The Effect of Primary Care Physician Supply and Income Inequality on Mortality Among Blacks and Whites in US Metropolitan Areas

Leiyu Shi, DrPH, MBA, and Barbara Starfield, MD, MPH

Objectives. This study assessed whether income inequality and primary care physician supply have a different effect on mortality among Blacks compared with Whites.

Methods. We conducted a multivariate ecologic analysis of 1990 data from 273 US metropolitan areas.

Results. Both income inequality and primary care physician supply were significantly associated with White mortality ($P < .01$). After the inclusion of the socioeconomic status covariates, the effect of income inequality on Black mortality remained significant ($P < .01$), but the effect of primary care physician supply was no longer significant ($P > .10$), particularly in areas with high income inequality.

Conclusions. Improvement in population health requires addressing socioeconomic determinants of health, including income inequality and primary care availability and access. (*Am J Public Health.* 2001;91:1246–1250)

Studies in the United States and elsewhere have shown the association between wide disparities in income of the wealthy and that of the less wealthy ("income inequality") and poor health.[1–8] Our previous published study showed that primary care may mitigate the adverse effects of income inequality.[9] We used 1990 US state-level data and found a significant association between higher primary care physician supply and lower mortality, longer life expectancy, and better birth outcome, even in the presence of high income inequality and other adverse sociodemographic characteristics.

The literature examining the effect of income inequality on racial/ethnic disparity in health has been limited. The few studies[8,9] that have included race/ethnicity used it as a control variable, thus eliminating the possibility of detecting racial/ethnic differences in determinants of health. If race/ethnicity-related differences are actually a differential response to other measured factors, then simply including race/ethnicity as a control variable will not address the interaction between race/ethnicity and other independent measures.

We used US metropolitan areas as the unit of analysis to assess whether income inequality and primary care physician supply have a different effect on mortality among Blacks compared with Whites, controlling for socioeconomic determinants of health. Although states are the principal sources of variation in policies affecting income inequality, metropolitan areas may be a more appropriate unit of analysis for variations in health care resources.

METHODS

Data and Measures

Data for this study came from several sources (see Acknowledgments). Although several measures were available, we decided to use the Gini coefficient because of its popularity in studies of income inequality. Higher values of the Gini coefficient indicate greater inequality in income distribution.

Age-adjusted total mortality has been used extensively as a health status indicator[5,10–13] and may reflect social inequalities, including racial/ethnic disparities. Socioeconomic disparities are often most clearly seen through differential mortality information.[15] Data on mortality are expressed as the number of deaths per 100 000. They were obtained from the compressed mortality files compiled by the Centers for Disease Control and Prevention with WONDER/PC software[15] or provided by the National Center for Health Statistics (see Acknowledgments).

The measure of primary care, consistent with our previous state-level analysis,[9] was primary care physician–to–population ratio, defined as the total number of primary care physicians (including family practice and general practice, general internal medicine, and general pediatrics) per 10 000 civilian population in office-based active patient care (excluding hospital-based practice, which comprises physicians in all-year residency training and full-time members of hospital staff).[16,17] This measure (primary care physician supply) was obtained from the area resource file. We recognize that the mere presence of more primary care physicians per population does not ensure that more individuals in the population are exposed to primary care.

Measures of socioeconomic status (SES) included per capita income, percentage of population with income below poverty level, percentage of population 25 years and older with less than a middle-school education, percentage of workforce population that is unemployed, and percentage of population that is urban.[14,17] The percentage of population that is Black also was included as a variable in the initial analysis.

Analysis

The current study was an ecologic study of the unmixed type (i.e., our analyses correlated ecologic variables with ecologic outcome).[18,19] The units of analysis were the 273 metropolitan areas defined by the federal Office of Management and Budget and used in the 1990 census.[14] Only variables characteristic of metropolitan areas were used.

To examine the association between primary care physician supply, income inequality, and total mortality, we first determined the bivariate correlations among these measures. Next, weighted linear multiple regression was used to examine their simultaneous associations with total mortality. This procedure takes into account a weight (based on metropolitan area population size) assigned to each observation that reflects the "relative amount of information" embodied in the observation.[20] The variable "pov-

erty" was not included in the multivariate models because it was highly correlated ($r > 0.40$) with several other independent variables, including income inequality. To examine whether an interaction was present between primary care physician supply and income inequality, we divided the analytic sample into low-income-inequality metropolitan statistical areas (MSAs) (n = 136) and high-income-inequality MSAs (n = 137) and performed regression analysis between primary care physician supply and mortality while controlling for SES.

To examine whether primary care physician supply and income inequality have a different effect on mortality among Blacks compared with Whites, we repeated the analyses (i.e., total sample and high- and low-income-inequality strata) with Black- and White-specific mortality, respectively. Comparisons of the predictors from these 2 sets of models could identify the relative effect of primary care physician supply and income inequality on mortality in Blacks compared with Whites.

RESULTS

Table 1 presents the bivariate correlations between total mortality and income inequality (i.e., the Gini coefficient), primary care physician supply, and SES measures. Income inequality was significantly and positively associated with total mortality ($P < .01$). Primary care physician supply was significantly and inversely related to total mortality. The SES covariates also were significantly associated with total mortality, reflecting that high SES (higher income, more education, lower unemployment, and urban residence) was inversely related to mortality.

TABLE 1—Bivariate Correlations Between Total Mortality and Its Determinants

	Total Mortality		
	Overall	White	Black
Gini coefficient	0.36**	0.24**	0.34**
Primary care physician–to–population ratio	–0.17**	–0.25**	–0.08
Per capita income	–0.24**	–0.28**	–0.15*
% Population without elementary education	0.28**	0.29**	0.30**
% Workforce population unemployed	0.21**	0.30**	0.15*
% Population urban	–0.11*	–0.13*	–0.16*
% Population below poverty	0.33**	0.28**	0.31**

*$P < .05$; **$P < .01$, based on Pearson correlation coefficients.

Table 2 presents the weighted regression coefficients of income inequality and primary care physician supply on total mortality. In the reduced models, labeled as Model 1, only income inequality and primary care physician supply were included. In the complete models, labeled as Model 2, SES covariates (not shown separately) and percentage of population that is Black were added. The comparison of these 2 sets of models identified several patterns.

In terms of model significance, including the SES covariates significantly increased the explanatory power of all the models, as reflected in the increases in R^2 between the re-

TABLE 2—Weighted Multiple Regression Coefficients of Income Inequality and Primary Care Physician–to–Population Ratio on Total Mortality: 273 US Metropolitan Areas, 1990

	Total Mortality					
	Overall		White		Black	
	Model 1[a]	Model 2[b]	Model 1[a]	Model 2[b]	Model 1[a]	Model 2[b]
Gini coefficient	875.50	283.17	457.20	420.11	2119.35	1918.64
	[135.62]	[116.15]	[106.25]	[121.57]	[345.38]	[402.75]
	(6.46***)	(2.44**)	(4.30***)	(3.46***)	(6.14***)	(4.76***)
Primary care physician–to–population ratio	–3.56	–1.33	–3.80	–2.33	–6.05	–6.97
	[1.08]	[0.96]	[0.85]	[0.93]	[3.61]	[4.54]
	(–3.29***)	(–1.38)	(–4.48***)	(–2.51***)	(–1.67*)	(–1.54)
% Population Black		426.51				
		[22.70]				
		(18.79***)				
R^2	0.16	0.64	0.12	0.18	0.15	0.19
Adjusted R^2	0.16	0.63	0.12	0.16	0.14	0.17
F test	25.92***	67.98***	19.00***	9.41***	19.22***	8.34***

Note. Parameter estimates are on top, SEs are in brackets, and *t* test values are in parentheses.
[a]Reduced model includes income inequality and primary care.
[b]Complete model includes per capita income, percentage of population without elementary education, percentage of workforce population unemployed, and percentage of population that is urban.
*$P < .10$; **$P < .05$; ***$P < .01$.

duced and complete models. The associations of income inequality and primary care physician supply with total mortality were consistent with those observed in the bivariate analysis. Including SES covariates in the models reduced the effect of both income inequality and primary care physician supply. In the complete models, income inequality remained significantly related to total mortality in the total population model ($P<.05$), but primary care physician supply did not. Among the covariates, percentage of population that is Black was the most significant predictor of mortality ($P<.01$), a finding that further justifies separate analysis for Black vs White mortality.

Table 2 also shows the results of the weighted regression coefficients of income inequality and primary care physician supply on White and Black mortality. In the reduced models for White mortality, both income inequality (positively associated, $P<.01$) and primary care physician supply (inversely associated, $P<.01$) were significantly associated with mortality, even after the inclusion of the SES covariates. In the reduced models for Black mortality, both income inequality ($P<.01$) and primary care physician supply ($P<.10$) were significantly associated with mortality. After the inclusion of the SES covariates, the effect of income inequality on Black mortality remained significant ($P<.01$), but the effect of primary care physician supply was no longer significant ($P>.10$).

Table 3 shows the results of the weighted regression coefficients of primary care physician supply on total mortality for low- and high-income-inequality MSAs. The differential effects of primary care physician supply on mortality among Whites compared with Blacks are evident when we examine the middle and bottom results of Table 3. Primary care physician supply exerted strong and significant influence on White mortality in both low- and high-income-inequality MSAs, but it was only weakly associated with Black mortality in low-income-inequality MSAs ($P<.10$ in the reduced model) and was not associated with Black mortality in high-income-inequality MSAs. The results of additional analyses indicated that the specialty physician–to–population ratio was not related to mortality in either the Black or the White populations, despite a very high correlation between the separate primary care physician and specialist physician population ratios.

DISCUSSION

The study results corroborate earlier findings that state-level income inequality and primary care physician supply were significantly associated with population health indicators.[9] The significant association between primary care physician supply and health indicators at both state and MSA levels suggests that areas with greater primary care presence are also likely to enjoy better health. These results contribute to the increasing evidence that aspects of health services have an independent effect on reducing population ill health.[14,16,21,22]

In interpreting the findings, several potential limitations merit consideration. Data on income include governmental transfers such as Aid to Families with Dependent Children. Thus, recent erosions in welfare support would further increase the disparities in in-

TABLE 3—Weighted Multiple Regression Coefficients of Primary Care Physician–to–Population Ratio on Total Mortality for Low- and High-Income-Inequality Metropolitan Statistical Areas (MSAs)

	Total Mortality			
	Low-Income-Inequality MSAs (n = 136)		High-Income-Inequality MSAs (n = 137)	
	Model 1	Model 2[a]	Model 1	Model 2[a]
Overall				
Ratio of primary care physicians to population	-3.97	-1.65	-2.87	-0.94
	[1.46]	[0.90]	[1.66]	[1.38]
	(-2.72***)	(-1.84*)	(-1.73*)	(-0.68)
% Population Black		505.76		390.13
		[33.95]		[29.89]
		(14.90***)		(13.05***)
White				
Ratio of primary care physicians to population	-4.08	-2.26	-3.36	-2.61
	[1.11]	[1.09]	[1.27]	[1.38]
	(-3.66***)	(-2.07**)	(-2.65***)	(-1.89*)
Black				
Ratio of primary care physicians to population	-10.97	1.82	0.52	-0.04
	[6.36]	[7.50]	[4.39]	[4.97]
	(-1.72*)	(0.24)	(0.12)	(-0.01)

Note. Parameter estimates are on top, SEs are in brackets, and *t* test values are in parentheses.
[a]Complete model includes percentage of population without elementary education, percentage of workforce population unemployed, and percentage of population that is urban.
*$P<.10$; **$P<.05$; ***$P<.01$.

come as compared with such disparities 10 years ago.

Primary care physician availability is probably an inadequate proxy for receipt of good primary care. Unfortunately, the data are not available to adequately characterize receipt of good primary care (as distinguished from receipt of ambulatory care services, which also include specialty care) at national or other levels. The importance of doing so is evident from our findings of an opposite effect of primary care and specialist physician supply on mortality. Measures such as insurance coverage; physician visits per capita, by race/ethnicity, and by SES (as measures of access); and percentage of population with a regular source of care (as a measure of continuity) pertain to both specialty care and primary care. Physicians in hospital-based office practices and emergency rooms who may deliver some primary care, particularly to low-income and uninsured populations, also were not included. The findings also are not necessarily generalizable to other types of geographic areas because there may be something unique in US metropolitan areas that does not apply elsewhere.

The importance of our findings from the viewpoint of policy is considerable because policies regarding organization of health services to strengthen primary care are likely to be more politically acceptable than policies to redistribute income. Significant improvement in the predictive power of the models was achieved after including socioeconomic covariates. This points to the necessity of building comprehensive models to test the relation between income inequality, primary care, and health indicators. SES measures attenuated but did not eliminate the effect of both income inequality and primary care physician supply on mortality, which suggests that socioeconomic characteristics are critical in influencing population health. From a policy perspective, improvement in population health likely will require a multipronged approach that addresses socioeconomic determinants of health and strengthens primary care.

Unlike most previous studies of income inequality and health, our study specifically examined the effect of race/ethnicity and socioeconomic correlates of mortality. A marked effect of race/ethnicity on the relation between income inequality, primary care, and mortality was found. That Black race remained an overriding determinant of disparities in mortality, even after inclusion of socioeconomic covariates, suggests that race/ethnicity is not merely a proxy for socioeconomic variables.[23–26] In areas with high income inequality, the role of primary care physician supply appears particularly limited in attenuating the adverse effect of income inequality on mortality in Blacks. This finding is likely to be a result of compromised access to primary care physicians for Black populations, even in the presence of primary care physicians.

Although income inequality was significantly associated with both White and Black mortality, its influence, as reflected in the regression coefficients, was much stronger on Black than on White mortality. This finding might be explained by the relation between income inequality and racial/ethnic discrimination. Racial/ethnic prejudice, either overt or covert, could subject Blacks to the experience of greater barriers to accessing community resources, including primary care, that are conducive to better health. Kennedy et al.[27] found that states that tolerated high income inequality also had high levels of racial/ethnic prejudice. Williams[23–25] emphasized the need for increased attention to factors that link race/ethnicity to health, including racism, migration, acculturation, and differential SES. From the viewpoint of public health, it is important to focus on the social origins of ill health, not only more proximal risk factors, as a way to reduce and ultimately eliminate health disparities. As Sen[14(p17)] pointed out, "the remedying of this inequality has to involve policy matters that go well beyond just creating income opportunities for the black population. It is necessary to address such matters as public health services, educational facilities, hazards of urban life, and other social and economic parameters that influence survival chances." ■

About the Authors

The authors are with the Department of Health Policy and Management, Johns Hopkins School of Public Health and Hygiene, Baltimore, Md.

Reprints will not be available from the author. Correspondence should be addressed to Leiyu Shi, DrPH, MBA, Department of Health Policy and Management, Johns Hopkins School of Public Health and Hygiene, 624 N Broadway, Room 409, Baltimore, MD 21205-1996 (e-mail: lshi@jhsph.edu).

This article was accepted October 6, 2000.

Contributors

L. Shi planned and designed the study, analyzed the data, and wrote the paper. B. Starfield assisted with the study plan and design and contributed to the writing of the paper.

Acknowledgments

Funding support for this study came in part from the Bureau of Primary Health Care, Health Resources and Services Administration.

Data on income inequality at the metropolitan area level were generously provided by Lynch et al.,[28] from the University of Michigan, who used them to study the association of income inequality and mortality in metropolitan areas of the United States.

Race/ethnicity-specific mortality indicators were produced and provided on our request by the Mortality Statistics Branch, Division of Vital Statistics, National Center for Health Statistics, because no such measures at the metropolitan area level were available from secondary sources. In particular, we thank Harry Rosenberg and Donna Hoyert for their efforts.

References

1. Kunst AE, Geurts JJM, van den Berg J. International variation of socioeconomic inequalities in self-reported health. *J Epidemiol Community Health.* 1995; 49:117–123.

2. Wilkinson RG. Income distribution and mortality: a "natural" experiment. *Sociol Health Illness.* 1990;12: 391–412.

3. Wilkinson RG. *Unhealthy Societies: The Afflictions of Inequality.* London, England: Routledge; 1996.

4. 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.

5. Kaplan GA, Pamuk E, 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.

6. Mackenbach JP, Kunst AE, Cavelaars AEJB, Groenhof F, Geurts JJM. Socioeconomic inequalities in morbidity and mortality in western Europe. The EU Working Group on Socioeconomic Inequalities in Health. *Lancet.* 1997;349:1655–1659.

7. Wilkinson RG. Socioeconomic determinants of health. Health inequalities: relative or absolute material standards? *BMJ.* 1997;314:591–595.

8. 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.

9. Shi L, Starfield B, Kennedy B, Kawachi I. Income inequality, primary care, and health indicators. *J Fam Pract.* 1999;48:275–284.

10. Bergner M. Measurement of health status. *Med Care.* 1985;23:696–704.

11. Donabedian A. Twenty years of research on the

quality of medical care, 1964–1984. *Eval Health Professions.* 1985;3:243–265.

12. Rice DP. Health status and national health priorities. *West J Med.* 1991;154:294–302.

13. Centers for Disease Control. Health status indicators: definitions and national data. *Stat Notes.* 1992;1:1–8.

14. Sen A. Mortality as an indicator of economic success or failure. *Econ J.* 1998;108:1–25.

15. Friede A, Reid JA, Ory HW. CDC WONDER: a comprehensive on-line public health information system of the Centers for Disease Control and Prevention. *Am J Public Health.* 1993;83:1289–1294.

16. Starfield B. *Primary Care: Balancing Health Needs, Services, and Technology.* New York, NY: Oxford University Press; 1998.

17. Evans RG, Barer ML, Marmor TR. *Why Are Some People Healthy and Others Not? The Determinants of Health of Populations.* New York, NY: Aldine de Gruyter; 1998.

18. Susser M. The logic in ecological, I: the logic of analysis. *Am J Public Health.* 1994;84:825–829.

19. Schwartz S. The fallacy of the ecological fallacy: the potential misuse of a concept and the consequences. *Am J Public Health.* 1994;84:819–824.

20. Rothman KJ. *Modern Epidemiology.* Boston, Mass: Little, Brown & Co; 1986.

21. Lantz PM, House JS, Lepkowski JM, Williams DR, Mero RP, Chen J. Socioeconomic factors, health behaviors, and mortality: results from a nationally representative prospective study of US adults. *JAMA.* 1998;279:1703–1708.

22. Bunker J, Frazier H, Mosteller F. Improving health: measuring the effects of medical care. *Milbank Q.* 1994;72:225–228.

23. Williams DR. The monitoring of racial/ethnic status in the USA: data quality issues. *Ethn Health.* 1999;4(3):121–137.

24. Williams DR. Race/ethnicity and socioeconomic status: measurement and methodological issues. *Int J Health Serv.* 1996;26:483–505.

25. Williams DR, Lavizzo-Mourey R, Warren RC. The concept of race and health status in America. *Public Health Rep.* 1994;109:26–41.

26. Jones CP. Levels of racism: a theoretic framework and a gardener's tale. *Am J Public Health.* 2000;90:1212–1215.

27. Kennedy BP, Kawachi I, Lochner K, Jones CP, Prothrow-Stith D. (Dis)respect and black mortality. *Ethn Dis.* 1997;7:207–214.

28. 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.