Socioeconomic Differentials in Mortality by Cause of Death

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TRADITIONAL STUDIES of mortality have tended to focus primarily on historical trends. At a time when there is considerable control over death there is much interest in the existence of mortality differences among different population subgroups, such as rural-urban areas, occupational classes, educational levels, and income groups.

The changing pattern of morbidity, especially the increase in the contribution to total mortality of certain diseases (such as heart disease) and the diminishing importance of others (for example, infectious and parasitic diseases), has led demographers, epidemiologists, and other health professionals to turn their attention to an examination of mortality patterns associated with different causes of death. Much of this examination consists of a search for clues to make possible further reductions in the overall level of mortality.

Although many mortality differentials have long been established, recently a number of them have been changing. Among these is the socioeconomic differential. At present, there is lack of agreement concerning the existence, as well as the extent,

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of such differentials. For example, many studies have indicated a pronounced inverse relationship between socioeconomic status and all deaths from all causes (*1–4*), whereas others have shown that the precise nature of the relationship between socioeconomic status and mortality, as well as the extent of such a relationship, varies considerably when different methodological procedures are followed (*5–8*). In addition, causes of death once thought to be limited almost exclusively to older ages, such as cancer and heart diseases, are now among the leading causes of death for people of middle and even younger ages.

The spread of public health programs and the rapid accumulation of medical knowledge, as well as changes which have taken place in the age structure of the population, are most often cited as factors underlying the unstable character of mortality differentials.

With these problems in mind, there is clearly a need for periodic reexaminations of the relationships between various aspects of mortality and socioeconomic status. The study described here focuses on an examination of the relationship between socioeconomic status and mortality from nine leading causes of death.

Methods

This study is a micro-level analysis of mortality in the city of Hartford, Conn., in which socioeconomic differentials in mortality from nine leading causes are examined. The general methodology is the social area analysis approach (*9, 10*). This approach examines variations in mortality among small geographic units within a city (generally census tracts or groups of tracts) that have been differentiated according to some index of socioeconomic status.

The derivation of the social rank scores involves three basic steps: (*a*) computation of scores to measure the occupation, education, and income compositions of the population, (*b*) computation of standardized scores for each of these three variables, and (*c*) combining these three standardized scores into a single social rank score (*11*).

Crude socioeconomic scores. Using official published statistics from the 1960 census of population, we completed the following three scores for each census tract:

OCCUPATION: The number of employed persons who were working at blue-collar occupations (craftsmen, operatives, and nonfarm laborers) per 1,000 employed persons.

EDUCATION: The number of persons age 25 and over who had completed less than 8 years of elementary school per 1,000 age 25 and over.

INCOME: The number of families per 1,000 families with annual incomes less than $3,000.

Standardized socioeconomic scores. The same crude score for the different component variables could indicate substantial differences in the overall socioeconomic composition of an area's population. On one hand, if the ratio of blue-collar workers to total employed was 100 to 1,000, it would indicate a relatively high status. On the other hand, a ratio of 100 to 1,000 for families with an annual income of less than $3,000 would indicate a relatively low status. Thus, it was necessary to convert the crude scores into more comparable "standard scores" before combining them into a single social rank score. This was done by a fairly simple procedure; for each variable, we assigned standardized scores between 0 and 100 to each census tract on the basis of that tract's relative rank position with regard to the crude scores. The three sets of standard scores for each census tract and their crude scores are shown in table 1.

Overall socioeconomic index scores. Before combining the three standardized scores for each census tract into a single overall social rank score, we introduced one more computation and subtracted each standardized score from 100. The rationale for introducing this additional step follows.

The three component variables are inverse indicators of socioeconomic status (the lower the crude score, the higher the relative level of socioeconomic status). However, we thought that it might be more desirable (certainly more logical) if the reverse were true and if a high score were indicative of a high socioeconomic status. Since all the standard scores for each variable fall between 0 and 100, it was a simple matter to subtract these scores from 100. This was necessary to make each component variable, as well as the overall socioeconomic index scores, a direct indicator of socioeconomic status. After the three standardized scores of the component variables for each census tract were subtracted from 100, the overall social rank score was derived as a simple arithmetic mean of these differences. These scores, as well as the modified standardized scores for the three components, are presented in table 2.

Delimitation of social areas. To facilitate subsequent analyses of the association between social rank and mortality, the 41 census tracts in the

metropolitan center were combined into four broad social rank groups. This grouping was based on the distribution of the social rank scores, and it was devised to yield a more or less normal distribution of census tracts among the social rank groups. The resulting four groups, the range of their social rank scores, and the number of census tracts in each are as follows:

Social rank area	*Range of social rank scores*	*Number of census tracts*
High:		
I	70 or more	9
II	60.0–69.9	10
III	45.0–59.9	11
Low:		
IV	less than 45	11

Table 1. Social rank component scores, crude and standardized, for census tracts, Hartford, Conn., 1960

Census tract	Crude scores			Standardized percentile scores		
	Occupation	Education	Income	Occupation	Education	Income
H–1	455.0	300.8	144.7	60.6	48.0	25.5
H–2	451.7	256.7	103.0	60.1	40.1	18.1
H–3	430.9	297.7	179.9	57.0	47.4	31.7
H–4	431.6	224.0	206.3	57.1	34.3	36.3
H–5	516.7	363.6	184.3	69.9	59.2	32.4
H–6	527.1	536.6	321.0	41.5	90.0	56.5
H–7	690.2	592.2	381.6	95.9	99.9	67.2
H–8	644.0	449.7	437.4	89.0	74.5	77.0
H–9	559.6	459.1	447.5	76.3	76.2	78.8
H–10–A	560.9	352.3	390.5	76.5	57.2	68.7
H–10–B	464.8	263.6	74.9	62.1	41.4	13.2
H–11–A	541.2	360.2	156.2	73.6	58.6	27.5
H–11–B	513.8	325.2	324.4	69.5	52.3	57.1
H–12	332.4	215.4	145.6	42.3	32.8	25.6
H–13	393.3	272.2	171.7	51.4	42.7	30.2
H–14	522.0	381.6	392.9	70.7	62.4	69.2
H–15	510.8	454.2	226.7	69.0	75.3	39.9
H–16	553.2	377.5	273.1	75.4	61.6	48.1
H–17	426.8	216.9	189.8	56.4	33.1	33.4
H–18	484.7	367.7	343.4	65.1	59.9	60.4
H–19–A	310.1	195.8	417.7	38.9	29.3	73.5
H–19–B	261.2	115.7	209.7	31.6	15.0	36.9
H–20	452.6	230.6	68.1	60.3	35.5	19.9
H–21	444.3	300.6	103.0	59.0	48.0	18.1
H–22	415.7	249.3	80.6	54.8	38.8	14.2
H–23	338.6	169.0	61.5	43.2	24.5	10.8
H–24	375.8	214.3	88.4	48.8	32.6	15.6
H–25	589.2	398.0	126.1	80.8	65.2	22.2
H–26	601.8	334.3	114.0	80.8	54.0	20.1
H–27	586.6	358.7	117.2	80.4	58.3	20.6
H–28	302.2	126.0	143.1	37.7	16.9	25.2
H–29	303.3	210.5	143.5	37.9	31.9	25.3
H–30	250.7	117.6	97.2	30.0	15.4	17.1
H–31	218.9	114.9	141.8	25.2	14.9	25.0
H–32	423.9	243.3	116.6	56.0	37.8	20.5
H–33	50.7	58.3	12.6	.0	4.8	2.2
H–34	311.1	211.5	104.5	39.1	32.1	18.4
H–35–A	474.5	151.8	120.0	63.6	21.5	21.1
H–35–B	252.6	143.4	67.2	30.3	20.0	11.8
H–35–C	182.3	191.8	66.4	19.7	28.6	11.7
H–36	502.7	273.0	67.7	67.8	43.1	11.9
H–37	241.6	119.0	95.8	28.6	15.6	16.9
H–38	459.0	269.8	82.5	61.2	42.5	14.5
H–39	282.8	158.3	101.6	34.8	22.6	17.9
H–40–A	352.5	188.6	62.0	45.3	28.0	10.9
H–40–B	604.2	330.3	389.9	83.0	53.2	68.6
H–40–C	356.3	194.8	42.3	45.8	29.1	7.4
H–40–D	359.3	187.7	48.6	46.3	27.9	8.6
H–41	496.8	249.1	74.6	66.9	38.8	13.1

NOTE: The basic formula for converting the absolute or crude scores to such relative percentile scores is as follows: $S = X(R - \emptyset)$ where for each of the three component variables (occupation, education, and income) S = the standardized score for any given census tract; R = the crude score for any given census tract; $\emptyset$ = the lower limit of the crude scores for all the census tracts; $X = \frac{100}{\text{range of the crude scores for all census tracts}}$.

We believe that the use of an ecological index of socioeconomic status which would compare various geographic areas at the same point in time and the same geographic areas at different points in time would be particularly important in relation to health services administration and the changes needed in health programing. (We are aware of the limitations of the use of the social area analysis, especially concerning the assumption of the homogeneity of certain geographic areas. However, in our view, whether social rank areas are completely homogeneous is not critically important if they can be differentiated from each other in relative terms. Several authors have discussed the limitations of the social area approach (*12–14*).) Furthermore, our selection of the social area index was more appropriate, since the only index of socioeconomic status that can be effectively obtained from Connecticut death certificates is the occupation of the deceased person. While occupation has been used extensively as an index of socioeconomic differentials of mortality (*15,*

Table 2. Social rank scores for census tracts in Hartford, Conn., 1960

Census tract	Modified standardized scores [1]			Social rank score	Social rank area
	Occupation	Education	Income		
H–1	39.4	52.0	74.5	55.2	III
H–2	39.9	59.9	81.9	60.6	II
H–3	43.0	52.6	68.3	54.6	III
H–4	42.9	65.7	63.7	57.4	III
H–5	30.1	40.8	67.6	46.2	III
H–6	58.5	10.0	43.5	37.3	IV
H–7	4.1	.0	32.8	12.3	IV
H–8	11.0	25.5	23.0	19.8	IV
H–9	23.7	23.8	21.2	22.9	IV
H–10–A	23.5	42.8	31.3	32.5	IV
H–10–B	37.9	58.6	86.8	61.1	IV
H–11–A	26.4	41.4	72.5	46.8	IV
H–11–B	30.5	47.7	42.9	40.4	IV
H–12	57.7	67.2	74.4	66.4	II
H–13	48.6	57.3	69.8	58.6	III
H–14	29.3	37.6	30.8	32.6	IV
H–15	31.0	24.7	60.1	38.6	IV
H–16	24.6	38.4	51.9	38.3	IV
H–17	43.6	66.9	66.6	59.0	III
H–18	34.9	40.1	39.6	38.2	IV
H–19–A	61.1	70.7	26.5	52.8	III
H–19–B	68.4	85.0	63.1	72.2	III
H–20	39.7	64.5	80.1	61.4	II
H–21	41.0	52.0	81.9	58.3	III
H–22	45.2	61.2	85.8	64.1	II
H–23	56.8	75.5	89.2	73.8	I
H–24	51.2	67.4	84.4	67.7	II
H–25	19.2	34.8	77.8	43.9	IV
H–26	19.2	46.0	79.9	48.4	III
H–27	19.6	41.7	79.4	46.9	III
H–28	62.3	83.1	74.8	73.4	I
H–29	62.1	68.1	74.7	68.3	II
H–30	70.0	84.6	82.9	79.2	I
H–31	74.8	85.1	75.0	78.3	I
H–32	44.0	62.2	79.5	61.9	II
H–33	100.0	95.2	97.8	97.7	I
H–34	60.9	67.9	81.6	70.1	II
H–35–A	36.4	78.5	78.9	64.6	I
H–35–B	69.7	80.0	88.2	79.3	I
H–35–C	80.3	71.4	88.3	80.0	I
H–36	32.2	56.9	88.1	59.1	III
H–37	71.4	84.4	83.1	79.6	I
H–38	38.8	57.5	85.5	60.1	II
H–39	65.2	77.4	82.1	74.9	I
H–40–A	54.7	72.0	89.1	71.9	I
H–40–B	17.0	46.8	31.4	31.7	I
H–40–C	54.2	70.9	92.6	72.6	I
H–40–D	53.7	72.1	91.4	72.4	I
H–41	33.1	61.2	86.9	60.4	II

[1] 100—standardized percentile.

16), there are some problems concerning such usage (*17*). The following are the most serious of the problems:

- "To measure the effects of occupation on mortality, age-specific death rates are needed for the productive period of life, omitting the retired at this age, who form only a small fraction of the total" (*18*).
- Occupation data from death certificates do not distinguish the lifelong career occupations of the deceased from their occupations immediately before their death.
- Earlier studies suggest that "although there are many occupations with specific health hazards, the relatively high mortality of the less favored economic classes may reflect in considerable degree the influence of daily environment" (*18, 19*).

The basic data for this study consisted of the average number of deaths due to nine causes that occurred among residents of Hartford from January 1, 1959, through December 31, 1961.

Finally, indirect standardization procedures (*20*) were used to estimate expected deaths from each cause in each of the four social rank groups. Also, mortality comparisons were made in terms of (*a*) differences between the reported and the expected deaths and (*b*) net excess mortality. These procedures are described more fully in the following section.

Findings

Observed versus expected deaths. Table 3 presents comparative figures on observed and expected deaths due to nine causes in each of the four social rank areas. In area 1, the one of highest socioeconomic status, observed deaths were generally fewer than expected deaths (that is, the number that would have occurred if age-specific rates for the city as a whole had prevailed in each of the areas). For cancer and the respiratory diseases, however, the differences were not large. In area 4, the one of lowest socioeconomic status, observed deaths from the several causes were, with the single exception of the genito-

Table 3. Observed and expected deaths

Causes of death	Observed[1] (O)	Expected[2] (E)	O–E	O–E / E (100) (percent)
Area 1				
Infectious and parasitic diseases	1	4.8	− 3.8	−79.2
Cancer	115	114.8	+ .2	+ .2
Diabetes	11	13.9	− 2.9	−20.9
Vascular lesions	67	72.4	− 5.4	− 7.5
Heart diseases	213	264.4	−51.4	−19.4
Respiratory diseases	27	27.8	− .8	− 2.9
Digestive diseases	20	25.4	− 5.4	−21.3
Genitourinary diseases	7	8.5	− 1.5	−17.6
Accidents	9	14.5	−5.5	−37.9
Total	470	546.5		
Area 2				
Infectious and parasitic diseases	1	2.9	−1.9	−65.5
Cancer	66	66.7	−.7	− 1.0
Diabetes	11	8.1	+2.9	+35.8
Vascular lesions	37	37.9	−.9	− 2.4
Heart diseases	147	147.3	−.3	− .2
Respiratory diseases	24	17.0	+7.0	+41.2
Digestive diseases	13	14.8	−1.8	−12.2
Genitourinary diseases	3	4.9	−1.9	−38.8
Accidents	7	9.0	−2.0	−22.2
Total	309	308.6		
Area 3				
Infectious and parasitic diseases	8	3.3	+ 4.7	+142.4
Cancer	84	78.9	+ 5.1	+ 6.5
Diabetes	14	9.5	+ 4.5	+ 47.4
Vascular lesions	58	47.6	+10.4	+ 21.8
Heart diseases	188	176.5	+11.5	+ 6.5
Respiratory diseases	27	20.1	+ 6.9	+ 34.3
Digestive diseases	33	17.3	+15.7	+ 90.8
Genitourinary diseases	6	5.7	+ .3	+ 5.3
Accidents	14	10.5	+ 3.5	+ 33.3
Total	432	369.4		
Area 4				
Infectious and parasitic diseases	10	2.5	+ 7.5	+300.0
Cancer	65	52.3	+12.7	+ 24.3
Diabetes	10	6.5	+ 3.5	+ 53.8
Vascular lesions	44	29.5	+14.5	+ 49.2
Heart diseases	135	111.5	+23.5	+ 21.1
Respiratory diseases	24	14.0	+10.0	+ 71.4
Digestive diseases	31	12.0	+19.0	+158.3
Genitourinary diseases	3	3.9	− .9	− 23.1
Accidents	15	7.5	+ 7.5	+100.0
Total	337	239.7		

[1] Obtained from unpublished 1960 death records of the Hartford Health Department. [2] Computed by applying age-specific death rates for each cause of death in Hartford to age groups in the four social areas separately.

urinary diseases, much higher than the expected number of deaths. Areas 2 and 3 fell between these two extreme positions, with area 2 generally showing fewer differences than area 3.

In column 4 of table 3 the difference between observed and expected deaths is expressed as a percentage of the expected number of deaths. The general pattern revealed by these percentages clearly points to a pronounced inverse relationship between socioeconomic status and mortality from all nine causes of death; the strongest association is for the infectious and parasitic diseases. The general trend from area 1 to area 4 is a shift from a negative deviation to an increasingly large positive difference. Although a perfect gradient is not observed for all causes, this does not detract from the major conclusion that the actual number of deaths tends to exceed the number expected

Table 4. Net excess deaths

Causes of death	Area differentials [1]	Number of observed death area differentials	Expected deaths	Net excess deaths [2]	Percent distribution of excess deaths by cause
			Area 2		
Infectious and parasitic diseases	1.655	0.6	2.9	+ 2.3	5.2
Cancer	.988	66.8	66.7	− .1	.....
Diabetes	1.716	6.4	8.1	+ 1.7	3.8
Vascular lesions	1.055	35.1	32.9	+ 2.8	6.3
Heart diseases	1.239	118.6	147.3	+29.8	67.4
Respiratory diseases	1.454	16.5	17.0	+ .5	1.1
Digestive diseases	1.116	11.7	14.8	+ 3.1	7.0
Genitourinary diseases	.743	4.1	4.9	+ .9	2.0
Accidents	1.253	5.6	9.0	+ 3.4	7.7
Total				+44.5	100.0
			Area 3		
Infectious and parasitic diseases	11.637	0.7	3.3	+ 2.6	5.0
Cancer	1.063	79.0	78.9	+ .1	.2
Diabetes	1.862	7.5	9.5	+ 2.0	3.9
Vascular lesions	1.317	44.0	47.6	+ 3.6	6.9
Heart diseases	1.322	142.1	176.5	+34.3	66.1
Respiratory diseases	1.383	19.5	20.1	+ .6	1.2
Digestive diseases	2.423	13.6	17.3	+ 3.7	7.1
Genitourinary diseases	1.278	4.7	5.7	+ 1.0	1.9
Accidents	2.148	6.5	10.5	+ 4.0	7.7
Total				+51.9	100.0
			Area 4		
Infectious and parasitic diseases	19.200	0.5	2.5	+ 2.0	5.9
Cancer	1.241	52.4	52.3	− .1	.....
Diabetes	1.944	5.1	6.5	+ 1.4	4.2
Vascular lesions	1.612	27.3	29.5	+ 2.2	6.5
Heart diseases	1.503	89.8	111.5	+21.7	64.4
Respiratory diseases	1.765	13.6	14.0	+ .4	1.2
Digestive diseases	3.281	9.5	12.0	+ 2.5	7.4
Genitourinary diseases	.934	3.2	3.9	+ .7	2.1
Accidents	3.222	4.7	7.5	+ 2.8	8.3
Total				+33.7	100.0

[1] $\text{Area differentials} = \dfrac{\dfrac{\text{Observed number of deaths in area X}}{\text{Expected number of deaths in area X}}}{\dfrac{\text{Observed number of deaths in area 1}}{\text{Expected number of deaths in area 1}}}$

[2] $\text{Net excess deaths} = \dfrac{\text{Number of observed deaths for the disease in the area}}{\text{Area differential for disease}} - \text{Expected number of deaths}$

NOTE: Excess deaths are defined as the net number of deaths that would have been saved if the mortality index of each of the three lower socioeconomic groups had been equal to that of group 1. Negative percentages may exist where mortality is positively associated with socioeconomic level and indicate additional deaths that would occur if all social areas had the same mortality index as area 1.

under uniform mortality conditions to a progressively larger degree as socioeconomic status declines.

The data in table 3 can be refined further by estimating, for each cause group, the number of deaths that would have been "saved" if the mortality indices for the three lower social rank areas had been equal to the indices for the highest status area (area 1).

These estimates of "excess mortality" have been calculated as follows:

1. For each of the social areas 2, 3, and 4, an index of mortality differentials was computed to show the differences between observed and expected deaths from each cause relative to the corresponding differences in area 1 (the social rank area of higher socioeconomic status).

2. The number of observed death area differentials (ODAD) are computed by dividing the number of observed deaths from each cause by the corresponding area differential. For example, ODAD from infectious and parasitic causes are computed as follows:

$$\underset{\text{Area 2}}{\frac{1}{1.655}} = 0.6 \qquad \underset{\text{Area 3}}{\frac{8}{11.637}} = 0.7 \qquad \underset{\text{Area 4}}{\frac{10}{19.200}} = 0.5$$

3. Net excess deaths from each cause of death are computed as the differences between ODAD and expected deaths. These estimates of "excess mortality" are summarized in table 4.

Net excess deaths. The data in table 4 point to a strong inverse relationship between mortality and socioeconomic status. With the exception of the genitourinary diseases in areas 2 and 4, all the "area differentials" (column 1 of table 4) point to excess mortality from all causes in the lower social rank areas relative to area 1. Moreover, the excess tends to become more pronounced as socioeconomic status decreases.

Again, as in table 3, it is clear that the socioeconomic differential is most pronounced for infectious and parasitic diseases. The differences for the leading causes of death (heart disease, cancer, and vascular lesions) are much smaller, but still point to an inverse association with socioeconomic status even for these chronic diseases.

At this point it should be noted that the differential sensitivity of specific causes of death to variations in socioeconomic status may be important indices for programs aimed at the further reduction of overall mortality. In terms of the data presented in the present study, it might be concluded that the significant point relates to the infectious and parasitic diseases, for which the socioeconomic differential is most pronounced. Since those causes accounting for the largest number of deaths in general also exhibit a socioeconomic differential, however, we may find the greatest potential for overall mortality reductions in them. To clarify this situation, it is necessary to measure the combined effects of (*a*) sensitivity to variations in socioeconomic status and (*b*) the relative importance of particular causes to total mortality. This has been done in columns 4 and 5 of table 4.

Column 4 shows, for each social rank area, the number of excess deaths due to each cause, and column 5 shows the excess due to each cause as a percentage of all excess deaths in that area. From the data in column 5, heart disease accounts for more than 60 percent of the excess deaths in all three areas. Excess deaths from digestive diseases and vascular lesions account for 12 to 15 percent of excess mortality in the three areas. Infectious and parasitic diseases, on the other hand, account for only about 5 to 6 percent of the excess deaths in each area. Clearly, then, although the socioeconomic differential is most heavily pronounced for the infectious and parasitic diseases, the major chronic diseases produce the greatest excess mortality in the lower social rank groups.

Conclusion

In conclusion, we suggest continued periodic research on mortality differentials from causes of death, especially from the chronic diseases that account for the largest number of deaths in general. The question of whether traditional socioeconomic differentials still exist or whether there is a reversing trend in some causes of death should be constantly reexamined. One way to improve the total mortality picture is through a narrowing of differentials such as those associated with socioeconomic status. Only through continual investigation of the changing pattern of these differentials will we find new clues to facilitate their elimination.

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The relationship between deaths during 1959–61 from nine leading causes and socioeconomic status was examined in the city of Hartford, Conn. Socioeconomic status was determined according to social rank areas, and mortality was measured by expected deaths and excess deaths. The measure of expected deaths shows how deaths from each cause in each of four social rank areas differ from those that would have occurred if age-specific death rates by cause for the total city had prevailed. The comparative measure of excess deaths approximates the assumption that age-specific death rates for each cause of death in the highest social rank area would be applied to the age composition of the three lower socioeconomic areas.

The major difference between the measurements of observed and expected deaths and excess deaths is that the measure of excess deaths yielded slightly larger relative differences in mortality among the four social rank areas by cause of death. A more important observation, however, is that, with minor exceptions, both measures of mortality demonstrated a clear inverse association between socioeconomic status and mortality from all nine causes. The extent of the association was strongest for infectious and parasitic diseases, respiratory and digestive diseases, diabetes, and accidents. An inverse relationship between mortality from heart diseases, cancer, and genitourinary diseases was also ascertained, but the strength of the association was less apparent.

Excess deaths (deaths which can be prevented) result mainly from chronic diseases, especially from heart disease. Therefore, in order to reduce the overall level of mortality of the lower socioeconomic group to a level closer to that of the higher socioeconomic groups, early diagnosis and better treatment should be provided for persons at lower socioeconomic levels.