State-Level Income Inequality and Individual Mortality Risk: A Prospective, Multilevel Study

Kim Lochner, ScD, Elsie Pamuk, PhD, Diane Makuc, DrPH, Bruce P. Kennedy, EdD, and Ichiro Kawachi, MD, PhD

ABSTRACT

Objectives. Previous studies have linked state-level income inequality to mortality rates. However, it has been questioned whether the relationship is independent of individual-level income. The present study tests whether state-level income inequality is related to individual mortality risk, after adjustment for individual-level characteristics.

Methods. In this prospective, multilevel study design, the vital status of National Health Interview Survey (NHIS) respondents was ascertained by linkage to the National Death Index, with additional linkage of state-level data to individuals in the NHIS. The analysis included data for 546 888 persons, with 19 379 deaths over the 8-year follow-up period. The Gini coefficient was used as the measure of income inequality.

Results. Individuals living in high-income-inequality states were at increased risk of mortality (relative risk = 1.12; 95% confidence interval = 1.04, 1.19) compared with individuals living in low-income-inequality states. In stratified analyses, significant effects of state income inequality on mortality risk were found, primarily for near-poor Whites.

Conclusions. State-level income inequality appears to exert a contextual effect on mortality risk, after income is adjusted for, providing further evidence that the distribution of income is important for health. (*Am J Public Health.* 2001; 91:385–391)

A growing number of studies, both internationally[1–3] and in the United States,[4–6] have shown striking associations between income inequality and increased population mortality. Researchers have debated, however, whether the relationship between income distribution and population mortality is independent of the well-established relationship between individual income and health and whether the association reflects a statistical artifact resulting from the curvilinear relation between individual income and individual risk of mortality.[7,8] These criticisms are based on associations of inequality and population health made with aggregate data; that is, both the dependent variable—mortality rates or life expectancy—and the independent variable—income inequality—are at the ecologic level (country, state, county, etc.). Such criticisms can be addressed by examining whether there is a contextual effect of income inequality on individual health outcomes; that is, whether the dependent variable—mortality risk—is at the individual level and the independent variable—income inequality—is at the ecologic level.

To date, only a few studies have had the necessary data elements to examine whether unequal income distribution is related to individual health outcomes. Fiscella and Franks[8] found that county-level income inequality was associated with individual mortality risk (hazard ratio [HR] = 0.23; 95% confidence interval [CI] = 0.06, 0.86), but when adjustment was made for family income, the association was no longer statistically significant (HR = 0.81; 95% CI = 0.22, 2.92). The authors concluded that family income confounded the association of income inequality to mortality reported at the ecologic level. However, their calculation of county-level income inequality, using data from the 1971–1975 National Health and Nutrition Examination Survey, may have been biased by the sample, which oversampled persons residing in high-poverty areas, women of childbearing age, and the elderly.

Using data from the Panel Study of Income Dynamics, Daly et al.[9] failed to find a significant association between state-level income inequality and mortality, except for the subgroup of individuals who were aged 25 to 64 years and who had incomes defined as middle income. In contrast, using data from the Behavioral Risk Factor Surveillance System, Kennedy et al.[10] examined the effect of state-level income inequality on individual self-rated health and found that individuals living in states in the highest quartile of income inequality were more likely to report poor or fair health than individuals living in the most egalitarian quartile, after adjustment for individual socioeconomic status (SES) indicators, demographic variables, and risk factors such as smoking and obesity (odds ratio = 1.25; 95% CI = 1.17, 1.33). Differences in methods of calculating income inequality, sample sizes, or choice of health outcomes are all possible reasons for the divergent findings across these studies.

Clearly, there is a need for more data on the association of income inequality and health that can address the potential confounding by individual-level variables. Our goal in the present study was to provide such a test of the relationship between state-level income inequality and mortality risk, after accounting for income as well as other sociodemographic characteristics of individuals. In addition, we sought to identify which socioeconomic groups

Kim Lochner, Bruce P. Kennedy, and Ichiro Kawachi are with the Department of Health and Social Behavior and the Harvard Center for Society and Health, Harvard School of Public Health, Boston, Mass. Elsie Pamuk and Diane Makuc are with the Office of Analysis, Epidemiology, and Health Promotion, National Center for Health Statistics, Hyattsville, Md.

Requests for reprints should be sent to Ichiro Kawachi, MD, PhD, Department of Health and Social Behavior, Harvard School of Public Health, 677 Huntington Ave, Boston, MA 02115 (e-mail: ichiro.kawachi@channing.harvard.edu).

This article was accepted July 25, 2000.

may be most affected by living in a state with high levels of income inequality.

Methods

Data Sources

We examined the relationship between state-level income inequality and individual mortality risk by combining 3 data sources: the National Health Interview Survey (NHIS), the National Death Index (NDI), and data from the US Bureau of the Census.

The NHIS is a continuing cross-sectional household interview survey conducted by the National Center for Health Statistics (NCHS). Each year, social, demographic, and health information is collected on approximately 49 000 households, including 132 000 persons. The NHIS sampling plan follows a stratified multistage probability sample of households and is representative of the US noninstitutionalized civilian population. The annual response rate of the NHIS is over 95%.[11] For this study, individual-level data were obtained from the core questionnaire of the NHIS person record. In addition, an NCHS in-house file allowed for the linkage of state-level geocodes to the NHIS.

The geographic variables, income inequality and poverty rates in state of residence, were calculated from data from the US Bureau of the Census and were appended to the NHIS. The state-level income inequality measure was obtained from household income data from the 1991–1993 Current Population Survey. State-level poverty rates were taken from the 1990 population census.

The NDI is a database of all deaths in the United States since 1979. Beginning with the survey year 1986, NHIS respondents 18 years and older can be linked to the NDI, allowing for the ascertainment of vital status for NHIS respondents. Using the linkage information provided by NCHS public use data files, we linked 8 years of the NHIS (1987–1994) to the NDI, providing mortality follow-up through December 31, 1995. This linked file, with state-level geocodes, will be referred to as the NHIS-NDI.

The NHIS sample is not designed to support state-level estimation. To determine whether each state is represented in the NHIS weighted sample in proportion to its actual share of the US population, we compared the distribution of the NHIS weighted sample to the US population across state-level income inequality categories, using 1990 decennial census data. We found the NHIS sample distribution to be similar to the US population over the categories.

Ascertainment of Vital Status

The health outcome of interest was time from the NHIS interview until death; respondents who had not died by the end of the follow-up (December 31, 1995) were assumed to be alive. Vital status was ascertained by linkage to the NDI. This study used the vital status classification recommended in the Multiple Cause of Death Public Use Data File. For the NHIS cohorts, it is estimated that these recommended cutoff scores correctly classify over 97% of the true matches (deceased) and over 97% of the false matches (alive).[12]

State-Level Predictor Variables

Our main predictor variable was level of income inequality in the state where a respondent resided at the time of the NHIS interview. We used the Gini coefficient as the measure of income inequality. The Gini coefficient is a widely used measure of income inequality that represents twice the area under the Lorenz curve (cumulative income categories plotted against cumulative population) and ranges theoretically from 0 (absolute equality) to 1.0 (absolute inequality).[13–15] It has the following mathematical interpretation: the Gini coefficient is equal to the expected absolute difference in incomes (as a proportion of the mean income) between any 2 persons drawn at random from the population. For example, a Gini coefficient of 30% implies that the absolute difference, on average, between the incomes of 2 people is equal to 60% of the mean income. A graphical interpretation of the Gini coefficient can be found in Kawachi and Kennedy.[16]

The Gini coefficients used in this analysis were constructed with data on household income from the Current Population Survey for the years 1991 to 1993 and were obtained from unpublished statistics, courtesy of the Luxembourg Income Study (T. M. Smeeding, PhD, project director of the Luxembourg Income Study, written communication, 1996). (The state Gini coefficients calculated from the 1991–1993 Current Population Survey data had a correlation of 0.74 with the state Gini calculated from the 1990 decennial census. Kawachi and Kennedy[16] showed that state Gini coefficients calculated from these 2 sources were similarly related to state mortality rates.) We adjusted incomes for state differences in taxes and cash transfers as well as differences in household composition, using an equivalence scale (with the equivalence elasticity set to 0.5). States were assigned to categories of income inequality on the basis of the distribution of the Gini coefficient across 48 states, as follows: Gini ≤ 0.324 (10 states); Gini = 0.327–0.339 (14 states); Gini = 0.340–0.355 (14 states); and Gini ≥ 0.360 (10 states). (Two states were not included in the NHIS sampling frame, and the District of Columbia was not considered a state in these analyses.) To examine the effects of inequality in states with the very highest levels of inequality, we split the highest income inequality category in half to create 2 new categories: Gini = 0.360–0.365 (5 states) and Gini = 0.367–0.374 (5 states); this resulted in 5 categories of state income inequality.

The state poverty rate was also included in the analyses.[17] It represents the proportion of persons whose incomes were below the official poverty threshold in 1989 and was analyzed as a continuous variable.

Individual-Level Variables

We included age, sex, race/ethnicity, marital status, and annual income, which were assessed at the time of the NHIS interview. We restricted the analysis to non-Hispanic White and Black men and women, aged 18 to 74 years at baseline. Marital status was dichotomized into married and unmarried, with the latter including persons who were widowed, divorced, separated, never married, or of unknown marital status.

NHIS respondents were asked to report their family income according to 1 of 27 categories (NHIS income categories were capped at $50 000 or more from 1987 to 1994). To adjust for inflation over the 8-year span of the study and to take into consideration family size, we created income categories that were expressed as income-to-poverty ratios. This variable represents the ratio of income to the appropriate poverty threshold.[18] For each year 1987 to 1994, we calculated the ratio as the midpoint of the reported family income category from the NHIS interview over the official poverty threshold for the family size reported on the NHIS interview. The official poverty thresholds for given family sizes were determined by the Bureau of the Census.[19] We categorized the ratio of income to poverty into 5 levels. A ratio below 1.00 indicates that the income was below the federal poverty level (poor persons). A ratio of 1.00 to 1.99 indicates that the income was 100% to 199% of the appropriate poverty threshold (near-poor persons). A ratio of 2.00 or greater indicates that the income was 200% of the appropriate poverty threshold. NHIS respondents with an income-to-poverty ratio of 2.00 or greater were categorized as middle income if their income was less than $50 000 and high income if their income was $50 000 or more. There was an additional category for unreported income.

Data Analysis

We calculated age-adjusted death rates for non-Hispanic Whites and Blacks com-

bined, as well as for each group separately, by categories of state-level income inequality and categories of family-level income. We standardized death rates by age to the 1990 US population as determined by the US Bureau of the Census,[20] using direct standardization.

We used Cox proportional hazards models[21] to analyze the relationship between income inequality in state of residence and individual mortality risk. All relative risk estimates were calculated with the survival procedure in Software for Survey Data Analysis (SUDAAN) to take into account the complex survey design of the NHIS.[22,23]

In model 1, our basic model, income inequality in the respondent's state of residence was categorized into 5 levels: low, low-moderate, moderate-high, high, and very high. These categories were included in the model as dummy variables with "low" inequality states as the referent group, with adjustment for age, sex, race/ethnicity, and marital status. Model 2 included further adjustment for state poverty rates. The fully adjusted model, model 3, included the state-level income inequality categories and state poverty rates, as well as income, age, sex, race/ethnicity, and marital status. We also examined the relationship stratified by race/ethnicity, sex, and income categories. The stratified models were adjusted for state poverty rates, age, and marital status.

The stratified analysis for Blacks differed from that for Whites in 2 ways. Since a small proportion of Blacks lived in states with the lowest levels of income inequality (weighted proportion = 7.0%), we collapsed the 2 lowest income inequality categories to include states with a Gini ranging from 0.295 to 0.339. There was also a small number of Blacks in the highest income category (weighted proportion = 9.0%), so we combined the middle- and high-income categories into a nonpoor category.

For both the overall and the stratified analyses, the proportional hazards assumption was checked by graphical examination of the log-log of the survivor functions for the categories of state-level income inequality categories, evaluated at the mean levels of the other covariates.[24] We observed no serious violation of the proportional hazards assumption.

The unweighted sample size for the NHIS-NDI file was 661 193. We restricted the analyses to non-Hispanic Whites and Blacks aged 18 to 74 years, yielding a sample size of 546 888. The average follow-up period was approximately 5 years. A total of 19 379 deaths were identified in the 8-year NDI follow-up period, representing 3% of the NHIS-NDI sample.

Results

Throughout this section, *Whites* and *Blacks* refer to non-Hispanic populations. Table 1 summarizes the characteristics of the study population. The weighted sample had slightly more women (52%) than men (48%) and was predominantly White (88%). The mean age was 42 years. Forty percent of the sample had income levels that fell into the middle-income category (i.e., more than 200% of poverty but less than $50 000). Blacks were much more likely to be poor (22% of Blacks vs 7% of Whites). Fifteen percent of NHIS respondents did not report their income, with Blacks (20%) more likely to not report their income than Whites (14%).

The state Gini coefficients ranged from a low of 0.295 in Iowa to a high of 0.374 in Texas and had a mean value of 0.339 and a standard deviation of 0.02. The percentage distribution of Blacks and Whites differed across the state income inequality categories. Approximately 11% of Whites, compared with only 7% of Blacks, lived in a state in the lowest inequality category. Furthermore, 58% of the Blacks in this lowest category resided in 1 state, Maryland. The majority of Blacks lived in high-income-inequality states, with 54% living in 10 states that made up the "high" or "very high" inequality categories.

We examined age-adjusted death rates by 4 categories of income inequality in the respondent's state of residence and 4 categories of income for the total sample as well as for Whites and Blacks separately. For the calculation of death rates, the 2 highest state income inequality categories were combined. For the overall sample, in addition to the distinctive graded relationship between individual-level income and mortality, within the near-poor

TABLE 1—Characteristics of the Sample Population[a]: National Health Interview Survey–National Death Index, 1987–1995

	Total Sample		Non-Hispanic Whites		Non-Hispanic Blacks	
	N (Unweighted)	% (Weighted)	n (Unweighted)	% (Weighted)	n (Unweighted)	% (Weighted)
Total	546 888		464 765		82 123	
Vital status						
Alive	527 509	96.7	449 034	96.7	78 475	96.2
Deceased	19 379	3.3	15 731	3.3	3 648	3.8
Individual characteristics						
Sex						
Male	256 939	48.4	223 005	48.9	33 934	45.1
Female	289 949	51.6	241 760	51.1	48 189	54.9
Race/ethnicity						
Non-Hispanic White	464 765	87.5				
Non-Hispanic Black	82 123	12.5				
Age, y						
18–24	72 223	13.9	58 203	13.3	14 020	18.2
25–44	249 961	46.2	212 140	45.8	37 821	48.7
45–64	160 347	28.6	137 778	29.1	22 569	25.0
65–74	64 357	11.4	56 644	11.8	7 713	8.1
Income level						
Poor	50 308	8.7	31 131	6.8	19 177	22.3
Near poor	88 917	16.0	71 385	15.3	17 532	20.9
Middle income	215 365	39.7	193 487	41.4	21 878	27.5
High income	109 079	20.7	102 447	22.3	6 632	9.0
Unknown	83 219	15.0	66 315	14.2	16 904	20.3

[a]Sample is restricted to non-Hispanic Whites and Blacks aged 18 to 74 years.

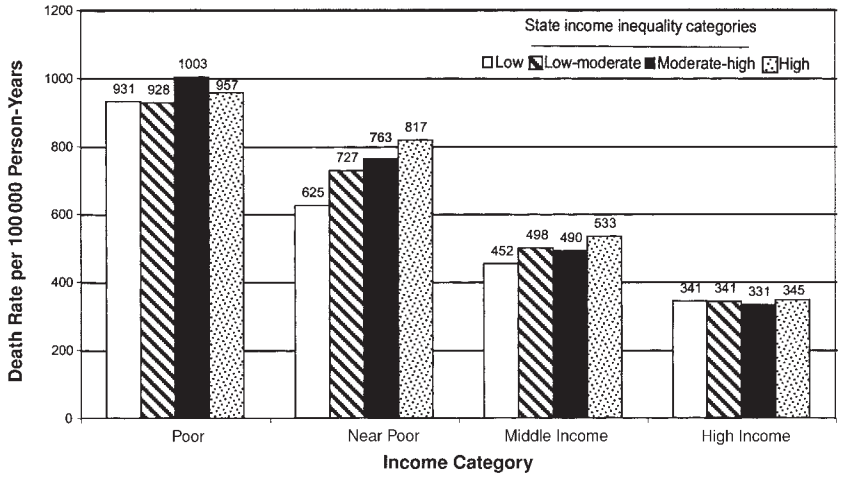

FIGURE 1—Age-adjusted death rates per 100 000 person-years for non-Hispanic Whites, by income inequality in state of residence and family income: National Health Interview Survey–National Death Index, 1987–1995.

and middle-income strata there was also a relationship between state-level income inequality and mortality. Near-poor persons living in states in the lowest income inequality category had significantly lower death rates (641 deaths per 100 000 person-years) than near-poor persons residing in other states (about 825 deaths per 100 000 person-years). The same pattern was evident for middle-income persons, although the differences were smaller (462 deaths per 100 000 person-years vs 546 deaths per 100 000 person-years). There was no noticeable relationship between income inequality in state of residence and mortality among poor or high-income persons (data not shown).

However, when we disaggregated the sample by race, the association between state-level income inequality and mortality was more pronounced among near-poor Whites than in the overall sample (Figure 1). Among near-poor Whites, when we compared the death rate in the highest-income-inequality states (817 deaths per 100 000 person-years) with that in the lowest, the excess mortality was 192 deaths per 100 000 person-years. Among Whites with middle incomes, the corresponding difference in mortality was 81 deaths per 100 000 person-years. Among Blacks, there was a clear gradient between income and mortality, but there was no consistent association of income inequality in state of residence (data not shown).

Table 2 presents relative risks and 95% confidence intervals for the effects of state income inequality on individual mortality risk. Model 1, which adjusts only for demographic variables, shows that individuals living in high-income-inequality states were at a slightly increased risk of death compared with individuals living in states with the lowest income inequality (relative risk [RR] = 1.10–1.14). In model 2, the state poverty rate was added to the model and the relative risk estimates for the income inequality categories were attenuated. The correlation between state poverty rate and state Gini coefficient was 0.46 ($P < .001$). The final model (model 3), to which family income was added, showed that individuals living in the highest-income-inequality states were at increased risk of death compared with those living in the lowest-income-inequality states

TABLE 2—Relative Risks[a] of Level of Income Inequality in State of Residence for Individual All-Cause Mortality: National Health Interview Survey–National Death Index, 1987–1995

	Model 1		Model 2		Model 3	
	RR	(95% CI)	RR	(95% CI)	RR	(95% CI)
Level of income inequality in state of residence[b]						
Very high	1.10	(1.03, 1.17)	1.02	(0.96, 1.09)	1.12	(1.04, 1.19)
High	1.14	(1.06, 1.23)	1.07	(0.99, 1.16)	1.11	(1.02, 1.19)
Moderate-high	1.11	(1.04, 1.18)	1.07	(1.01, 1.14)	1.10	(1.03, 1.17)
Low-moderate	1.11	(1.04, 1.18)	1.08	(1.01, 1.15)	1.08	(1.02, 1.16)
Low	1.00		1.00		1.00	
Poverty rate in state of residence			1.01	(1.00, 1.02)	1.00	(1.00, 1.01)
Family income[c]						
Poor					2.69	(2.48, 2.91)
Near poor					2.14	(2.00, 2.29)
Middle income					1.52	(1.43, 1.61)
High income					1.00	
Unknown					1.68	(1.57, 1.80)

Note. RR = relative risk; CI = confidence interval.

[a]Relative risks are estimated from a Cox proportional hazards model. All models have additional adjustment for age in single years, sex, race/ethnicity, and marital status (see "Methods" section).

[b]State income inequality categories are based on distribution of Gini coefficients across 48 states (see "Methods" section). Low-inequality states are Iowa, Vermont, Delaware, Wisconsin, Utah, Hawaii, South Dakota, Connecticut, Maryland, and Kansas. Low-moderate-inequality states are Indiana, Pennsylvania, Minnesota, Maine, Oregon, New Mexico, Wyoming, Ohio, Montana, Rhode Island, Washington, Alaska, Michigan, and North Carolina. Moderate-high-inequality states are Idaho, Nevada, South Carolina, Massachusetts, West Virginia, Colorado, New Jersey, Tennessee, Virginia, Arkansas, Missouri, Oklahoma, New Hampshire, and Arizona. High-inequality states are Illinois, Mississippi, Alabama, Florida, and Kentucky. Very-high-inequality states are New York, California, Louisiana, Georgia, and Texas.

[c]Family income was converted to income-to-poverty ratios before categorizing (see "Methods" section).

TABLE 3—Relative Risks[a] of Level of Income Inequality[b] in State of Residence for Individual All-Cause Mortality, Stratified by Family Income[c]: Non-Hispanic Whites, National Health Interview Survey–National Death Index, 1987–1995

	Non-Hispanic White Men Aged 18–74 y			Non-Hispanic White Women Aged 18–74 y		
	No. of Deaths	RR	(95% CI)	No. of Deaths	RR	(95% CI)
Poor persons living in states with—						
Very high income inequality	151	0.76	(0.56, 1.04)	163	1.08	(0.78, 1.51)
High income inequality	108	0.91	(0.65, 1.27)	104	1.09	(0.78, 1.53)
Moderate-high income inequality	190	0.96	(0.73, 1.25)	186	1.14	(0.84, 1.55)
Low-moderate income inequality	216	0.96	(0.76, 1.22)	219	1.12	(0.84, 1.50)
Low income inequality	89	1.00		69	1.00	
Near-poor persons living in states with—						
Very high income inequality	454	1.23	(1.03, 1.48)	378	1.41	(1.15, 1.73)
High income inequality	270	1.16	(0.96, 1.40)	201	1.26	(1.01, 1.57)
Moderate-high income inequality	468	1.15	(0.97, 1.36)	365	1.36	(1.13, 1.63)
Low-moderate income inequality	652	1.11	(0.94, 1.31)	492	1.26	(1.07, 1.50)
Low income inequality	229	1.00		142	1.00	
Middle-income persons living in states with—						
Very high income inequality	1056	1.18	(1.03, 1.36)	605	1.11	(0.91, 1.36)
High income inequality	473	1.11	(0.96, 1.30)	289	1.16	(0.93, 1.45)
Moderate-high income inequality	857	1.04	(0.92, 1.19)	540	1.15	(0.95, 1.39)
Low-moderate income inequality	1131	1.06	(0.93, 1.20)	711	1.19	(0.98, 1.43)
Low income inequality	444	1.00		258	1.00	
High-income persons living in states with—						
Very high income inequality	344	1.32	(0.99, 1.76)	170	0.84	(0.61, 1.14)
High income inequality	85	1.19	(0.86, 1.64)	52	0.88	(0.62, 1.26)
Moderate-high income inequality	219	1.19	(0.92, 1.56)	122	0.81	(0.60, 1.09)
Low-moderate income inequality	213	1.17	(0.89, 1.53)	118	0.79	(0.58, 1.09)
Low income inequality	87	1.00		64	1.00	
Persons with unknown incomes living in states with—						
Very high income inequality	391	1.04	(0.84, 1.29)	287	0.91	(0.71, 1.18)
High income inequality	221	1.00	(0.80, 1.25)	150	0.90	(0.69, 1.17)
Moderate-high income inequality	281	0.94	(0.76, 1.17)	251	1.14	(0.89, 1.46)
Low-moderate income inequality	482	1.03	(0.86, 1.24)	393	1.16	(0.91, 1.47)
Low income inequality	171	1.00		120	1.00	

Note. RR = relative risk; CI = confidence interval.
[a]Relative risks are estimated from a Cox proportional hazards model, adjusted for the state poverty rate, age in single years, and marital status.
[b]State income inequality categories are based on distribution of Gini coefficients across 48 states (see "Methods" section).
[c]Family income was converted to income-to-poverty ratios before categorizing (see "Methods" section).

(RR = 1.12; 95% CI = 1.04, 1.19). In addition, the relationship of state income inequality to mortality risk showed a significant linear trend ($P = .001$), indicating that the relative risk increased with rising inequality.

As expected, poor persons had a risk of death more than twice that of persons with high family incomes (RR = 2.69; 95% CI = 2.48, 2.91). Men had a higher risk of death than women (RR = 2.00; 95% CI = 1.93, 2.07), Blacks had a higher risk than Whites (RR = 1.24; 95% CI = 1.18, 1.30), and unmarried persons had a higher risk than those who were married (RR = 1.37; 95% CI = 1.32, 1.42).

Table 3 presents results for Whites. No relationship was evident between income inequality in state of residence and mortality for poor White men, but there was a relationship for White men at higher income levels. Near-poor White men living in the highest-income-inequality states had a higher risk than those living in the lowest-income-inequality states (RR = 1.23; 95% CI = 1.03, 1.48). Although the relative risk estimates for the other inequality categories were not statistically significant, there was a significant linear trend across the 4 categories ($P = .04$). A similar pattern was found for middle-income (RR = 1.18; 95% CI = 1.03, 1.36; P for trend = .005) and high-income (RR = 1.32; 95% CI = 0.99, 1.76; P for trend = .08) White men. Among White women, the increased risk of mortality in high-income-inequality states was evident only among those who were near-poor. Compared with near-poor White women living in the lowest-inequality states, the relative risks for near-poor White women living in higher-income-inequality states ranged from 1.41 to 1.26, with a significant linear trend across the 4 categories ($P = .03$).

Because of the small sample sizes for Blacks residing in states with low levels of income inequality, we collapsed the low and low-moderate categories. Similarly, there were too few Blacks in the high-family-income category to examine separately, so we collapsed the middle-income and high-income categories into a nonpoor category. Given these restrictions on the Black sample, the results for near-poor Black women were similar to those for near-poor White women. Although not all of the state income inequality categories approached traditional levels of statistical significance, the relative risks associated with living in higher-income-inequality states for near-poor Black women ranged from 1.26 to 1.64 (P for trend = 0.17). In contrast to the other groups, income inequality in the state of residence had no effect on Black men at any income level (data not shown).

Discussion

Our findings demonstrate a contextual effect of state income inequality on individual mortality risk after state poverty levels and individual sociodemographic characteristics are controlled for. In addition, a strong relationship between income and mortality was evident, with poor persons having a risk of death more than twice that of high-income persons.

Although the contextual effect of state income inequality on mortality may appear modest compared with the effect of individual-level income, because income inequality is also related to the socioeconomic gradient, it affects mortality risk through SES.

Prior multilevel studies examining a contextual effect of income inequality on individual health outcomes have reached different conclusions. Our findings do not support the conclusions of Fiscella and Franks[8] that the relationship between income inequality and mortality reported in the ecologic studies was due to the correlation between individual-level income and income inequality. Nor do our findings support the argument by Gravelle[7] that the curvilinear shape of the relationship between individual-level income and individual mortality risk is sufficient to explain the relationship between income distribution and mortality risk. Still others have argued that multilevel studies showing a contextual effect of income inequality—after adjustment for individual-level income—cannot rule out the possibility of residual confounding of individual income when income is modeled as a categorical variable. Since family income data in the NHIS are collected as a categorical variable, we acknowledge that not using income as a continuous variable may have hindered our ability to rule out completely the residual confounding effect of income on health. However, we believe that this is unlikely to have materially affected our results.[25]

The analyses stratified by sex, race/ethnicity, and individual-level family income suggest that the effect of state-level income inequality on mortality risk is strongest for near-poor non-Hispanic White men and women. In addition, mortality risk increases in a general dose–response relationship with White men at all levels of income above poverty. These findings are similar to those of Kennedy et al.[10] and Daly et al.[9] It is also noteworthy that among high-income White men, the mortality risk from living in high-inequality states approaches statistical significance. We did not find a contextual effect of state income inequality on mortality risk among those whose family income fell below the poverty line. For such persons, it is possible that poverty is a more important determinant of mortality than state-level inequality.

Although the finding that income inequality influences mortality risk for the near-poor applied to both White and Black women, there are several possible reasons why we did not find comparable results between Whites and Blacks overall. First, the sample size was much smaller for Black persons than for White persons. Although we combined 8 years of the NHIS, once we stratified by race/ethnicity, sex, and family income, we collapsed the 2 lowest categories of state income inequality and the 2 highest family-income categories to have sufficient numbers of Black deaths in each cell. Second, the state may not be the most meaningful geographic level for examining the health effects of income inequality on Blacks. In the NHIS sample, there were few Blacks living in the low-income-inequality states, and they may be more likely to reside in urban areas, which might have high income inequality. Finally, other social factors, such as residential segregation, racial discrimination, and poverty, may be more salient factors contributing to the risk of mortality for Blacks.[26,27]

The evidence linking income inequality to both population and individual health outcomes continues to grow,[28,29] although the mechanism underlying this association remains undetermined.[30] Thus far, 2 broad mechanisms have been proposed. One involves differential levels of social spending in areas such as basic education, employment training, health care, and housing.[4,6] The other potential pathways relate to psychosocial processes that are damaging to health, such as the sense of relative deprivation, latent social conflict, and erosion of social bonds.[31–33] These 2 mechanisms are not mutually exclusive but rather are likely to reinforce each other, operate to a greater or lesser extent at different geographic levels of income inequality, or both.

Additional studies examining income inequality at different levels of geographic aggregation, as well as identifying the population subgroups most at risk, will continue to advance our understanding of the material and psychosocial processes linking income inequality to health. For example, the different effects of state-level income inequality on male vs female mortality risk suggest that future studies should examine cause-specific mortality to determine whether state-level income inequality has a stronger association with those causes of death that are more common in men than in women (e.g., coronary heart disease, homicide, injuries).

Comparing the specific characteristics of localities (states, metropolitan areas, etc.) with high and low levels of inequality may also lead us to specific mechanisms. State policies can either contribute to or mitigate the effects of state-level income inequality. For example, states can establish state-level minimum wage standards above the federal standard. There are also state variations in the use of regressive sales and excise taxes, in encouragement of collective bargaining, in investment in skills-building programs, and in efforts to strengthen the unemployment insurance system.[34] Also, 10 states now offer the Earned Income Tax Credit, which benefits low- and moderate-income working families.[35] With the exception of Massachusetts and New York, the states offering the Earned Income Tax Credit fell into the lowest 2 state income inequality categories used in these analyses.

While the graded relationship between individual-level income and mortality in the United States is a familiar picture,[36–38] the results of this study provide further support for a contextual effect of income inequality on health status. Health inequality research that examines the effect of the social environment on health furthers our understanding of how health inequalities are generated and perpetuated. □

Contributors

K. Lochner and I. Kawachi designed the study and analyses. K. Lochner analyzed the data and wrote the paper. E. Pamuk, D. Makuc, and I. Kawachi contributed to the analyses and to the interpretation and writing of the paper. B. P. Kennedy contributed to the conception and design of the paper.

Acknowledgments

This analysis was conducted while K. Lochner was an Association of Schools of Public Health Fellow at the National Center for Health Statistics. I. Kawachi and B. P. Kennedy are recipients of Robert Wood Johnson Foundation Investigator Awards in Health Policy Research.

References

1. Rodgers GB. Income and inequality as determinants of mortality: an international cross-section analysis. *Popul Stud*. 1979;33:343–351.
2. Wilkinson RG. Income distribution and life expectancy. *BMJ*. 1992;304:165–168.
3. Wilkinson R. *Unhealthy Societies: The Afflictions of Inequality*. London, England: Routledge; 1996.
4. Kaplan GA, Pamuk ER, Lynch JW, Cohen RD, Balfour JL. Inequality in income and mortality in the United States: analysis of mortality and potential pathways. *BMJ*. 1996;312:999–1003.
5. Kennedy BP, Kawachi I, Prothrow-Stith D. Income distribution and mortality: cross sectional ecological study of the Robin Hood index in the United States. *BMJ*. 1996;312:1004–1007.
6. Lynch JW, Kaplan GA, Pamuk ER, et al. Income inequality and mortality in metropolitan areas of the United States. *Am J Public Health*. 1998; 88:1074–1080.
7. Gravelle H. How much of the relation between population mortality and unequal distribution of income is a statistical artefact? *BMJ*. 1998; 316:382–385.
8. Fiscella K, Franks P. Poverty or income inequality as predictor of mortality: longitudinal cohort study. *BMJ*. 1997;314:1724–1727.
9. Daly MC, Duncan GJ, Kaplan GA, Lynch JW. Macro-to-micro links in the relation between income inequality and mortality. *Milbank Q*. 1998; 76:315–339.
10. Kennedy BP, Kawachi I, Glass R, Prothrow-Stith D. Income distribution, socioeconomic status, and self rated health in the United States: multilevel analysis. *BMJ*. 1998;317:917–921.
11. Massey JT, Moore TF, Parsons VL, Tadros W. De-

sign and estimation for the National Health Interview Survey, 1985–94. National Center for Health Statistics. *Vital Health Stat 2*. 1989;No. 110.

12. National Center for Health Statistics. *National Health Interview Survey Multiple Cause-of-Death Public Use Data File, CD-ROM, 1986–94 Survey Years, Dates of Death, 1986–95* [CD-ROM]. Hyattsville, Md: National Center for Health Statistics; 1997.
13. Cowell F. *Measuring Inequality*. Oxford, England: Philip Allan; 1977.
14. Coulter P. *Measuring Inequality: A Methodological Handbook*. Boulder, Colo: Westview Press; 1989.
15. Lee W-C. Characterizing exposure-disease association in human populations using the Lorenz Curve and Gini Index. *Stat Med*. 1997;16: 729–739.
16. Kawachi I, Kennedy BP. The relationship of income inequality to mortality: does the choice of indicator matter? *Soc Sci Med*. 1997;45: 1121–1127.
17. US Census Bureau. 1990 census of population, CP-2-1 "Social and economic characteristics," table 154. Available at: http://www.census.gov/hhes/poverty/census/cphl162.html. Accessed November 1, 2000.
18. *Current Population Reports, P60-203, Measuring 50 Years of Economic Change Using the March Current Population Survey.* Washington, DC: US Census Bureau; 1998.
19. US Census Bureau. Table 1. Weighted average poverty thresholds for families of specified size 1959 to 1999. *Current Population Reports*, series P-23, no. 28 and series P-60, no. 68 and subsequent years. Available at: http://www.census.gov/hhes/poverty/histpov/hstpov1.html. Accessed November 1, 2000.
20. National Center for Health Statistics. *Health, United States, 1998 With Socioeconomic Status and Health Chartbook.* Hyattsville, Md: National Center for Health Statistics; 1998.
21. Cox D. Regression models and life tables. *J Royal Stat Soc*. 1972;B34:187–220.
22. *SUDAAN, Release 7.0.* Research Triangle Park, NC: Research Triangle Institute; 1996.
23. National Center for Health Statistics. Variance Estimation for Person Data Using SUDAAN and the National Health Interview Survey, Public-Use Person Data Files, 1987–94. Available at: http://www.cdc.gov/nchs/about/major/nhis/sudaan.htm. Accessed November 1, 2000.
24. Allison P. *Survival Analysis Using the SAS System: A Practical Guide*. Cary, NC: SAS Institute Inc; 1995.
25. Milyo J. Income distribution, socioeconomic status, and self rated health in US. Authors ignored data in their study. *BMJ*. 1999;318: 1417–1418.
26. Krieger N, Sidney S, Coakley E. Racial discrimination and skin color in the CARDIA study: implications for public health research. Coronary Artery Risk Development in Young Adults. *Am J Public Health*. 1998;88: 1308–1313.
27. Collins CA, Williams DR. Segregation and mortality: the deadly effects of racism. *Sociol Forum*. 1999;14:495–523.
28. Wilkinson RG. Socioeconomic determinants of health. Health inequalities: relative or absolute material standards? *BMJ*. 1997;314:591–595.
29. Kawachi I, Kennedy B, Wilkinson R. *The Society and Population Health Reader: Income Inequality and Health.* New York, NY: New Press; 1999.
30. Davey Smith G. Income inequality and mortality: why are they related? *BMJ*. 1996;312: 987–988.
31. Kawachi I, Kennedy BP, Lochner K, Prothrow-Stith D. Social capital, income inequality, and mortality. *Am J Public Health*. 1997;87: 1491–1498.
32. Kawachi I, Kennedy BP. Health and social cohesion: why care about income inequality? *BMJ*. 1997;314:1037–1040.
33. Wilkinson RG. Comment: income, inequality, and social cohesion. *Am J Public Health*. 1997; 87:1504–1506.
34. Larin K, McNichol E. *Pulling Apart: A State-by-State Analysis of Income Trends.* Washington, DC: Center on Budget and Policy Priorities; 1997.
35. Johnson N, Lazere E. *Rising Number of States Offer Earned Income Tax Credits.* Washington, DC: Center on Budget and Policy Priorities; 1998.
36. Adler NE, Boyce T, Chesney MA, et al. Socioeconomic status and health. The challenge of the gradient. *Am Psychol*. 1994;49:15–24.
37. Sorlie PD, Backlund E, Keller JB. US mortality by economic, demographic, and social characteristics: the National Longitudinal Mortality Study. *Am J Public Health*. 1995;85: 949–956.
38. Pamuk E, Makuc D, Heck K, Reuben C, Lochner K. *Socioeconomic Status and Health Chartbook. Health, United States, 1998*. Hyattsville, Md: National Center for Health Statistics; 1998.