US Childhood Mortality, 1950 through 1993: Trends and Socioeconomic Differentials

ABSTRACT

Objectives. This study examined trends and differentials in US childhood mortality from 1950 through 1993 according to sex, race/ethnicity, education, family income, and cause of death.

Methods. Log-linear, multiple regression, and Cox proportional hazards regression models were applied to the data from the National Vital Statistics System, the National Longitudinal Mortality Study, and the Area Resource File.

Results. Substantial declines in US childhood mortality have occurred in the past 4 decades, primarily due to decreases in mortality from unintentional injuries, cancer, pneumonia and influenza, and congenital anomalies. The overall declining trend, however, has been dampened by a twofold to threefold increase in the suicide and homicide rates among children since 1968. Male, Black, American Indian, Hawaiian, and Puerto Rican children and those in the lower socioeconomic strata were at an increased risk of death.

Conclusions. Increasing trends in mortality from violence, firearm injuries, and human immunodeficiency virus/acquired immunodeficiency syndrome pose a major obstacle to continued declines in US childhood mortality. Reducing socioeconomic disparities and improving access to and use of health care may bring about further declines in overall and injury-related childhood mortality. (*Am J Public Health.* 1996;86: 505–512)

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Introduction

Monitoring and improving the health status of children are among the most important goals set forth by the US Department of Health and Human Services.[1,2] The United States lags well behind many industrialized countries despite impressive gains in reducing childhood mortality.[3-7] The long-term decline has been unequal among age and sociodemographic subgroups and also for cause-of-death categories.[3,7-9] Large differences exist in terms of gender, race and ethnicity, maternal education, and family income.[3,7,8,10,11]

In the United States, national estimates for such ethnic minorities as Asian Americans and Hispanics, however, are generally lacking,[3] and since death certificates do not carry the relevant information, education and income differentials have rarely been discussed.[10] This paper attempts to fill these gaps by examining childhood mortality trends in the United States from 1950 through 1993 by sex, race and ethnicity, and cause of death and analyzing socioeconomic differentials within a multivariate framework.

Materials and Methods

Data Sources

We used the following data sources to analyze mortality trends and differentials: (1) the National Vital Statistics System (1950 through 1993), (2) the National Longitudinal Mortality Study (1979 through 1985), and (3) the Area Resource File. Mortality data from the National Vital Statistics System are produced by the National Center for Health Statistics (NCHS) and are based on information from every death certificate filed in the United States. Detailed descriptions of the National Vital Statistics System have been provided elsewhere.[3,12-14] Census population data served as denominators for computing vital statistics rates.[15,16]

The National Longitudinal Mortality Study, a prospective study of mortality in the United States, was conducted by the National Heart, Lung and Blood Institute in collaboration with the US Bureau of the Census and NCHS.[17] The public-use study file consisted of five Current Population Survey cohorts between 1979 and 1981 whose survival (mortality) experiences were studied for 5 years. Data from death certificates on the fact of death and the cause of death were combined with the socioeconomic and demographic characteristics of the 1979 through 1981 population cohort by means of the National Death Index.[18-20]

The Area Resource File, developed and maintained by the Health Resources and Services Administration, is a computerized county-based data set that contains time series information on a variety of socioeconomic and health characteristics for every county in the United States.[21,22]

Source. Data were derived from the National Vital Statistics System, 1950 through 1993. The 1993 data are provisional, based on a 10% sample of deaths. Data for Blacks prior to 1968 were actually for non-Whites and are thus conservative estimates of the "true" death rates for Black children.
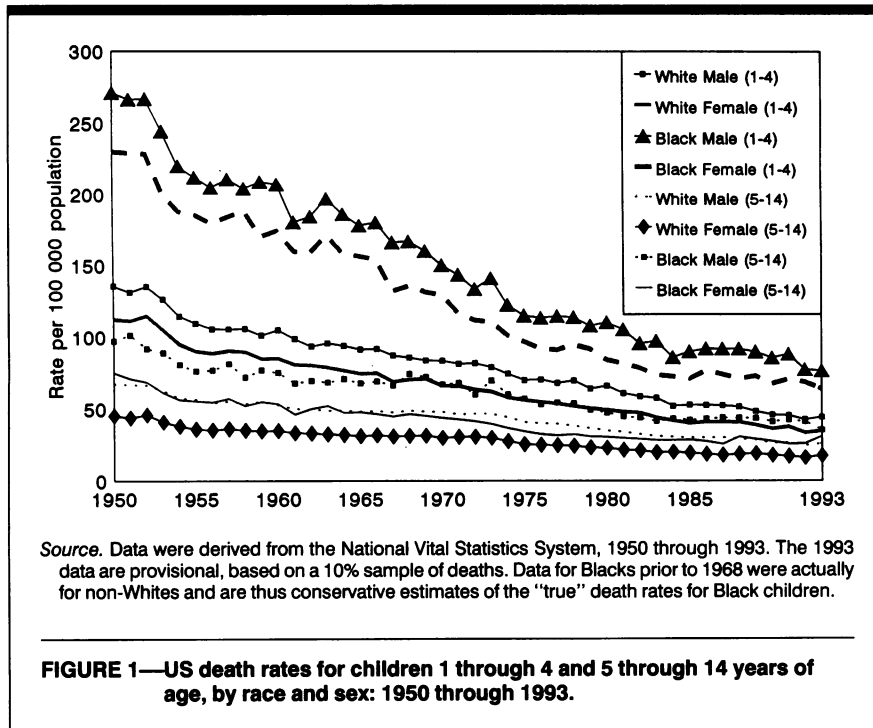
FIGURE 1—US death rates for children 1 through 4 and 5 through 14 years of age, by race and sex: 1950 through 1993.

Statistical Analysis

A simple regression model, expressing the death rate as a log-linear function of time, was used to describe time trends in childhood mortality, which essentially behaved in a monotonically increasing or decreasing fashion for most of the age, race, sex, and cause-of-death groups. The pace of mortality decline or increase was approximated by annual exponential rates of change.[23]

Microlevel family income differentials in childhood mortality were examined with the Cox proportional hazards regression,[19,24-27] while ecological analyses of socioeconomic (education, occupation, and income/poverty) differentials were performed by means of multiple regression.

Results

Trends in Mortality among Children 1 to 4 Years of Age

Examination of the long-term trend in mortality among young children 1 to 4 years of age revealed that the death rate for this age group has generally been decreasing since 1950 at an average rate of 2.65% per year. The rate of decline has been somewhat faster in the past 20 years or so than during 1950 through 1970.

Trends in sex differentials. Throughout the period 1950 to 1993, female children 1 to 4 years of age maintained a 15% to 25%

lower mortality rate than their male counterparts. The sex differential has increased slightly in the past few decades, female children having experienced a somewhat faster rate of mortality decline than male children. The average annual decreases during 1950 to 1993 were 2.57% for boys and 2.76% for girls.

Trends in race differentials by sex. Between 1950 and 1993, young Black children, regardless of sex, experienced mortality at almost twice the rate of young White children. Since mortality declined faster for Black male and female children than for White male and female children, the race differential decreased slightly for both male and female children over the 43-year period (see Figure 1). However, in the past 10 years or so, the Black–White ratio has increased somewhat. During 1950 to 1993, the average annual decreases in mortality among young children were 2.52% for White boys, 2.71% for White girls, 2.89% for Black boys, and 3.07% for Black girls.

Trends in race and ethnic differentials by sex. In Figure 1, the long-term racial differential in young childhood mortality is described in terms of White–Black differences. In Table 1, we show detailed data for additional ethnic minorities. Until now, such data have generally been lacking at the national level for specific Asian and Hispanic subgroups, partly because of small numbers of deaths and the unavailability of reliable population

counts for these groups.[3,14,28] Moreover, the quality of ethnic-specific mortality data from death certificates has also been questioned; the vital statistics death rates are said to be underestimated by 22% for American Indians, 8% to 12% for Asians/Pacific Islanders, and 7% for Hispanics.[29,30]

Except for Japanese and Cubans, whose death rates were based on relatively small numbers of deaths, death rates for Asian/Pacific Islander and Hispanic subgroups and American Indians in Table 1 may be viewed as fairly robust estimates of their mortality. Even if one were to inflate the reported rates to compensate for the suspected underestimation in ethnic mortality data, Asians and Pacific Islanders as a group showed the lowest young childhood mortality of all race/ethnic groups in both 1979 through 1981 and 1989 through 1991. However, mortality varied greatly among Asians and Pacific Islanders. Chinese, Japanese, and Filipino children 1 to 4 years of age had lower death rates than Hawaiians and other Asians. This was true for both boys and girls. Black, American Indian, and Hawaiian male and female children had the highest death rates in both time periods. Among Hispanics, Cuban children had lower death rates than their White counterparts, and Puerto Rican and Central and South American children had higher rates.

Except for Filipinos and other Asians, childhood mortality appeared to have declined for all groups between 1979 through 1981 and 1989 through 1991. The death rate seemed to have increased among both male and female Filipino children and among female children of "other Asian" ethnicity. Caution should be exercised in interpreting the change in Hispanic mortality; the states reporting Hispanic mortality data in 1979 through 1981 and 1989 through 1991 accounted for considerably different proportions of the total US Hispanic population.

Trends in leading causes of death. Table 2 shows deaths and death rates for the 10 leading causes of death among children 1 to 4 years of age during 1989 through 1991. These causes of death were coded according to the *International Classification of Diseases*, 9th Revision (ICD-9), which has been in effect in the United States since 1979.[3] Accidents (unintentional injuries) were the leading cause of death, accounting for about 37% of all deaths among young children in 1989 through 1991. Motor vehicle accidents accounted for 13% of all young childhood

TABLE 1—US Deaths and Death Rates per 100 000 Population for Children 1 to 4 and 5 to 14 Years of Age, by Race/Ethnicity and Sex, 1979 through 1991

| Race/Ethnicity | 1989–1991 | | | | | | 1979–1981 | | | | | |
| | Total | | Male | | Female | | Total | | Male | | Female | |
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
Children 1–4 years of age												
White	15 027	42.3	8 512	46.7	6 515	37.7	18 031	57.1	10 405	64.2	7 626	49.6
Black	5 528	80.1	3 103	88.9	2 425	71.1	5 640	98.0	3 164	109.0	2 476	86.8
American Indian	316	63.5	197	77.9	119	48.7	342	90.8	185	104.5	157	91.8
Asian and Pacific Islander	554	37.2	302	39.7	252	34.6	314	40.7	190	48.7	124	32.6
Chinese	54	19.3	29	20.0	25	18.4	42	31.1	26	37.4	16	24.5
Japanese	15	12.7	9	15.0	6	10.3	30	35.9	17	39.8	13	31.8
Filipino	73	28.4	40	30.1	33	26.5	38	23.3	21	25.2	17	21.4
Other Asian[a]	378	48.3	204	51.3	174	45.2	170	48.7	106	61.1	64	36.4
Hawaiian	34	67.3	20	77.2	14	56.8	34	84.9	20	97.8	14	79.7
Hispanic[b]	2 518	48.9	1 399	53.1	1 119	44.4	342	57.1	208	68.1	134	45.6
Mexican	1 736	46.2	967	50.4	769	41.9	236	60.0	143	71.4	93	48.2
Puerto Rican	203	51.6	116	57.7	87	45.3	62	58.1	41	74.6	21	40.8
Cuban	45	36.2	24	37.5	21	34.8	1	...	0	...	1	...
Other Hispanic[c]	534	60.7	292	65.1	242	56.1	43	46.0	24	49.5	19	42.4
Children 5–14 years of age												
White	19 247	22.8	11 811	27.2	7 436	18.1	25 143	29.1	15 620	35.2	9 523	22.6
Black	5 628	35.1	3 447	42.6	2 181	27.5	6 041	38.8	3 694	47.1	2 347	30.4
American Indian	333	28.6	202	34.2	131	22.9	350	38.6	224	48.8	126	28.1
Asian and Pacific Islander	611	17.7	359	20.5	252	14.9	371	20.3	216	22.9	155	17.5
Chinese	87	13.9	49	15.2	38	12.6	50	14.8	22	12.5	28	17.2
Japanese	24	9.8	14	10.8	10	7.9	40	17.2	23	19.4	17	14.8
Filipino	100	15.8	55	17.1	45	14.4	55	13.1	33	15.2	22	10.9
Other Asian[a]	363	20.1	219	24.0	144	16.0	189	25.5	115	29.9	74	20.6
Hawaiian	37	29.9	22	34.9	15	24.6	37	37.6	23	46.0	14	29.0
Hispanic[b]	2 450	21.9	1 518	26.6	932	17.0	352	24.9	214	29.7	138	19.8
Mexican	1 706	21.1	1 054	25.6	652	16.5	234	25.4	142	30.4	92	20.3
Puerto Rican	199	22.5	132	28.9	67	15.6	73	28.0	45	33.6	28	22.0
Cuban	45	16.8	28	20.4	17	13.1	3	...	1	...	2	...
Other Hispanic[c]	500	25.6	304	30.6	196	20.5	42	19.3	26	23.5	16	25.3

Source. Data were derived from the National Center for Health Statistics' Mortality Detail Files, 1979–1981 and 1989–1991.
[a]Includes Asian Indians, Koreans, Vietnamese, Cambodians, Laotians, Indonesians, and other Asian and Pacific Islanders.
[b]Based on data from 45 reporting states and the District of Columbia for 1989–1991; the 1979–1981 Hispanic data are based on 15 reporting states.
[c]Includes Central and South Americans and other and unknown Hispanic groups.

deaths, whereas all other accidents (including deaths from drowning and deaths from fires and flames) accounted for about one of every four deaths. Congenital anomalies and cancer were the second and third leading causes, accounting for 12.6% and 7.2% of all deaths among children 1 to 4 years old. Homicide was the fourth leading cause, accounting for 5.6% of all young childhood deaths. Other prominent causes of death among young children during 1989 through 1991 were heart disease, pneumonia and influenza, perinatal conditions, human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) infection, septicemia, and benign neoplasms.

Table 2 also shows deaths and death rates in 1979 through 1981 for the same causes of death that were the 10 leading causes in 1989 through 1991. The top six

causes were identical in both time periods. Between 1979 through 1981 and 1989 through 1991, the largest mortality declines occurred for pneumonia and influenza, accidents, cancer, and congenital anomalies. As a result, the mortality among young children dropped by 24% in just 10 years. However, the young childhood mortality would have dropped even further during this period had it not been for an 8% increase in homicide, a 50% increase in mortality from perinatal conditions, and an 80% increase in HIV/AIDS mortality between 1987 and 1993.

Yearly trends in major causes of death. Trends in yearly death rates from 1968 through 1992 for six major causes of young childhood mortality are shown in Figure 2. It is important to note that, except for pneumonia and influenza, there were no significant comparability breaks (i.e., clas-

sification changes) between the eighth and ninth revisions of the ICD for the causes listed in Figure 2. A comparability ratio of 0.9264 was applied to death rates from pneumonia and influenza during 1968 through 1978 (the period during which the ICD-8 was in effect) before the regression-based average annual percentage change in rates was computed.[31]

Young childhood mortality from all of the major causes except homicide showed generally a downward trend throughout the 24-year period, although mortality declined at a much faster pace for pneumonia and influenza (8.32% annually) than for cancer (3.53%), motor vehicle accidents (3.19%), injuries excluding motor vehicle crashes (2.79%), and congenital anomalies (2.66%). The homicide rate among young children, on the other hand, rose by 86% between 1968

TABLE 2—US Deaths and Death Rates per 100 000 Population for Children 1 to 4 and 5 to 14 Years of Age, for the 10 Leading Causes of Death, 1979 through 1991

Cause of Death (ICD-9 Code[s])	1989–1991		1979–1981	
	No.	Rate	No.	Rate
Children 1–4 years of age				
All causes	21 437	48.2	24 341	63.3
Accidents and adverse effects (E800–E949)	8 005	18.0	9 811	25.5
Motor vehicle accidents (E810–E825)	2 835	6.4	3 454	9.0
All other accidents and adverse effects (E800–E807, E826–E949)	5 170	11.6	6 357	16.5
Congenital anomalies (740–759)	2 695	6.1	3 065	8.0
Malignant neoplasms (140–208)	1 545	3.5	1 805	4.7
Homicide and legal intervention (E960–E978)	1 199	2.7	974	2.5
Diseases of the heart (390–398, 402, 404–429)	895	2.0	941	2.4
Pneumonia and influenza (480–487)	606	1.4	765	2.0
Certain conditions originating in the perinatal period (760–779)	408	0.9	236	0.6
Human immunodeficiency virus infection (*042–*044)	390	0.9	. . .	. . .
Septicemia (038)	285	0.6	228	0.6
Benign neoplasms (210–239)	217	0.5	133	0.3
Children 5–14 years of age				
All causes	25 829	24.5	31 913	30.4
Accidents and adverse effects (E800–E949)	11 400	10.8	15 779	15.1
Motor vehicle accidents (E810–E825)	6 336	6.0	8 274	7.9
All other accidents and adverse effects (E800–E807, E826–E949)	5 064	4.8	7 505	7.2
Malignant neoplasms (140–208)	3 267	3.1	4 445	4.2
Homicide and legal intervention (E960–E978)	1 541	1.5	1 249	1.2
Congenital anomalies (740–759)	1 435	1.4	1 681	1.6
Diseases of the heart (309–398, 402, 404–429)	884	0.8	942	0.9
Suicide (E950–E959)	770	0.7	461	0.4
Pneumonia and influenza (480–487)	391	0.4	567	0.5
Chronic obstructive pulmonary diseases (490–496)	350	0.3	239	0.2
Human immunodeficiency virus infection (*042–*044)	252	0.2	. . .	. . .
Cerebrovascular diseases (430–438)	242	0.2	291	0.3

Source. Data were derived from the National Center for Health Statistics' Mortality Detail Files, 1979–1981 and 1989–1991.

Trends in Mortality among Children 5 to 14 Years of Age

Historically, the death rate for children 5 to 14 years of age has been the lowest of all age-specific death rates in the United States.[3] Between 1950 and 1993, mortality for this age group declined in a consistently downward fashion at an average rate of 2.14% per year. However, the relative pace of mortality decline was slightly more rapid in the second than in the first half of the 43-year period.

Trends in sex differentials. Throughout 1950 through 1993, the older childhood mortality rate was 40% to 60% higher for boys than for girls. The male–female ratio has increased slightly in the past few decades, female youngsters having experienced a somewhat faster rate of mortality decline than male youngsters. The average annual rates of decline during 1950 through 1993 were 2.11% for boys and 2.19% for girls.

Trends in race differentials by sex. Between 1950 and 1993, Black children 5 to 14 years old experienced about 50% higher mortality than White children of the same age group. During the period, the mortality for Black boys did not decline as fast as it did for White boys; as a result, the Black–White ratio either remained the same or increased slightly (see Figure 1). Among girls, however, Black children experienced a more rapid mortal-

and 1992; during the 24-year period, the average annual rate of increase was 1.70% (see Figure 2).

ity decline than did White children, which generally meant the narrowing of the Black–White differential over the 43-year period. However, in the past 10 years or so, the Black–White mortality ratio has increased for girls as well. During 1950 through 1993, the average annual decreases in mortality among children 5 to 14 years of age were 2.11% for White boys, 2.20% for White girls, 2.07% for Black boys, and 2.32% for Black girls.

Trends in race and ethnic differentials by sex. The bottom panel of Table 1 shows detailed race/ethnic differentials in mortality among children 5 to 14 years old in 1989 through 1991 and 1979 through 1981. Just as in the case of younger children, Asians and Pacific Islanders as a group evidenced the lowest mortality rates in both periods. Specifically, Chinese, Japanese, Filipino, and Cuban children had significantly lower death rates than Whites, Blacks, Hawaiians, and American Indians. This was true among both boys and girls. Black, American Indian, and Hawaiian male and female youngsters had the highest death rates in both periods.

Death rates among children 5 to 14 years old decreased between 1979 through 1981 and 1989 through 1991 for all race/ethnic and sex groups except Chinese boys and Filipinos, whose mortality appeared to have risen, albeit insignificantly. However, the death rates for Chinese and Filipino boys in 1989 through 1991 were still 44% and 37% lower than the rate for White boys, and the death rate was 20% lower for Filipino girls than for White girls.

Trends in leading causes of death. Table 2 (bottom panel) shows mortality from the 10 leading causes of death among children 5 to 14 years of age during 1989 through 1991. Accidents were the leading cause of death, accounting for 44% of all deaths in the period. Motor vehicle crashes accounted for more than half of all accidental deaths. Cancer was the second leading cause of death. Homicide, the fourth leading cause of death in 1979 through 1981, ranked as the third leading cause in 1989 through 1991, accounting for 6 of every 100 deaths among youngsters. Congenital anomalies ranked as the fourth leading cause, followed by heart disease, suicide, pneumonia and influenza, chronic obstructive pulmonary diseases, HIV infection, and stroke.

Table 2 (bottom panel) also displays mortality in 1979 through 1981 from the same causes that ranked as the 10 leading

causes of death in 1989 through 1991. The top seven causes were the same in the two periods, although the rankings of homicide and suicide changed. Between 1979 through 1981 and 1989 through 1991, the observed mortality decline of 19.4% among children 5 to 14 years old was primarily due to substantial decreases in mortality from accidents, cancer, heart disease, and pneumonia and influenza. However, mortality among older children would have fallen even more during this period had it not been for a 66% increase in suicide, a 23% increase in homicide, and a 46% increase in mortality from chronic obstructive pulmonary diseases. Furthermore, the death rate from HIV/AIDS among older children increased fourfold between 1987 and 1993.

Yearly trends in major causes of death. Trends in yearly death rates between 1968 and 1992 for seven major causes of death among children 5 to 14 years old are depicted in Figure 3. Mortality fell fairly rapidly and consistently for pneumonia and influenza (at an annual rate of 7.14%), nonvehicular injuries (3.90%), cancer (3.12%), congenital anomalies (2.95%), and motor vehicle crashes (2.63%). Between 1968 and 1993, the suicide rate among older children more than doubled, and the homicide rate tripled. The average annual increases in mortality were 2.45% for suicide and 4.49% for homicide.

Socioeconomic Differentials in Childhood Mortality

Differentials by family income. Family income differentials in childhood mortality were examined by applying the Cox proportional hazards model to the National Longitudinal Mortality Study data for 1979 through 1985. In this longitudinal data set, only 42 deaths had occurred among 39 152 children 1 to 4 years of age during the 5-year follow-up. Classifying these deaths by family income (< $10 000, $10 000 through $14 999, and ≥ $15 000) produced still smaller frequencies in each income category. Nevertheless, the expected negative relationship between family income and mortality held. According to the results of the hazards regression model that controlled for sex, race, and rural/urban residence, young children with family incomes of less than $10 000 and $10 000 through $14 999, respectively, had 3 (95% confidence interval [CI] = 1.39, 8.05) and 3.4 (95% CI = 1.16, 7.85) times higher risks of mortality than their counterparts with family incomes of $15 000 or more. Fur-
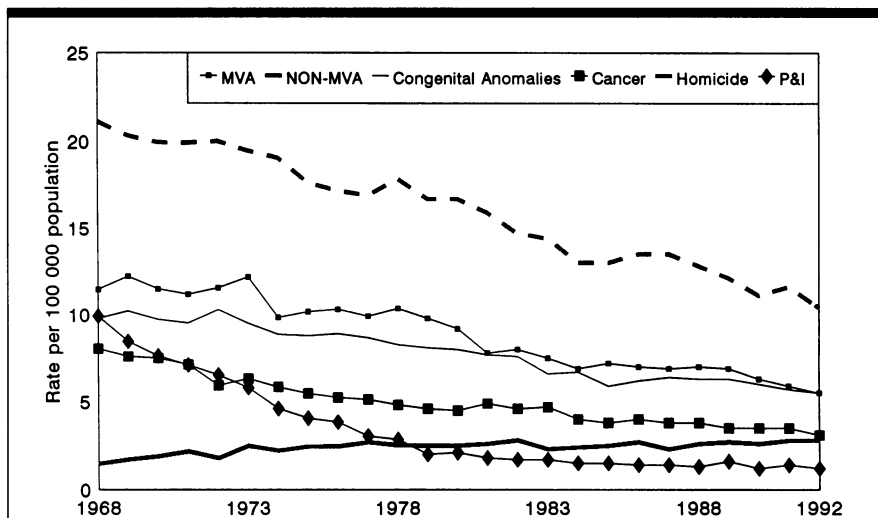
Source. Data were derived from the National Vital Statistics System, 1968 through 1992. MVA = motor vehicle accidents; NON-MVA = accidents excluding motor vehicle crashes; P&I = pneumonia and influenza.

FIGURE 2—US death rates from selected major causes of death: children 1 through 4 years of age, 1968 through 1992.
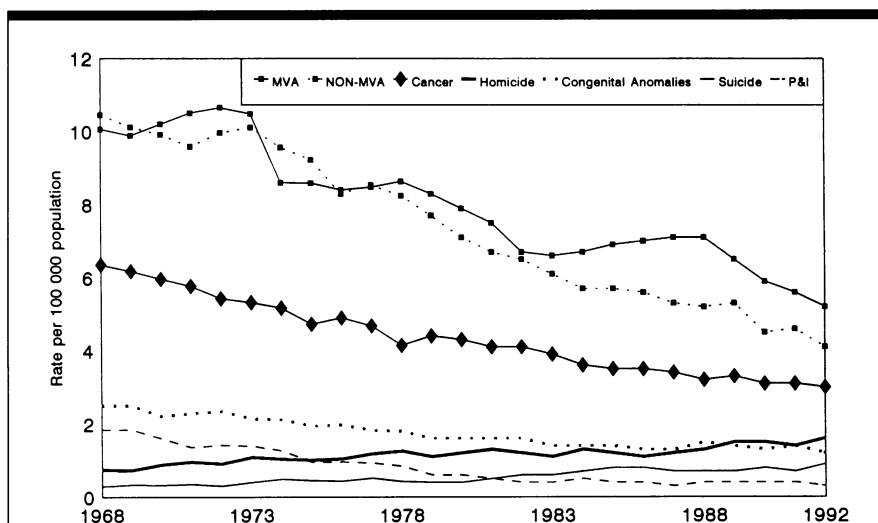
Source. Data were derived from the National Vital Statistics System, 1968 through 1992. MVA = motor vehicle accidents; NON-MVA = accidents excluding motor vehicle crashes; P&I = pneumonia and influenza.

FIGURE 3—US death rates from selected major causes of death: children 5 through 14 years of age, 1968 through 1992.

thermore, the racial differential in young childhood mortality was partly accounted for by family income.

Mortality estimates by family income were obtained for 102 292 children 5 to 14 years of age in 1979 through 1981, of whom 150 had died by the end of the follow-up period. Although stratifying these deaths by family income yielded

sufficiently large numbers of deaths in each income category, no consistent gradient in mortality was found by detailed income categories. In the hazards regression controlling for sex, race, and rural/urban residence, only those youngsters with family incomes of $20 000 or more showed significantly lower mortality risks than those with family incomes of less

TABLE 3—Ordinary Least Squares Regression of US Childhood Mortality on Socioeconomic Variables, 1980 through 1988 (n = 3080 Counties)

Independent Variable	Model 1[a]			Model 2[b]			Model 3[c]		
	b	SE(b)	β	b	SE(b)	β	b	SE(b)	β
Children 1–4 years of age									
Persons 25+ years of age with 12+ years of education in 1980, %	−0.436*	0.050	−0.155	−0.112**	0.057	−0.040	−0.010	0.077	−0.004
Families below poverty level in 1979, %	1.204*	0.097	0.218	...	...	...	0.414*	0.155	0.075
Persons 16+ years of age in white-collar occupations in 1980, %	−0.157**	0.070	−0.041	...	...	...	−0.026	0.117	−0.007
Blacks, American Indians, Asians, and Hispanics in 1980, %	0.509*	0.035	0.257	0.498*	0.040	0.251	0.438*	0.047	0.221
Women divorced in 1980, %	1.426*	0.337	0.076	2.838*	0.389	0.151	2.845*	0.408	0.152
Persons living in urban areas in 1980, %	−0.061*	0.022	−0.051	−0.190*	0.027	−0.158	−0.163*	0.031	−0.136
Constant	...	...	...	48.222*	3.726	...	37.939*	5.625	...
R^2	...	...	...	...	...	.090	...	...	.092
df	...	...	3078	...	...	3075	...	...	3073
Children 5–14 years of age									
Persons 25+ years of age with 12+ years of education in 1980, %	−0.194*	0.022	−0.157	−0.104*	0.027	−0.084	0.017	0.035	0.014
Families below poverty level in 1979, %	0.481*	0.043	0.198	...	...	...	0.242*	0.069	0.100
Persons 16+ years of age in white-collar occupations in 1980, %	−0.203*	0.031	−0.119	...	...	...	−0.206*	0.052	−0.120
Blacks, American Indians, Asians, and Hispanics in 1980, %	0.137*	0.016	0.157	0.117*	0.018	0.135	0.096*	0.021	0.110
Women divorced in 1980, %	0.231	0.149	0.028	0.974*	0.175	0.118	1.178*	0.183	0.143
Persons living in urban areas in 1980, %	−0.047*	0.009	−0.089	−0.076*	0.012	−0.014	−0.037*	0.014	−0.071
Constant	...	...	...	32.331*	1.673	...	28.430*	2.516	...
R^2	...	...	...	...	...	.051	...	...	.060
df	...	...	3078	...	...	3075	...	...	3073

Note. b = unstandardized regression coefficient; β = standardized regression coefficient.
Source. Data were derived from the Health Resources and Services Administration's Area Resource File. Death rate per 100 000 population was used.
[a]Unadjusted for other independent variables.
[b]Includes all but poverty and occupation variables.
[c]Includes all independent variables.
*P < .01; **P < .05.

than $20 000 (hazard ratio = 1.62, 95% CI = 1.08, 2.41).

Since injury and violence represent major components of overall childhood mortality, a hazards regression was run for external-cause mortality (ICD-9 codes E800 through E999). The National Longitudinal Mortality Study sample consisted of 141 444 children 1 to 14 years of age, of whom 115 had died from external causes by the end of the follow-up period. The results suggest a stronger and more consistent effect of family income on external-cause mortality than on overall mortality. Specifically, in comparison with children 1 to 14 years old with family incomes of $20 000 or more, the estimated hazard ratios were 1.87 (95% CI = 1.12, 3.13) for children with family incomes of less than $10 000 and 1.62 (95% CI = 1.01, 2.60) for children with family incomes of $10 000 through $19 999.

Differentials by education and poverty. The county-level data from the Area Resource File were used in conducting an areal analysis of the relationship between socioeconomic status and childhood mortality. Death rates for 1980 through 1988 were regressed separately for children 1 to 4 and 5 to 14 years of age on such social structural variables as education, poverty, occupation, marital disruption, urbanization, and minority concentration.[32,33] These

independent variables from the 1980 census were measured, respectively, by the percentage of persons 25 years of age or more with 12 years or more of schooling, the percentage of families below the poverty level, the percentage of persons 16 years of age or more in white-collar occupations, the percentage of women who were divorced, the percentage of persons living in urban areas, and the percentage of each county's population that was Black, American Indian, Asian, or Hispanic. Some health services variables, such as the number of physicians and health care facilities per 100 000 population, were also considered but subsequently excluded from the analyses because their inclusion in the regression models added very little to the proportion of variance explained (R^2) and did not significantly alter the relationship between the social structural variables considered and childhood mortality.

The results of the regression analyses showing the effects of socioeconomic variables are presented in Table 3. Model 1 shows bivariate correlations (betas) between social structural variables and mortality. Model 2 shows the effect of education, independent of minority concentration, divorce rate, and urbanization. Model 3 gives the effect of poverty, independent of education, occupation, and other covariates. As expected, education and poverty were both significantly related to mortality among children 1 to 4 and 5 to 14 years of age. The lower the level of educational attainment and the greater the poverty, the higher the childhood mortality rates.

The other findings worth noting were lower childhood mortality rates associated with higher levels of urbanization and white-collar occupations. Minority concentration and female divorce rates were positively associated with mortality. A comparison of the unstandardized regression coefficients suggests that poverty, female divorce rate, minority concentration, and urbanization had much stronger effects on the mortality of younger children than on that of older children.

Discussion

The past 4 decades have witnessed substantial declines in US childhood mortality that have tended to be somewhat more rapid for younger than for older children. These declines have occurred primarily as a result of impressive drops in mortality from unintentional injuries, cancer, pneumonia and influ-

enza, and congenital anomalies. In fact, childhood mortality would have fallen even more had it not been for a doubling of the homicide rate among younger children and a twofold to threefold increase in the suicide and homicide rates among older children since 1968.

Overall improvements in socioeconomic and living conditions, better nutrition, advances in medical knowledge and technology, improved medical care, and the introduction of Medicaid in 1965 have been suggested as factors contributing to long-term reductions in childhood mortality, especially mortality resulting from "biologic" causes.[9,34] Declines in childhood mortality from motor vehicle crashes reflect the increasing attention to motor vehicle safety, mandatory use of seat belts, and efforts to curb drinking and driving.[9,35] Mortality has declined even in the face of rising child poverty since 1973[36] and increasing financial constraints characterizing the US health care system.[9] This trend may reflect the prominent role of Medicaid, a program that has, over the years, provided improved access to necessary medical services for millions of poor children.[34,37] Prospects for further improvements in child survival could be seriously jeopardized by funding cutbacks for publicly funded programs such as Medicaid.

Despite overall reductions in US childhood mortality, substantial differences remain across sex, race/ethnic, and socioeconomic groups. Male children had significantly higher death rates than female children. Black children, especially those 1 to 4 years of age, had almost twice the risk of death as White children. American Indian, Hawaiian, Puerto Rican, and Central and South American children also had significantly increased mortality risks.

The evidence presented in this study establishes socioeconomic status as a major underlying determinant of childhood mortality, a finding consistent with that of previous studies.[10,11] Both education and income showed a profound net impact on childhood mortality; individual- and structural-level effects of income and poverty were especially pronounced for younger children and accounted for some of the racial disparities in childhood mortality. The residual racial difference in childhood mortality may reflect racial differences in access to and use of health care services, behavioral factors, and other forms of social and economic inequality not captured by family income. Reduction of socioeconomic disparities

may result in improved child survival, but it is not a practical recommendation from a programmatic standpoint. The variables amenable to modification through policy are more proximate health care variables (e.g., health insurance coverage, primary care characteristics such as type of physician and facilities for health care, health care expenditures, and use of primary care and preventive services) that could not be included in our study because of lack of data.[38,39] Future research should examine the relative impact of these variables in reducing childhood mortality.

Finally, childhood mortality continues to be higher in the United States than in most of its international peers,[4-7] not only because of higher mortality from medical causes (e.g., heart disease) but also, in substantial part, because of the excess mortality from injury and violence. For instance, in comparison with Japan and Sweden, childhood mortality from homicide, suicide, and unintentional injuries is about two to four times higher in the United States.[3-5] Certainly, recent trends in increased mortality from suicide, homicide, firearm injuries, and HIV/AIDS pose a major obstacle to continued declines in US childhood mortality.[40] □

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