10 Years After NHANES I: Mortality Experience at Initial Followup, 1982–84

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The NHANES I Epidemiologic Followup Study has been developed and funded by these agencies: National Institute on Aging; National Center for Health Statistics; National Cancer Institute; National Heart, Lung, and Blood Institute; National Institute of Arthritis, Diabetes, and Digestive and Kidney Diseases; National Institute of Mental Health; National Institute of Alcohol Abuse and Alcoholism; National Institute of Allergy and Infectious Diseases; and National Institute of Neurological and Communicative Disorders and Stroke. The field work was conducted by Westat, Inc., under contract No. 23380-2049.

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Synopsis

The NHANES I Epidemiologic Followup Study (NHEFS) was initiated jointly by the National Center for Health Statistics and the National Institute on Aging in collaboration with other National Institutes of Health and Public Health Service agencies. The goal of NHEFS is to examine the relationship of baseline clinical, nutritional, and behavioral factors assessed in the first National Health and Nutrition Examination Survey (NHANES I—1971-75) to subsequent morbidity and mortality.

Tracing for the initial followup began in 1981 and ended in 1984. This article compares the mortality experience of the NHEFS cohort with survival probabilities and cause-of-death distributions derived from U.S. vital statistics data. The analysis was done for 28 age-race-sex specific subgroups. The survival of each group of the NHEFS cohort corresponds quite closely to that expected on the basis of the U.S. life table survival probabilities. Mortality differentials by age, race, and sex are also quite similar between NHEFS and U.S. vital statistics. In addition, the cause-of-death distributions among NHEFS participants are quite similar to those expected based on national vital statistics. Thus, there do not seem to be any serious biases in the mortality data. The NHEFS, therefore, provides a unique resource for assessing the effects of baseline sociodemographic, health, and nutritional factors on future mortality in a large, heterogeneous sample that is representative of the nation's population.

THE first National Health and Nutrition Examination Study (NHANES I) was conducted from 1971 to 1975 by the National Center for Health Statistics (NCHS), and it collected extensive health-related information on a probability sample of the civilian noninstitutionalized U.S. population (*1-3*). The NHANES I Epidemiologic Followup Study (NHEFS) uses the NHANES I as the baseline for a longitudinal study. The NHEFS was initiated jointly in 1982 by the National Institute on Aging and the NCHS. Its purpose is to investigate the relationships of baseline physiological, nutritional, social, psychological, and demographic factors to subsequent morbidity or mortality from specific diseases and conditions. The design of the NHEFS has been described elsewhere (*4,5*), and the results of the data collection are presented in an accompanying article (*6*).

Tracing of NHANES I participants for the initial wave of followup began in 1981 and ended in August 1984. Because of the complexities of the NHANES I sampling procedures, initial nonresponse on NHANES I (30 percent), and loss to followup on NHEFS (7 percent), it is important to compare the mortality experience of the NHEFS

cohort with survival probabilities and causes of death derived from U.S. vital statistics data. Large deviations from national data would suggest bias in the data base and limit the validity of epidemiologic results derived from NHEFS. The results of the comparison are reported in this paper.

Method

All NHANES I examinees aged 25 years and older in 1971–75 (n = 14,407) were included in NHEFS. Of this cohort, 7 percent (1,027) were lost to followup and 14 percent (2,022) had died. The number of deaths and the percent deceased among the NHEFS cohort are given in the accompanying paper (*6*). Comparisons of the mortality experience of the cohort with national vital statistics need to be made using separate age groups and survival analysis techniques that take into account variation in length of followup. Controlling for length of followup is particularly important in this sample because the sample design of the NHANES I changed over the course of the survey, and the sampling probabilities used were based on factors that are related to survival, such as residing in a poverty area. (See references *1–3* for a description of the NHANES I design.)

For example: Due to the design of NHANES I, the proportion of low-income people examined in 1971–72 was much greater than that in 1974–75. The probability of dying during the followup period would be greater for the low-income participants who were examined earlier in the survey merely because they had been followed for a longer period—and not because they were at low-income levels. Thus, the relationship between income and mortality will be distorted if length of followup is not properly controlled in the analysis.

Cumulative survival rates and standard errors for 28 age-race-sex specific subgroups were calculated using the Kaplan-Meier product limit method (*7*). Graphs of survival curves are presented as well as tables of survival probabilities at 5 and 8 years. Five-year survival was chosen because it is the approximate midpoint of the followup period. Eight-year survival is presented also because more than 90 percent of the cohort were followed for at least 8 years. Survival rates beyond 8 years become highly unstable, especially for small subgroups. Ten-year age groups were used for ages 25–54 years and 5-year age groups, for ages 55–75. Race was categorized as white or black. Persons of other races were omitted from this analysis.

Persons who could not be traced (4.8 percent of white men, 7.0 percent of white women, 12.6 percent of black men, and 11.6 percent of black women) have been excluded from the survival calculations. By making these exclusions, we are assuming that mortality among persons lost to followup is identical to that for persons successfully traced. Those found alive have been censored at last date known alive (usually the date of the followup interview).

Survival among persons in each age group of the NHANES sample was compared with survival probabilities derived from U.S. life tables using the midpoint of the age interval. For example, survival for persons ages 55–59 years at the baseline examination was compared with the U.S. survival probability for persons age 57 years. For each age-race-sex group, the U.S. life table for 1973 provided the expected probability of surviving 1 year after the baseline examination (1973 was selected because it is the midpoint of the examination period). Information from U.S. life tables for the years 1974 through 1982 was used to calculate the probabilities of surviving 2–10 years after the baseline examination. For each age-race-sex group, the expected proportion surviving n years is given by the following formula:

$$\prod_{i=0}^{n-1} \left(1 - {}_1q_{a+i,\,1973+i} \right)$$

where

${}_1q_{x,y}$ = probability that persons in a given race-sex group alive at age x will die within 1 year according to U.S. life table for year y.

a = midpoint of age interval at baseline (1973).

Expected survival probabilities were calculated from successive life tables rather than from just the initial (1973) life table to take into account the decrease in U.S. death rates that occurred over this period. However, the U.S. life tables only approximate the expected survival of the NHANES sample. Differences in survival probabilities between the NHANES I sample and the U.S. population are expected due to the sample design of NHANES I. Because NHANES is a sample of noninstitutionalized persons, survival probabilities would be expected to be higher than those for the U.S. population, which includes institutionalized persons. This effect would be greatest among elderly persons, and it would decrease over time as the sample approaches the institutionalization patterns of the U.S. population. On the other hand, because income is inversely related to mortality,

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the oversampling of persons with low incomes in NHANES I would lead to a counterbalancing expectation of lower survival probabilities in the NHANES I sample than in the U.S. population. Women of childbearing age and the elderly also were oversampled, but since results are presented by age and sex, the mortality comparisons would not be affected by this aspect of the design.

To assess the effect of the sample design of the mortality experience of the cohort, survival probabilities were calculated separately for three subgroups. The NHANES I design oversampled residents of poverty areas (that is, geographic units with a substantial percent of the population below poverty). The rate of oversampling by residence in a poverty area was greatest during 1971–72, reduced during 1973–74, and eliminated entirely for those selected as part of the augmentation sample in 1974–75. For white men and women aged 65–69 and 70–74 years at baseline, cumulative survival probabilities were calculated for those examined between 1971 and 1974 residing in poverty areas, for those examined between 1971 and 1974 residing in nonpoverty areas, and for those examined as part of the augmentation sample.

To determine whether the patterns of mortality among the four race-sex groups were comparable to what would be expected based on national vital statistics, proportional hazards models (*8*) were estimated for three age groups (25–44, 45–64, and 65 and older). Each model included three dummy variables to compare the race-sex groups (relative to white women) and a continuous variable to further adjust for age.

Finally, the distributions of causes of death for decedents in NHEFS were compared with those for all U.S. deaths based on national vital statistics, using four race-sex groups. Because the age distribution of NHEFS is different from the U.S. distribution, the comparisons were age-adjusted using the indirect method. For each race-sex group, the expected number of deaths for each cause in NHEFS was calculated by applying the percentage of deaths for that cause in vital statistics to the number of NHEFS deaths in each age group:

$$e_c = \sum_{a=1}^{7} p_{ac}\, d_a$$

where

e_c = expected number of deaths for cause c.

p_{ac} = proportion of deaths from cause c in age group a (from U.S. vital statistics).

d_a = number of NHEFS deaths in age group a.

a = 30–44, 45–54, 55–64, 65–69, 70–74, 75–79, 80–84.

Note that deaths were tabulated according to age at death rather than age at the baseline examination as in the survival comparisons. U.S. vital statistics for 1979 (*9*) were used as the basis for comparison because that year was the closest to the midpoint of the followup period in which deaths were coded according to the International Classification of Diseases, Ninth Revision. Underlying cause of death for NHEFS was coded from the death certificates for 1,935 decedents (death certificates have not yet been located for the other 4 percent of the deaths). Fourteen deaths were excluded from the calculations because they occurred among persons outside the 30- to 84-year age range considered, and one death was excluded because the medical portion of the death certificate could not be obtained.

Causes of death were initially aggregated into the NCHS standard 34-cause list (*9*). Causes with fewer than 5 expected deaths (for whites) were combined so that the final list included 19 causes for men and 20 causes for women (the discrepancy is due to breast cancer). Observed and expected deaths for each race-sex group were compared using the standard chi-square statistic.

Because of the several differences between NHEFS and the U.S. population (that is, oversampling of certain population subgroups, exclusion of institutionalized persons), precise agreement between NHEFS and U.S. vital statistics would not be expected. The comparisons presented in this paper are designed to help determine

whether the mortality experience of the NHEFS sample is reasonably close to mortality in the U.S. population. Although standard errors and significance tests are used to compare NHEFS results with expected values based on U.S. vital statistics, modest departures from the null hypotheses are not necessarily serious. Such "significant" differences need to be interpreted carefully with respect to their magnitude and implications for deriving useful results in future epidemiologic studies. It should also be noted that standard errors and significance tests are based solely on the sample sizes in each group and do not reflect the effects of a complex survey design.

Results

Survival. Cumulative survival probabilities and their associated standard errors for 5 and 8 years of followup for each age-race-sex group of the NHEFS cohort and for the U.S. population are presented in table 1. In general, the survival of each group of the NHEFS cohort corresponds quite closely to that expected on the basis of the U.S. life table survival probabilities. Differences between observed and expected survival probabilities are generally greatest among the blacks. However, the smaller number of blacks in the sample makes these estimates less stable, particularly in the younger age groups. The only groups with survival significantly different from that expected at both 5 and 8 years of followup are white women aged 45–54 years and black women aged 65–69 years.

Graphs of the cumulative probabilities survival for the three subgroups related to residence in a poverty area are presented in figures 1–4. Residence in a poverty area is clearly related to survival among white men aged 65–69 years. Persons examined during 1971–74 who resided in poverty areas experienced significantly higher mortality than the population residing in nonpoverty areas. Survival for persons examined as part of the augmentation sample falls between the other two subgroups. Although white women aged 65–69 years residing in nonpoverty areas also experienced lower mortality than did those in poverty areas, the difference is not as large as that found for men aged 65–69 years (and is not statistically significant). There are no differences among the three subgroups for those aged 70–74 years.

Comparison of race-sex groups. Table 2 presents the results of proportional hazards models to assess the relative risk of death for each race-sex group (white women were used as the base comparison). In each age group, white women have

Table 1. Cumulative survival probabilities after 5 and 8 years based on U.S. vital statistics compared with NHEFS sample (with standard error)

Race-sex-age	5 years			8 years		
	U.S. population	NHEFS cohort[1]	SE (NHEFS)[1]	U.S. population	NHEFS cohort[1]	SE (NHEFS)[1]
White men						
25–34 years ..	.992	.993	.003	.986	.988	.004
35–44 years ..	.982	.980	.005	.968	.965	.007
45–54 years ..	.953	.944	.008	.918	.918	.009
55–59 years ..	.910	.938	[2].012	.847	.869	.017
60–64 years ..	.867	.873	.019	.778	.782	.023
65–69 years ..	.806	.814	.013	.683	.694	.016
70–74 years ..	.724	.766	.017	.569	.585	.020
Black men						
25–34 years ..	.975	1.000	.000	.959	.972	.016
35–44 years ..	.955	.955	.022	.924	.955	.022
45–54 years ..	.909	.900	.025	.849	.843	.031
55–59 years ..	.860	.860	.046	.772	.754	.057
60–64 years ..	.828	.837	.056	.722	.744	.067
65–69 years ..	.762	.783	.032	.625	.656	.037
70–74 years ..	.682	.709	.042	.536	.530	.046
White women						
25–34 years ..	.996	.997	.001	.993	.992	.002
35–44 years ..	.990	.993	.002	.982	.986	.003
45–54 years ..	.975	.990	[2].003	.957	.976	[2].005
55–59 years ..	.956	.970	.008	.922	.928	.013
60–64 years ..	.936	.954	.011	.889	.912	.014
65–69 years ..	.902	.910	.009	.829	.834	.012
70–74 years ..	.843	.857	.013	.734	.758	.016
Black women						
25–34 years ..	.990	.983	.008	.983	.962	.011
35–44 years ..	.976	.982	.007	.959	.958	.011
45–54 years ..	.950	.942	.019	.916	.903	.024
55–59 years ..	.920	.945	.027	.866	.918	.032
60–64 years ..	.899	.931	.033	.832	.879	.043
65–69 years ..	.845	.901	[2].022	.747	.813	[2].029
70–74 years ..	.768	.787	.036	.652	.645	.043

[1]Probabilities and standard errors were estimated by the Kaplan-Meier product limit method.
[2]Difference between U.S. and NHEFS rates are significant at .05 level.
NOTE: NHEFS = NHANES I Epidemiologic Followup Study.

Table 2. Relative risk of death (with 95 percent confidence interval) for race-sex groups by age at baseline, NHEFS sample

Race-sex	25–44 years	45–64 years	65 years and older
White men ..	2.18 (1.46,3.24)	2.34 (1.88,2.91)	1.87 (1.66,2.10)
Black men...	3.44 (1.74,6.80)	4.45 (3.30,6.00)	2.14 (1.77,2.57)
White women	1.00	1.00	1.00
Black women	3.17 (2.03,4.94)	1.89 (1.31,2.72)	1.28 (1.04,1.58)

NOTE: NHEFS = NHANES I Epidemiologic Followup Study.

Figure 1. Survival curves for white men aged 65-69 years according to residence

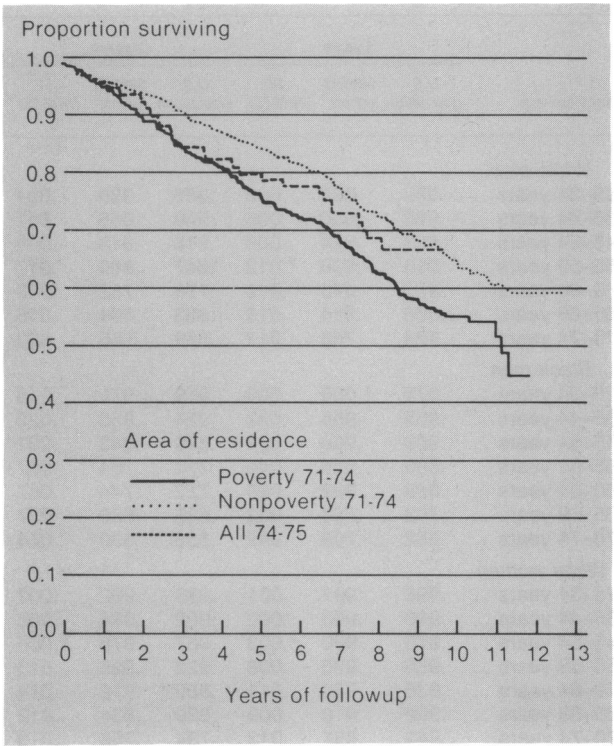

Figure 2. Survival curves for white women aged 65-69 years according to residence

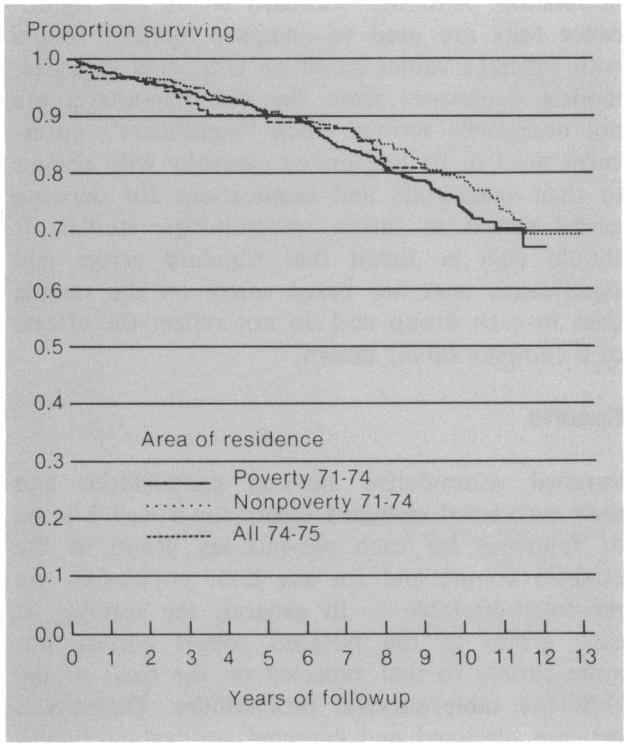

Figure 3. Survival curves for white men aged 70 years and older according to residence

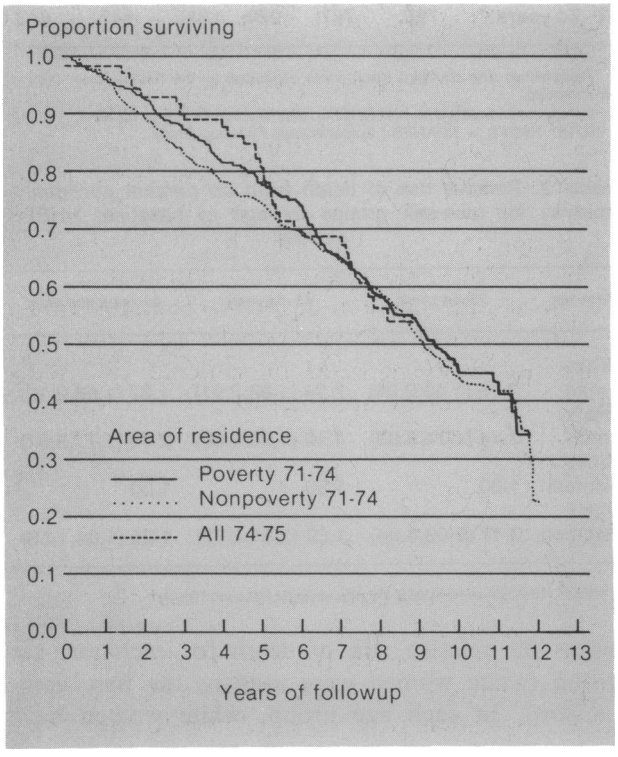

Figure 4. Survival curves for white women aged 70 years and older according to residence

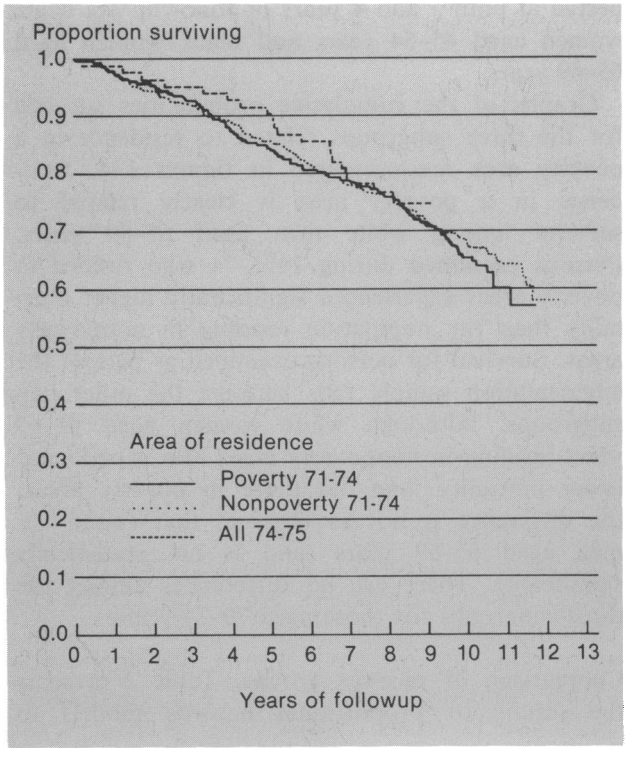

Table 3. Observed and expected numbers of deaths in the NHANES I Epidemiologic Followup Study: Men 30–84 years of age

Cause of death	White			Black		
	Observed	Expected	Standardized deviate[1]	Observed	Expected	Standardized deviate[1]
Infectious diseases	8	6.19	0.73	4	2.70	0.79
Cancer:						
Digestive organs	54	59.15	−0.67	18	14.63	0.88
Respiratory organs	71	81.81	−1.20	12	17.21	−1.26
Genital organs	19	22.85	−0.81	11	9.15	0.61
Urinary organs	18	12.47	1.56	1	1.86	−0.63
Leukemia	10	8.24	0.61	3	1.15	1.73
All other	37	40.94	−0.62	5	8.36	−1.16
Diabetes	10	13.54	−0.96	1	3.94	−1.48
Cardiovascular diseases:						
Ischemic heart disease	334	318.13	0.89	54	47.05	1.01
Other heart diseases	75	78.32	−0.37	25	28.21	−0.60
Cerebrovascular diseases	69	64.93	0.50	18	19.93	−0.43
Other cardiovascular diseases	23	26.43	−0.67	7	4.94	0.93
Pneumonia and influenza	29	18.70	2.38	4	4.83	−0.38
Chronic obstructive pulmonary diseases	54	42.13	1.83	8	4.89	1.40
Chronic liver disease and cirrhosis	10	15.86	−1.47	3	3.57	−0.30
Nephritis, nephrotic syndrome, and nephrosis	6	6.77	−0.30	5	3.03	1.13
Symptoms, signs, and ill-defined conditions	13	8.88	1.38	6	5.15	0.38
All other diseases	52	60.45	−1.09	16	15.91	0.02
Motor vehicle accidents	7	12.14	−1.48	0	2.33	−1.53
All other accidents and adverse effects	32	33.21	−0.21	7	9.11	−0.70
		$X^2_{19} = 25.40$			$X^2_{19} = 19.15$	

[1] $(O-E) \div \sqrt{E}$

the lowest and black men have the highest death rates. Among 25- to 44-year-olds, black women have higher mortality than white men (although the confidence intervals overlap). There is a steady decline with increasing age in the relative risk for black women. Among men, the relative risk is slightly higher in the 45- to 64-year age group than in the 25- to 44-year group but decreases among those 65 years and older (especially for blacks). These patterns are remarkably similar to those observed using age-specific death rates from U.S. vital statistics (*8*).

Cause of death. Table 3 compares the cause-of-death distribution of male decedents in NHEFS with the expected numbers based on national vital statistics for 1979. There are no significant differences between the observed and expected distributions for whites ($P = .148$) nor blacks ($P = .447$). In fact, there are only two causes for which the individual standardized deviates are close to 2: an excess number of deaths from pneumonia and influenza for white men (29 deaths observed versus 18.70 expected) and from chronic obstructive pulmonary diseases for both whites (54 versus 42.13) and blacks (8 versus 4.89).

White women (table 4) show a borderline significant difference between observed and expected deaths ($P = .076$). The major components of the chi-square statistic result from excess numbers of deaths from infectious diseases (9 observed deaths versus 4.13 expected), nephritis, nephrotic syndrome and nephrosis (10 versus 4.84), and motor vehicle accidents (12 versus 6.81). The overall chi-square statistic for black women was not significant ($P = .359$). However, there did appear to be an unusually large number of deaths from stroke (34 observed versus 19.55 expected).

Overall, the cause-of-death distributions among NHEFS participants appear to be quite similar to what was expected based on national vital statistics. Inspection of age-specific cause-of-death distributions generally revealed the same level of agreement.

Conclusions

This paper presented comparisons of the mortality experience of the NHEFS cohort with national vital statistics. Some differences in survival probabilities between the NHANES I sample and the U.S. population were expected due to the sample

Table 4. Observed and expected numbers of deaths in the NHANES I Epidemiologic Followup Study: Women 30–84 years of age

Cause of death	White			Black		
	Observed	Expected	Standardized deviate[1]	Observed	Expected	Standardized deviate[1]
Infectious diseases	9	4.13	2.40	1	2.45	−0.93
Cancer:						
Digestive organs	43	43.85	−0.13	11	10.62	0.12
Respiratory organs	17	23.74	−1.38	3	4.54	−0.72
Breast	34	29.87	0.75	6	6.04	−0.02
Genital organs	15	19.13	−0.94	5	5.40	−0.17
Urinary organs	8	5.00	1.34	0	1.02	−1.01
Leukemia	7	5.52	0.63	1	0.97	0.03
All other	31	29.59	0.26	6	6.37	−0.15
Diabetes	21	14.84	1.60	5	6.32	−0.53
Cardiovascular diseases:						
Ischemic heart disease	164	173.12	−0.69	36	35.29	0.12
Other heart diseases	57	58.24	−0.16	20	24.05	−0.83
Cerebrovascular diseases	67	61.56	0.69	34	19.55	3.27
Other cardiovascular diseases	18	14.87	0.81	2	4.27	−1.10
Pneumonia and influenza	8	11.00	−0.91	0	2.74	−1.66
Chronic obstructive pulmonary diseases	10	13.68	−0.99	1	1.45	−0.38
Chronic liver disease and cirrhosis	5	8.24	−1.13	3	3.31	−0.17
Nephritis, nephrotic syndrome, and nephrosis	10	4.84	2.35	5	2.75	1.36
Symptoms, signs, and ill-defined conditions	6	5.28	0.32	5	3.85	0.59
All other diseases	43	47.99	−0.72	13	14.87	−0.48
Motor vehicle accidents	12	6.81	1.99	2	1.27	0.65
All other accidents and adverse effects	13	16.76	−0.92	4	5.84	−0.76
		$X^2_{20} = 29.61$			$X^2_{20} = 21.66$	

[1] $(O-E) \div \sqrt{E}$

'In each age group, white women have the lowest and black men have the highest death rates. . . . These patterns are remarkably similar to those observed using age-specific death rates from U.S. vital statistics.'

design of NHANES I. However, in all but two age-race-sex subgroups, the observed and expected survival curves were similar, and differences could be explained by sampling variation. Cause-of-death distributions and mortality patterns by age, race, and sex were also quite similar to what was expected based on U.S. vital statistics. Thus, there do not seem to be any serious biases in the mortality data. The NHEFS therefore provides a unique resource for assessing the effects of baseline sociodemographic, health, and nutritional factors on future mortality in a large, heterogeneous sample that is representative of the nation's population.

The NHEFS is an ongoing project. Although data collection for the initial followup ended in 1984, an additional round of data collection for persons age 55 years and older at baseline was started in 1985, and another followup of the entire cohort is scheduled for 1986–87. Efforts will continue to locate those currently lost to followup. The cohort will continue to be matched against the National Death Index (*10*) to identify additional decedents over the next several years.

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Management of Tuberculosis in Urban Homeless Indigents

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Portions of this paper were presented at the National Consensus Conference on Tuberculosis sponsored by the American College of Chest Physicians in West Palm Beach, FL, on February 2, 1984.

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Synopsis

Tuberculosis patients who are homeless, indigent, and alcoholic infrequently complete a course of chemotherapy, risking treatment failure, recurrence, and continued spread of infection in the community. Obstacles to successful treatment include an erratic schedule, mistrust of authority, and uncooperative or aggressive behavior.

Successful management of this problem requires the use of proven case holding techniques, a correct choice of drug regimen, and a prompt and appropriate response to the patient who is lost or refuses treatment.

Nine- and six-month drug regimens with proven success are now available; however, the direct observation of medication-taking should be maximized.

Patient default may be further minimized by encouraging prompt notification of the health department. Occasionally, the threat or use of existing public health laws on confinement for purposes of treatment are required for noncompliant patients.

MORE AMERICANS WERE HOMELESS in the winter of 1983-84 than at any time since the Great Depression (*1*).

Epidemiologic studies have shown an increased risk of tuberculosis among persons of lower socioeconomic status (*2*) and among unmarried men in large cities (*3*). Poor nutritional status and emotional stress have also been cited as possible risk factors for tuberculosis (*4,5*). Those performing recent screening studies at clinics and shelters for homeless persons have found from 1.6 to 6.8 percent of the clients to have active tuberculosis (*6,7*). These rates are 150 to 300 times the national average (*8*), higher than rates for most groups of refugees and immigrants (*9*), and well above the 1 percent threshold at which screening is recommended (*10*).

Homeless and indigent persons represent a significant reservoir of both current and future tuberculosis. In addition to high rates of disease, screening has also found 35 to 50 percent of them to be infected (without current disease) as demonstrated by a reactive tuberculin skin test (*11*). These persons may be at sufficiently high risk of future tuberculosis to warrant isoniazid preventive therapy. However, neither increased screening nor expanded preventive therapy efforts should be the primary focus of improved tuberculosis control activities because the major obstacle to effective implementation of tuberculosis control continues