veterans Administration Cooperative Study. N Engl J Med 1986;314:1547–52.
20. Cohn JN, Johnson G, Ziesche S, et al. A comparison of enalapril with hydralazine-isosorbide dinitrate in the treatment of chronic congestive heart failure. N Engl J Med 1991;325:303–10.
21. The SOLVD Investigators. Effect of enalapril on survival in patients with reduced left ventricular ejection fractions and congestive heart failure. N Engl J Med 1991;325:293–302.
22. The SOLVD Investigators. Effect of enalapril on mortality and the development of heart failure in asymptomatic patients with reduced left ventricular ejection fractions. N Engl J Med 1992;327:685–91.
23. Marantz PR, Tobin JN, Wassertheil-Smoller S, et al. The relationship between left ventricular systolic function and congestive heart failure diagnosed by clinical criteria. Circulation 1988;77:607–12.
24. Dougherty AH, Naccarelli GV, Gray EL, Hicks CH, Goldstein RA. Congestive heart failure with normal systolic function. Am J Cardiol 1984;54:778–82.
25. Grossman W. Diastolic dysfunction in congestive heart failure: mechanisms and clinical implications. N Engl J Med 1991;325:1557–64.
26. Remes J, Reunanen A, Aromaa A, Pyörälä K. Incidence of heart failure in eastern Finland: a population-based surveillance study. Eur Heart J 1992;13:588–93.
27. Gibson TC, White KL, Klainer LM. The prevalence of congestive heart failure in two rural communities. J Chronic Dis 1966;19:141–52.
28. Eriksson H, Svärdsudd K, Larsson B, et al. Risk factors for heart failure in the general population: the study of men born in 1913. Eur Heart J 1989;10:647–56.
29. Wilhelmsen L, Eriksson H, Svärdsudd K, Caidahl K. Improving the detection and diagnosis of congestive heart failure. Eur Heart J 1989; 10(suppl C):13–8.
30. Phillips SJ, Whisnant JP, O'Fallon WM, Frye RL. Prevalence of cardiovascular disease and diabetes mellitus in residents of Rochester, Minnesota. Mayo Clin Proc 1990;65:344–59.
31. Garrison GE, McDonough JR, Hames CG, Stulb SC. Prevalence of chronic congestive heart failure in the population of Evans County, Georgia. Am J Epidemiol 1966;83:338–44.
32. Epstein FH, Ostrander LD, Johnson BC, et al. Epidemiological studies of cardiovascular disease in a total community—Tecumseh, Michigan. Ann Intern Med 1965;62:1170–87.
33. Landahl S, Svanborg A, Åstrand K. Heart volume and the prevalence of certain common cardiovascular disorders at 70 and 75 years of age. Eur Heart J 1984;5:326–31.
34. Schocken DD, Arrieta MI, Leaverton PE, Ross EA. Prevalence and mortality rate of congestive heart failure in the United States. J Am Coll Cardiol 1992;20:301–6.
35. Yusuf S, Thom T, Abbott RD. Changes in hypertension treatment and in congestive heart failure mortality in the United States. Hypertension 1989;13(suppl I):I-74–9.
36. SHEP Cooperative Research Group. Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic hypertension: final results of the Systolic Hypertension in the Elderly Program (SHEP). JAMA 1991;265:3255–64.
37. Pfeffer MA, Braunwald E, Moye LA, et al. Effect of captopril on mortality and morbidity in patients with left ventricular dysfunction after myocardial infarction: results of the Survival and Ventricular Enlargement Trial. N Engl J Med 1992;327:669–77.
38. The CONSENSUS Trial Study Group. Effects of enalapril on mortality in severe congestive heart failure: results of the Cooperative North Scandinavian Enalapril Survival Study (CONSENSUS). N Engl J Med 1987; 316:1429–35.