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INEQUALITY, PHYSICIAN DISTRIBUTION, AND HEALTH IN ILLINOIS COUNTIES: A THREE-STAGE LEAST SQUARES MODEL

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ABSTRACT

Government health policies often do not succeed as planned, possibly due to *income inequality*. Its importance is often overlooked when searching for the causes of poor health and when developing strategies to improve the health of Americans. This research uses an advanced statistical technique to study the relationship between income inequality, racial/ethnic, and rural/urban disparities in health for counties in Illinois. Primary care physician to population ratios were also controlled in three-stage least squares econometric models. Mortality data were used as the health measure. Simultaneity between certain variables was accounted for: something not previously studied.

Income inequality in the Illinois counties significantly affected mortality: greater inequality yielding greater mortality. Primary care doctors to population had no significant effect on mortality. Higher percent smokers increased mortality. Medicare payments per number of persons 65 years or greater significantly reduced mortality. Per capita government payments had a similar significant effect. Predicting primary care physicians to total population yielded no simultaneity effects from mortality.

Medicare and total government payments results indicate that certain aspects of the Illinois/Federal health system are working well. Our Gini income inequality variable shows that higher income inequality increases mortality, something not often found at a lower level of aggregation. Controlling for simultaneity and primary care doctors to population did not eliminate the income inequality effect on mortality. Policy recommendations are that our government should address the findings of this and other studies, and increase the health of our disadvantaged citizens by lessening the level of inequality in our country.

INTRODUCTION

Government health policies often do not succeed as planned, possibly due to a factor being studied here: *income inequality*. Its importance is often overlooked by governmental agencies when searching for the causes of poor health in America and when developing strategies to improve the health of Americans. It has been posited that a sufficient amount of primary care practice in an area may compensate for the effects of income inequality on health.[1,2] One goal of our research is to examine the effect of this variable when controlling for the amount of primary care in a geographical area, which

has been done previously but without taking account of simultaneity between physician and health variables.

Similarly, racial/ethnic and rural/urban variables may produce differentials in health that undermine government efforts to improve the health of inner city and rural residents. We hope to determine the magnitude of these effects. If the effects are strong, they may indicate that these disparities may lessen and frustrate government health programs. Shi and his colleagues[1,2] have examined the relationship between income inequality and primary care physician level, and mortality for U.S. states and metropolitan areas. However, these authors have not controlled for certain other variables or simultaneity. Simultaneity refers to a relationship of mutual dependence (instantaneous feedback) between two variables in a statistical model.

A controversy exists as to whether the health of residents of rural areas is inferior to or superior to that of urban areas.[3,4] Research also indicates that areas that have greater income inequality and/or larger populations of racial and ethnic minorities have poorer health[5-7]. Determining whether these three types of disparities lead to ill health and higher mortality is the first step in solving these problems through policy manipulations.

The research question can be phrased as "Are income inequality, racial/ethnic minority status, and rural/urban status significant predictors of health when primary care level is controlled in county geographic areas in Illinois controlling for other relevant variables in quantitative models?"

METHODS

Theoretical Framework

A theoretical framework from Macinko et al.[5] helps to specify our quantitative health outcome model. According to these authors, national policies and culture are the prime determinants of health. National policies that are outside the health sector affect macroeconomics, international relations, and income redistribution. National policies do not vary in our study since we are limited to considering Illinois counties at one point in time. However, we have the percentage voting democrat for president in the year 2000 election. Navarro and colleagues[6] argue that voting for parties with a focus on welfare state income re-distribution should lead to better health. We predict that there may be a political culture in a county reflected in the voting pattern and that the influence of liberalism as opposed to conservatism should lead to better health in a county (controlling for per capita income and income inequality) since democrats would possibly advocate for better health for all citizens as opposed to republicans possibly advocating more high-tech/sophisticated health care. We also posit that percent democrat will affect variable hospital beds per capita, and the physician variables, with democratic counties likely to increase these health facilitators to increase the health of as many citizens as is possible.

Macinko et al.[5] state that culture represents beliefs and practices specific to national, subnational, religious, or ethnic groups that contribute to different preferences for various types of political and legal institutions, social participation, institutional development, lifestyle choices, and overall priorities. These factors affect health. We studied the variables percent black and percent Hispanic to partially address this.

Health determinants that are more proximal in these authors' scheme include macro level elements such as the environment and demographics. A country's national socioeconomic environment also influences health status (as in Navarro and colleagues[6]). The health system represents an interface between individuals and the political system. Health care is produced by system inputs (physicians, medicines, and facilities) that interact with the population through various processes (medical consultations, surgeries, and deliveries) and result in health outcomes.[5] Physician, and hospital variables are incorporated into our model as well as income inequality (Gini index) and per capita income

Individual resources affecting health can be social, economic, or biological. Social networks and support also determine health. Economic resources include income and working conditions. Social and economic conditions combine into socioeconomic status measured by income; social status measured by education; and work status, measured by occupation. One's genetic makeup is another individual resource.[5] Our model has per capita income, and educational variables to partially determine the effects of these variables.

Behavioral factors include lifestyle, particularly drinking and smoking. Participation and volunteering are also individual behaviors that have been linked to health.[5] Smoking status, as well as social capital indicators home ownership, social cohesion/crime rate, percent with high school education and percent graduate and professional represent these factors.

Primary care is thought to mediate the effects of other health determinants. A strong primary care system will improve preventative care, and reduce some of the ill effects of social inequalities. Good primary care also means better referral, coordination, and continuity of care, which lead to better health.[5] A primary care variable is included in our models.

Data considerations limit our ability to test the entire theory but as indicated we have some variables (where a large multi-variable model is clearly needed) to partially study this theory.

Additionally, various mechanisms have been posited linking income inequality and health. Mayer and Sarin[7] discuss four mechanisms relating economic inequality to infant mortality and to health in general. The first is the non-linear relationship between income and health. An extra dollar increase in income for the poor will have a greater beneficial effect on health than an extra dollar increase in income for the rich. This means that income redistribution from rich to poor will increase overall health. We initially wanted to incorporate this log-linear specification but could not use the natural log specification because of multi-collinearity problems, opting instead for a linear specification.

The second mechanism is that the effect of income inequality is likely to depend on the geographic proximity of the rich to the poor. It is thought that economic inequality increases economic segregation and vice versa. Economic segregation is associated with higher levels of adult mortality. We, of course have a measure of income inequality but not economic segregation. A third mechanism, the "neo-materialist" view, holds that inequality affects health due to the level and distribution of material resources. Health

could worsen if an increase in inequality reduces state spending on medical care for the poor (or on other goods and services related to health). Consequently, we use Medicare spending (per those 65 and over), Medicaid spending, and total government payments in our health equation.

Mechanism number four is the psychosocial mechanism. It is argued that inequality decreases health through social comparisons that reduce social capital, trust, and efficacy. Ranking low in the social hierarchy produces negative emotions such as shame and distrust that lead to worse health through neuro-endocrine mechanisms and stress-induced behaviors such as smoking, excessive drinking, taking dangerous drugs, etc. Trust, belonging to organizations, volunteering, and efficacy affect health in an area, as do norms of reciprocity and social cohesion. We have a measure of smoking status and social capital indicators home ownership, crime rate, percent high school graduates, and percent graduate and professionals.

We posit that these macro-level independent variables (all the independent variables in the model excluding the study of interactions) combine in a linear additive way in each equation to predict particular dependent variables in our statistical models. We also test certain interactions.

DISCUSSION OF VARIABLES

Secondary data from Federal and state governments' websites and publications, mainly collected in the 2000 census were used exclusively in our research. We here discuss variables (means and standard deviations are presented in Table 1) that are not obvious in meaning.

Percent Systems hospitals measured the proportion of hospitals in a county that are part of a large system. Level of pollution is a multiplicative measure of air pollution where the amount of particulate matter is multiplied times the amount of sulfur dioxide times the amount of nitrogen times the amount of organic matter times the amount of carbon dioxide in the air in a particular county. A multiplicative measure was used due to the cumulative effect that pollution and other environmental problems seem to have.

Income inequality was measured by the Gini coefficient. The Gini coefficient, named after an Italian statistician, is based on a cumulative frequency curve, the Lorenz curve, which compares the distribution of a variable like income with that of a uniform distribution. The equality distribution is represented by a diagonal line on a graph (representing perfect equality) and the greater the deviation from this line, the greater is the inequality. The Gini coefficient ranges from 0 to 1 with 0 representing perfect equality and 1 perfect inequality.[2] The Gini coefficient was used here because it seems to give the best indication of income inequality in terms of including inequality at all income levels rather than being sensitive to the tails of the distribution, as other measures are. The Gini coefficient also made our results more comparable to those of other studies.

Education was measured by the proportion of the population with a high school education and by the proportion of the population who are graduate or professional. Primary care physician to population ratio was measured through American Medical Association (AMA) and American Osteopathic Association (AOA) data using the Area

TABLE 1

VARIABLES, MEANS, AND STANDARD DEVIATIONS

Variable	Mean	Standard Deviation
Endogenous Variables		
Percent Graduate and Professional	5.296078	3.030372
Percent without Health Insurance	10.60693	3.219169
Public School Expenditures per capita	1,207.53	252.0436
Hospital Beds per capita	2.517679	2.056953
Age Adjusted 5-yr Average Mortality Rate	810.3875	67.7207
Percent Home Ownership	75.81373	5.789937
Primary Care Doctors to Population	47.94153	27.9645
Percent High School Graduates	80.8951	5.29727
Percent Smokers	25.40404	4.03176
Crime Rate	2,618.578	1401.679
INSTRUMENTAL VARIABLES		
Per Capita Income	23,928.27	4736.755
Population Density	72.1123	244.7497
GINI Income Inequality	.4103195	.0320498
Pollution	1,313.948	1,0980.56
Percent Democrat	43.98137	6.742487
Climate	.627451	.48571
Percent Black	.0445827	.0674011
Percent Hispanic	.0365547	.092924
Percent System Hospitals	.269708	.3685223
Medicaid Payments	486.8595	332.0297
Medicare Payments	4.984902	.7268469
Government Payments	3.661371	.7293524
Presence of a Large Park	.4803922	.5020826
Physical Size of a County	1411.634	577.6932
Percent Poverty	11.29706	3.826289
Percent Rural	51.03501	26.60105
Total Population	121,757	541,449.3
Population Migration	-1,081.235	13,447.28
Unemployment	5.772152	1.558706
Percent 65 and over	.1565653	.0293621
Household Size	2.481078	.1408665
Presence of a Medical School	.0490196	.2169752

Resource File[8] for the year 2001. Care was taken in setting up the physician variables so no double counting of Osteopaths occurred. Per capita income was also thought to positively predict health status. Proportion of the population that is black has been mentioned as having a strong effect on health and this variable will be supplemented with the proportion Hispanic. Hospital beds per capita has not been studied extensively in relation to health, but should impact a county's health positively. Percent of the population in a county that is rural should have an effect on health, although given the McLaughlin et al.[3,4] studies, somewhat at odds with conventional wisdom, we do not know in which direction. Due to multi-collinearity problems (percent rural was multi-collinear with many variables) population density was substituted for percent rural population.

The mortality data came from the Wonder website[9] of the Center for Disease Control. All cause 5-year average 1997-2001 (but with accidental deaths deleted) was utilized as an endogenous variable in the models. A pertinent question is "why use a 5-year average when studying simultaneous feedback between physician and health variables?" Using mortality data for a specific year for counties produced weak and non-significant relationships with health probably due to the small numbers of events and the subsequent high impact of random error in the data. Using a 5-year average seems to address these problems producing significant relationships where one would expect them. Although the one-year specification would have been more correct, we feel that our results are still of import although interpretation of simultaneity effects must be done cautiously and are somewhat tentative.

IDENTIFICATION

Identification was accomplished through the use of 22 instrumental variables. We feel that our model has been identified given the information in the Macinko et al.[5] theoretical treatment, the Mayer and Sarin[7] statement of inequality effect mechanisms on health, and in the results from prior research. Multi-collinearity necessitated some alterations in the various models.

ESTIMATION TECHNIQUES

Three-stage least squares (Davidson[10], Theil[11]) was used to estimate the effects of the variables. This technique takes into account the correlations among disturbances from the various equations in the models, as well as compensating for the fact that endogenous variables are random, and therefore correlated with disturbance terms in OLS estimation. Utilizing the disturbance correlation information leads to more efficient parameter estimates. The simultaneous equation format allowed controlling for simultaneity between endogenous variables, something that the authors believe has not been previously examined. The 3SLS analysis was carried out using the Stata computer statistical package.

RESULTS

One ten-equation model (model I) based on Illinois county-level data was run using Stata's 3SLS program. The endogenous dependent variables in the model were: (1)

percent graduate and professional; (2) hospital beds per population; (3) public school expenditures; (4) primary care physicians to population; (5) the mortality health measure; (6) percent owner occupied housing; (7) percent high school graduate; (8) percent who smoke; (9) percent without health insurance and (10) crime rate. A second model with crime rate deleted (model II) was also run to explore the crime rate-income inequality trade-off. Eight variables reached statistical significance in the model II mortality equation and only four variables are significant in model I (see Table 2). Model I has only the percent without health insurance, percent Hispanic, percent smoker, and the Gini index of income inequality as significant variables at the .05 level (one-tailed for the Gini index). The signs of percent without health insurance and percent Hispanic are the opposite of that predicted. This will be discussed later.

Model II has eight statistically significant variables predictive of mortality. Again percent without health insurance and percent Hispanic follow the same pattern. Both are negatively related to mortality. Our social capital indicator, percent home ownership also has an effect the opposite of that predicted. Increasing home ownership increases mortality. Smoking is shown to increase mortality and is highly statistically significant (p=.000). Gini index is also significant and this time at p=.007. Pollution has a significant effect the opposite of that predicted. Medicare payments per 65 year olds is statistically significant at the .05 level with a one-tailed test since direction is as predicted. Higher Medicare payments lower mortality. Overall total government payments to population also has a significant (.05 level two-tailed) effect. Increased payments lower the rate of mortality. Medicaid payments did not have a significant effect on mortality.

Although non-significant, climate had an effect on mortality at a p= .074 level. Direction was not predicted so a one-tailed test could not be carried out. Significance would have indicated higher mortality for the warmer southern Illinois climates.

Interactions were tested using several multiplicative specifications. None proved to be statistically significant when entered into the model I and model II mortality equations. Variables interacted included Gini in turn with: percent black, percent Hispanic, population density (our proxy for rural/urban), social capital indicator home ownership, social capital indicator crime rate, social capital indicator percent high school graduates, and percent graduate and professional.

The primary care to population equation in model I (not shown in tables) yielded six significant variables. Percent democrat had a negative effect on the number of primary care doctors to population. Per capita income had a positive effect on the dependent variable. Public school expenditures negatively affected primary care doctors to population. Mortality negatively impacts primary care doctors to population. Percent smokers has a negative effect and an increased crime rate leads to more primary care doctors to population.

In model II, percent voting democrat negatively and significantly (two-tailed test) affects the number of primary care physicians to population. Graduate and professionals has a significant effect in the predicted direction but only one-tailed. Per capita income significantly and directly impacts primary care (two-tailed test). More hospital beds per capita significantly increases primary care doctors to population. The percent of smokers significantly and directly impacts (two-tailed test) primary care, with more smokers

TABLE 2

Three-stage Least Squares Coefficients for the Mortality Equation, Model I

	Coefficient	t-value	Probability
Constant	-784.186	-.30	.761
Percent without health insurance	-28.457	-2.85	.004
Percent voting democrat	5.615	.79	.429
Percent graduate and professional	-28.261	-1.17	.243
Primary care to population	-1.220	-.69	.490
Per Capita Income	.006	.44	.660
Percent Black	-218.622	-.28	.777
Percent Hispanic	-318.480	-2.08	.037
Percent System Hospitals	5.847	.29	.772
Population Density	.258	.72	.469
Percent Home Ownership	3.609	.37	.709
Percent Smokers	36.663	2.15	.032
GINI Income Inequality	2312.36	1.71	.087
Pollution	-.015	-.81	.417
Climate	37.847	1.26	.207
Medicare Payments	-34.379	-1.45	.146
Government Payments	-101.022	-1.24	.214
Percent High School Graduates	-.155	-.01	.994
Hospital Beds Per Capita	6.245	.21	.834
Crime Rate	.034	1.30	.195
Medicaid Payments	-.014	-.30	.767

Three-stage Least Squares Coefficients for the Mortality Equation, Model II

	Coefficient	t-value	Probability
Constant	-3138.376	-2.15	.032
Percent Without Health Insurance	-29.948	-3.10	.002
Percent Voting Democrat	9.730	1.34	.179
Percent Graduate and Professional	-19.423	-1.10	.271
Primary Care to Population	-.518	-.28	.782
Per Capita Income	-.005	-.62	.535
Percent Black	495.137	1.14	.253
Percent Hispanic	-343.667	-2.26	.024
Percent System Hospitals	-8.223	-.41	.685
Population Density	.309	1.42	.154
Percent Home Ownership	16.377	2.08	.038
Percent Smokers	44.626	3.61	.000
GINI Income Inequality	2583.576	2.70	.007
Pollution	-.027	-2.33	.020
Climate	49.462	1.78	.074
Medicare Payments	-39.785	-1.70	.090
Government Payments	-129.940	-2.27	.023
Percent High School Graduates	15.058	1.47	.142
Hospital Beds Per Capita	30.377	1.42	.155
Medicaid Payments	.001	.03	.979

meaning more primary care doctors to population. Increased Medicaid and Medicare payments significantly lower the number of primary care doctors to population—Medicare only at a .05 one-tailed level. Mortality and the Gini index have no significant effect on the number of primary care doctors to population.

DISCUSSION

Great attention has been focused on the relationship between income inequality and health over the last several years. [1-4,12-20]. Health status has been found to decrease at higher levels of area inequality. This relationship has been confirmed using both self-reported health[17-21] and mortality measures.[1-4,7,12-16] Studies have been carried out in individual,[22] nation-state,[13-15] state,[2,14], county,[3,4] tract/neighborhood,[16] and multi-level[19] analyses, and in foreign countries[13,15] as well as the U.S.[1-4,7,12,13] The Gini coefficient seems to be the most popular measure of income inequality although other measures have also yielded significant relationships between inequality and health.[2,16]

Shi and various colleagues have found[1,2,5,23] that income inequality has a significant effect on health even after controlling for the effect of primary care physicians to population (also statistically significant). Shi et al.[23] in a recent study looked at the relationship between primary care and all cause, heart disease, and cancer mortality in all U.S. counties for the year 1990. Greater primary care reduced rates of all three types of mortality. Counties with the lowest levels of these resources experienced 2 to 3 percent higher mortality than counties with higher levels of primary care resources. High income inequality produced 11 to 13 percent higher mortality.

In one study of stroke,[22] income inequality effects disappeared when covariates of this variable such as education levels, unemployment, racial/ethnic composition, and percent urban were controlled in addition to primary care, which remained significant. We are here determining whether inequality has independent significant effects on health when co-variates are controlled.

Gulliford[24] reports on an ecological analysis of health outcomes for health authorities (areas) in England in 1999. After deprivation score, ethnic group, and social class were controlled, a per unit increase in general practitioners (G.P.) supply decreased all cause mortality significantly ($p = .002$) Adjustment for limiting long-term illness lowered the effect to marginal significance ($p = .06$) Higher G.P. supply was significantly associated with a decrease in hospital admission rates for acute and chronic conditions.

McLaughlin and Stokes[3] examined rural/urban differences in mortality controlling for relevant economic characteristics of U. S. counties in 1990. They find that non-metro counties have slightly *lower* death rates when they are standardized for the population's age, sex, and race composition. With controls for various factors, percent rural was significantly and negatively related to mortality for non-metro counties. Interaction between metro/non-metro status and inequality yielded differential effects on mortality.

Racial/ethnic effects on health were also studied by McLaughlin and Stokes.[4] They found that even after adjustment of mortality rates for age, sex, and race, higher percentage black is still associated with higher mortality rates. Dummy variables for Gini quartiles were utilized in a weighted least squares regression analysis and the

Gini dummies, per capita income, percent black, if the county was in the South, and percent rural were all significant. Percent rural was significantly and negatively related to mortality for non-metro counties. Different and complex results were found between counties with high and low percentages of blacks when interactions between inequality and racial concentration effects on mortality were studied. Interactions between non-metro status and inequality quartiles yielded an income inequality gradient for non-metro counties and an inverted U-shape function for inequality effects on mortality for metro counties. Levels of age-sex-race adjusted mortality are lower in non-metro than in metro counties, except for the highest inequality quartile. Data limitations prevented examining social cohesion which should be greater in rural counties and may therefore account for lower mortality in these areas. We have tested this interaction using a crime rate indicator of social capital/cohesion.

An income inequality-mortality gradient was absent in metro counties suggesting that limited social cohesion or the minimizing of the material dimensions of inequality through federal investments in metro areas may reduce the influence of within-county inequality on mortality. When the concentration of blacks is controlled, income inequality has only minor and inconsistent effects on mortality in metro counties. In non-metro counties, inequitable income distributions exert large and consistent effects even with controls for the concentration of blacks.

Shi and Starfield[25] assessed whether income inequality and primary care physician supply had a different effect for blacks compared to whites, finding that it does. Shi et al.[21] showed that higher quality primary care levels were associated with reduced (but not eliminated) racial and ethnic disparities in health. This relationship is particularly pronounced for minorities living at or below the poverty level, a qualification being that the study "does not specify the directionality of the primary care and health relationship.[21]"

This qualification highlights the primary significance of our proposed three-stage least squares model of inequality, physician distribution, and health. Simultaneity between primary care and health is tested in a multi-equation model where correlations between disturbance terms for endogenous variables are used to adjust coefficient estimates to determine the effects of variables and whether simultaneity or uni-directionality exists in the relationship. To our knowledge, no study has examined this. Effect coefficients in prior studies may be biased due to failure to account for simultaneity. Should the disparities hold when simultaneity is taken into account, it would strengthen conceptual explanations of health outcomes and provide a firmer basis for policies to reduce income inequality, racial/ethnic, and rural/urban disparities thereby improving health.

In our study health is measured by mortality data for Illinois counties. The McLaughlin and Stokes study is improved upon by including measures of social cohesion/social capital and primary care physician to population ratio. The interaction effects between rural/urban county and income inequality and race/ethnicity are given further study to determine whether they are robust and understandable in their effects on health. Studying the effects of racial/ethnic, rural/urban and income inequality in a new set of data after the passage of ten years time, 2000 as opposed to 1990, gives our

study added significance. Relationships between variables may have changed, as well as the levels of variables. Controlling for primary care physicians per population, certain measures of social capital, a measure of environmental pollution, and the lifestyle variable percent smokers are logical next steps to improving on McLaughlin and Stokes' two previous county level analyses.

Of the two models tested in our study (see Table 2 for the models) , the proper specification seems to be model II—crime rate excluded from the mortality equation. The crime rate variable clearly does not represent a social capital effect as it is not statistically significant in model I but does reduce the effect of income inequality in the mortality equation. Income inequality remains statistically significant but only at a .05 level, one-tailed.

As mentioned, the signs of percent without health insurance and percent Hispanic are the opposite of that predicted. It may be that these variables are capturing the effect of age distribution not totally controlled when mortality was standardized for age. This may be the case since those without health insurance and Hispanics tend to be younger,[26] therefore healthier and less likely to suffer mortality.

Another sign that was contrary to expectation is that for home ownership: increasing home ownership increases mortality, possibly due to the fact that homeowners are generally older—another contribution of age not totally controlled by age standardizing mortality. McLaughlin and Stokes found that race had an effect even though their mortality data was standardized for race.[4]

In model II, pollution has a significant effect the opposite of that predicted. This may indicate the effects of urbanization—a population, although beset by air pollution, mobilized with sufficient health facilities and doctors to promote health, overcoming the negative effects of pollution. Population density was our measure of urbanity since we could not use the percent rural due to multi-collinearity problems, but population density may not capture all of the rural/urban affects on mortality hence the negative sign for the pollution variable.

Our results seem to confirm the significant effect of income inequality in counties of Illinois on mortality, even when simultaneity is accounted for. Controlling for the effect of primary care doctors to population, although with an effect in the predicted direction, did not yield significance as had been found in the work of Shi and his colleagues. Percent smokers had the predicted important effect on mortality. Medicare payments and total government payments significantly reduced mortality, which reinforces the perceived value of these welfare state measures. Medicaid payments had no significant effect on mortality.

In sum, percent without health insurance, percent Hispanic, percent home ownership, and pollution's effects were in direction opposite our expectations. Explanations offered for these results hinged on postulations that they represented age and urbanization effects not controlled by other means in the models. Social capital variables added little to the explanation. Crime rate (Model I) had no significant effect. Percent home ownership, although statistically significant, had an effect on mortality opposite the prediction. Percent high school graduates positively affected health although not significantly. Percent system hospitals, hospital beds per capita, percent black, population density, per capita income, and percent graduate and professional did not significantly affect mortality. Climate attained near significance but did not because direction was not predicted.

MULTI-COLLINEARITY

In previous macro-level research by the first author[27], multi-collinearity was dealt with by excluding one of a pair of multi-collinear variables, then determining results, and then excluding the other variable of the pair. The variable with the strongest relationship was chosen for inclusion in the equation. This produced no problems as one variable (of the several instances of multi-collinearity between variables) was always significant and the other not. In the current study, however certain variables were considered theoretically important, such as Gini income inequality, and were chosen to be included while other multi-collinear correlates were not. The over-riding theoretical importance of certain variables took precedence, in other words.

LIMITATIONS

Two main limitations exist in our research study, firstly in the development of the models. They are somewhat arbitrary. Other models are possible. In particular, other variables not included were multi-collinear with some of the variables in the current model. In the previous paper this did not prove to be a serious obstacle. However, in the current study decisions about which variables to include in certain equations were not done according to statistical considerations but rather due to theoretical considerations, most primary being regarding the Gini income inequality variable. It was included in all relevant equations with multi-collinear pair partner excluded, due to its theoretical priority.

Another limitation, using the 5-year average of mortality rather than a one-year (2001) measure, should be noted. We do not feel that this greatly lessens the veracity of our findings although it does depart from recommended practice to a certain degree. It can justifiably be argued that primary care physicians to population is (although this data is not available to us) strongly correlated from year to year so that a 5-year average of this variable would not be greatly different from the single year used in our study.

CONCLUSIONS

Our results indicate that certain aspects of the Illinois/Federal health system are working well. Medicare payments reduce mortality, as do total government payments. Medicaid payments have no significant effects on mortality although they undoubtedly have other positive health and welfare consequences not measured here.

Smoking increases mortality—re-confirming what has been almost universally found. Income inequality has a significant negative effect on health as measured by mortality in our sample of Illinois counties. These income inequality findings are somewhat novel as such effects have usually been found only in studies at a higher level of aggregation such as states or nations.

Controlling for simultaneity (as best as was possible given our necessitated use of a 5-year average for mortality), did not eliminate the income inequality effect. Simultaneity was not found between primary care doctors to population and health. Concerning the hypothesized reciprocal effect between primary care doctors to population and health, mortality negatively but not significantly affected total primary care doctors to population and vice versa. The prediction was for a positive effect between mortality and the number of primary care doctors to population. Thus the sign was the opposite of that predicted.

Our social capital indicators were generally poor proxies for social capital. Disparities variables that have had effects in other studies like per capita income and percent black had no significant effect here. Furthermore, our rural/urban indicator population density had no significant effect on mortality.

Schroeder[28] argues that the U.S. does poorly in international health comparisons because we value entrepreneurship over egalitarianism thereby tolerating large gaps in incomes, total wealth, educational quality, and housing that have unintended health consequences. He cites lack of a labor party and the limited role played by dispersed and weak U.S. governmental health agencies as causes of poor performance on measures of health.

Should the findings of our study be supported in future research on the U.S., a quote from 45 years ago prior to the war on poverty would (unfortunately) still be salient today.

> Here is one of the most familiar forms of the vicious circle of poverty. The poor get sick more than anyone else in the society. That is because they live in slums jammed together under unhygienic conditions, they have inadequate diets, and cannot get decent medical care. When they become sick, they are sick more often and longer than anyone else, they lose wages and work, and find it difficult to hold a steady job. And because of this they cannot pay for good housing, for a nutritious diet, for doctors. At any given point in the circle, particularly when there is a major illness, their prospect is to move to an even lower level and to begin the cycle, round and round, toward ever more suffering...
>
> The individual cannot usually break out of this vicious circle. Neither can the group, for it lacks the social energy and political strength to turn its misery into a cause. Only the larger society, with its help and resources, can really make it possible for these people to help themselves.[29]

Our findings indicate that this statement should be broadened to the situation where there are *extremes* of wealth and poverty in an area (e.g. an Illinois county). Furthermore, rural dwellers face similar problems often related to the difficulty of obtaining primary care doctors for economically depressed areas. Long travel distances to primary care and lack of health insurance deter them from getting needed healthcare.

Our results show that Medicare payments and overall government payments significantly reduce mortality. Hopefully our government will address the findings of our study and other studies and take corrective policy action to lessen income inequality and thereby improve the health of our disadvantaged citizens.

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REFERENCES

1. Shi L. Starfield B. Kennedy B. Kawachi I. Income Inequality, Primary Care, and Health Indicators. J of Family Practice. 1999; 48(4), 275-84.
2. Shi L. Macinko J. Starfield B. Wulu J. Regan J. Politzer R. The Relationship Between Primary Care, Income Inequality, and Mortality in US States, 1980-1995. J of the American Board of Family Practice. 2003; 16, 412-22.
3. McLaughlin DK., Stokes CS. Nonoyanta A. Residence and Income Inequality: Effects on Mortality Among US Counties. Rural Sociology. 2001; 66(4), 579-98.
4. McLaughlin DK. Stokes CS. Income Inequality and Mortality in US Counties: Does Minority Racial Concentration Matter? American Journal of Public Health. 2002: 92(1), 99-104.
5. Macinko J. Starfield B. Shi L. The Contribution of Primary Care Systems to Health Outcomes within Organization for Economic Cooperation and Development (OECD) Countries, 1970-1998. Health Services Research. 2003; 38(3), 831-65.
6. Navarro V. Borrell C. Benach J. Muntaner C. Quiroga A. Rodriquez-Sanz M. Verges N. Guma J. Pasarin I.The Importance of the Political and the Social in Explaining Mortality Differentials Among the Countries of the OECD, 1950-1998. International Journal of Health Services. 2003; 33(3), 419-94.
7. Mayer SE. Sarin A. Some Mechanisms Linking Economic Inequality and Infant Mortality. Social Science and Medicine. 2005; 60(3), 439-55.
8. Area Resources File. National Ccnter for Health Workforce Analysis. Bureau of Health Professions. HRSA. Department of Health and Human Services. Februrary 2003.
9. CDC Wonder Website at http://www.wonder.cdc.gov/WelcomeA.html
10. Davidson J. Econometric Theory. Blackwell Publishers. Malden, Massachusetts. 2000.
11. Theil H. Principles of Econometrics. John Wiley and Sons. New York. 1971.
12. Kennedy B. 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-
13. Sanmartin C. Ross NA. Tremblay. Wolfson M. Dunn. Lynch J. Labour Market Income Inequality and Mortality in North American Metropolitan Areas. J of Epdemiology and Community Health. 2003; 57, 792-7.
14. Wolfson M. Kaplan G. Lynch J. Ross N., Backlund E. Relation Between Income Inequality and Mortality: Empirical Demonstration. BMJ 1999; 319(7215) 953-7.
15. Ross NA. Wolfson MC. Dunn JR. Berthelot J-M. Kaplan GA., Lynch JW. Relation Between Income Inequality and Mortality in Canada and in the United States: Cross Sectional Assessment Using Census Data and Vital Statistics. BMJ. 2000; 320(7238): 898-902.
16. Rodgers GB. Income and Inequality as Determinants of Mortality: An International Cross-Section Analysis. International Journal of Epidemiology. 2002; 31, 533-8.
17. Hou F. Myles J. Neighbourhood Inequality, Neighbourhood Affluence and Population Health. Social Science and Medicine. 2005: 60(7), 1557-69.
18. Blakely TA. Kennedy BP. Glass R. Kawachi I. What is the Lag Time Between

Income Inequality and Health Status? J Epidemiology Community Health 2000; 54, 318-19.
19. Lopez R. Income Inequality and Self-Rated Health in US Metropolitan Areas: A Multi-Level Analysis. Social Science and Medicine. 2004; 59(12), 2409-19.
20. Kahn RS. Wise PH., Kennedy BP. Kawachi I. State Income Inequality, Household Income, and Maternal Mental and Physical Health: Cross Sectional National Survey. BMJ 2000; 321(7272) 1311-15.
21. Shi L. Green LH. and Kazakova S. Primary Care Experience and Racial Disparities in Self-Reported Health Status. J Am Board Fam Pract 2004; 17, 443-52.
22. Shi L. Macinko J. Starfield B. Xu J. Politzer R. Primary Care, Income Inequality, and Stroke Mortality in the United States: 1985-1995. Stroke. 2003; 34, 1958-67.
23. Shi L. Starfield B. Politzer R. Regan J. Primary Care, Self-Rated Health, and Reductions in Social Disparities in Health. Health Services Research. 2002:37(3), 529-50.
24. Gulliford MC. Availability of Primary Care Doctors and Population Health in England: Is there an Association? Journal of Public Health Medicine. 2002; 24(4), 252-4.
25. Shi L. Starfield B. The Effect of Primary Care Physician Supply and Income Inequality on Mortality among Blacks and Whites in US Metropolitan Areas. Am J Public Health. 2001; 91(8), 1246-50.
26. Kreiger N.Williams D. Changing to the 2000 Standard Million: Are Declining Racial/Ethnic and Socioeconomic Inequalities in Health Real Progress or Statistical Illusion? Am J Public Health 2001;91(8), 1209-13.
27. Mistretta M. Differential Effects of Economic Factors on Specialist and Family Physician Distribution in Illinois: A County Level Analysis. J Rur Health. 2007;23(3), 215-21.
28.Schroeder S. Shattuck Lecture. We Can Do Better—Improving the Health of the American People. N Engl J Med. 2007; 357(12): 1221-8.
29. Harrington M. The Other America: Poverty in the United States. Simon and Schuster. New York. 1962.