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Rising U.S. income inequality and the changing gradient of socioeconomic status on physical functioning and activity limitations, 1984–2007

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ABSTRACT

This study examines the interactive contextual effect of income inequality on health. Specifically, we hypothesize that income inequality will moderate the relationships between individual-level risk factors and health. Using National Health Interview Survey data 1984–2007 ($n = 607,959$) and U.S. Census data, this paper estimates the effect of the dramatic increase in income inequality in the U.S. over the past two decades on the gradient of socioeconomic status on two measures of health (i.e., physical functioning and activity limitations). Results indicate that increasing income inequality strengthens the protective effects of family income, employment, college education, and marriage on these two measures of health. In contrast, high school education's protective effect (relative to less than a high school education) weakens in the context of increasing income inequality. In addition, we find that increasing income inequality exacerbates men's disadvantages in physical functioning and activity limitations. These findings shed light on research about growing health disparities in the U.S. in the last several decades.

Introduction

Numerous studies in medical sociology and social epidemiology have demonstrated that socioeconomic status has a positive effect on health. That is, higher socioeconomic status leads to higher possibility of better health and a lower risk of disease. This relationship has been claimed as a fundamental cause of individual health, with the relationship consistently observed across social groups, regions, and periods (Link & Phelan, 1995).

But this relationship is not fixed; numerous studies have documented the changing gradient of socioeconomic status on health, morbidity and mortality. For example, demographers have found that the inverse relationship between socioeconomic status and U.S. mortality rates has become significantly stronger since 1960 – a pattern observed across gender, race and marital status (Feldman, Makuc, Kleinman, & Cornoni-Huntley, 1989; Hummer, Rogers, & Eberstein, 1998; Pappas, Queen, Hadden, & Fisher, 1993; Preston & Elo, 1995).

Thus, although socioeconomic status may be fundamental causes of disease and death, its strength may be shaped by other factors. In this study, we examine whether rising income inequality in the past two decades contributes to widening health disparities in the U.S., using National Health Interview Survey data and U.S. Census data from 1984 to 2007. We examine both the direct effect of income inequality and its interactive effects with socioeconomic status (SES) and demographic variables known to predict health.

Background

Socioeconomic status and health

The inverse relationship between socioeconomic status (typically measured by income, education and/or occupation) and risk of disease is well established at the individual level. Socioeconomic status (SES) has been identified as a fundamental cause for individual health, because it embodies access to important resources, affects multiple disease outcomes through multiple mechanisms, and consequently maintains an association with disease even when intervening mechanisms change (Link & Phelan, 1995). This relationship is consistently observed across social groups, regions and periods. The mechanisms accounting for this relationship include greater exposure to stress and hardship and more limited access to valuable resources (e.g., food, housing, health care, and medical knowledge), which can help prevent and cure disease, among low SES individuals (George, 2005). In addition, this relationship is often best depicted as a continuous but nonlinear "gradient" in which benefits to health observed for a given increment in income are larger for individuals at the lower end of the income

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distribution than for those at the higher end (Daly, Duncan, Kaplan, & Lynch, 1998; Gravelle, 1998; Preston, 1975; Rodgers, 1979).

Fundamental cause theory assumes that the direction of causality is from SES to health. But selection effects also operate such that poor health can increase the probability of low or declining SES (e.g., Smith, 1999, 2005). Most research, however, indicates that the major causal direction is from SES to health. Nonetheless little is known about the possibility that macro-level socio-economic contexts may alter the relationship between individual-level SES and health.

Changing gradient of SES on health

Recent studies in demography, medical sociology and epidemiology have observed rising socioeconomic differentials in health in the U.S. in the past several decades (e.g., Feldman et al., 1989; Hummer et al., 1998; Meara, Richards, & Cutler, 2008; Pappas et al., 1993; Preston & Elo, 1995; Zheng & Land, 2012). For example, Pappas et al. (1993) report steeper increases in socioeconomic disparity in mortality differentials since 1960 and this result holds across gender, race and marital status. More recently, mortality differentials across socioeconomic statuses grew between 1990 and 2000 (Jemal, Ward, Anderson, Murray, & Thun, 2008; Meara et al., 2008). Research also has identified growing educational disparities in old-age disability (Schoeni, Martin, Andreski, & Freedman, 2005), disability-free life expectancy (Crimmins & Saito, 2001), and total life expectancy (Meara et al., 2008) over recent decades. Similarly, a trend toward widening gaps in self-rated health by educational levels for middle-aged and older adults has continued since the early 1980s (Goesling, 2007; Liu & Hummer, 2008) and for all ages among younger cohorts (Lynch, 2003; Zheng, Yang, & Land, 2011).

Health disparities also have widened across race, ethnicity and marital status. Racial gaps in mortality and life expectancy continue to widen, which are largely explained by a slower rate of decline among blacks than whites for heart disease, while HIV infection, diabetes, pneumonia and homicide decrease life expectancy more for blacks than whites (Kochanek, Maurer, & Rosenberg, 1994). With regard to marital status, in the past several decades male mortality differences between the married and unmarried have widened (Hummer et al., 1998; Smith, 1996), and women's self-rated health has improved more for the married than for the widowed, divorced and separated (Liu & Umberson, 2008). All these findings suggest that the relationship between SES and health is not fixed and that the strength and shape (i.e., linear or nonlinear) of the relationship may be shaped by contextual factors beyond individual characteristics and resources. As we demonstrate in the following section, one of these contextual factors may be income inequality.

Contextual effects, income inequality and health, and implications for health disparities

Although SES has been identified as a fundamental cause of health, the contextual effects approach suggests that we need to determine whether and how social conditions or social contexts affect this association. The contextual effects approach focuses on how the social context affects population or individual health. To link macro environmental characteristics to population and individual health is consistent with "medical sociologists' longstanding contention that characteristics of the societies in which we live influence health and well-being independent of individual resources, skills and behaviors" (McLeod, Nonnemaker, & Call, 2004: 249–250). The founder of sociology – Durkheim – demonstrated the utility and strength of contextual effects research through his original and marvelous study on suicide (Durkheim, [1897] 1951).

Income inequality is a potentially salient contextual factor and has been proposed as "an indicator and determinant of the *scale* of socioeconomic stratification in a society" (Wilkinson & Pickett, 2007: p. 1966, emphasis added) and an indicator of the extent of hierarchical and social differentiation across societies (or other geopolitical units). Early studies reported that income inequality negatively affects population and individual health (e.g., Kawachi, Kennedy, Lochner, & Prothrow-Stith, 1997; Wilkinson, 1992). Later research, however, disputed this conclusion (e.g., Beckfield, 2004; Mellor & Milyo, 2001). It is fair to say that despite nearly two decades of intense investigation, it remains unclear whether there is a significant, non-spurious relationship between income inequality and health.

Scholars who remain committed to the original argument have suggested and empirically examined three possible mechanisms linking income inequality to health (e.g., Kawachi & Kennedy, 1999). First, as income inequality increases, the wealthiest segment of society is posited to be less willing to invest in public services such as education and health care, which eventually harms the health of the poorest segment of the population and perhaps the middle class as well (Davey Smith, 1996; Dunn, Burgess, & Ross, 2005; Lynch, Davey Smith, Kaplan, & House, 2000). Second, income inequality tends to erode social cohesion, which also generates increased health risks, especially for the socioeconomically disadvantaged (Coburn, 2000; Kawachi et al., 1997). Third, high levels of income inequality increase relative deprivation, which creates high levels of stress among the deprived and endangers their health (Kawachi & Kennedy, 1999; Kondo, Kawachi, Subramanian, Takeda, & Yamagata, 2008; Wilkinson & Pickett, 2007).

The convention has been to examine only the direct effects of income inequality on health. Recently, however, some investigators have examined both the direct and interactive effects of income inequality on multiple health outcomes (e.g., Backlund et al., 2007; Mansyur, Amick, Harrist, & Franzini, 2008; Modrek, Dow, & Rosero-Bixby, 2012). The interaction of income inequality and individual income has been examined most frequently, with the specific hypothesis that the effects of individual income will be amplified under conditions of high income inequality. If public investment decreases, social cohesion decreases and relative deprivation increases under conditions of high income inequality, both the practical significance (e.g., for avoiding health risks and obtaining health care) and meaning of individual economic achievement may be more important than under conditions of relatively low income inequality. Race and gender interactions also have been estimated in a few studies (e.g., Subramanian & Kawachi, 2006; Zimmerman & Bell, 2006). But until now, no studies have *systematically* tested the interactive effects of income inequality and individual-level sources of disadvantage on health.

The theoretical rationale for the interactive effects is that higher income inequality will exacerbate social conditions (i.e., reduce public investment, decrease life opportunities, reduce social cohesion, and amplify relative deprivation), which will increase the importance of personal resources to maintain health. Therefore, disadvantaged groups will be harmed more by rising income inequality than advantaged groups. Consequently, we hypothesize significant socioeconomic, marital status, racial/ethnic, and gender interactions with income inequality such that increasing income inequality has stronger health effects on individuals in lower status positions than for those in higher status positions. An exception to this pattern may be gender. Because women have longer life expectancy than men and evidence suggests that they are less sensitive to income inequality and related mechanisms, e.g., relative deprivation (e.g., Eibner &

Evans, 2005; Jones & Wildman, 2008; Yngwe, Fritzell, Lundberg, Diderichsen, & Burstrom, 2003; Zheng, 2009), their relative advantage over men in the realm of physical health may widen with increasing income inequality.

Several researchers note that over the past few decades, income inequality in the United States has increased at the same time that rates of mortality and some chronic illnesses have declined. They question whether this is *prima facie* evidence that income inequality has not harmed health during that time period. This is clearly not the case, however, because rising income inequality could partially suppress general trends of improving health, declining disability, and increased longevity (Zheng, 2009). Moreover, SES, marital status, and racial/ethnic health disparities increased during the past 30 years in the U.S. (e.g., Warner & Hayward, 2006; Warren & Hemandez, 2007). Thus, some population subgroups have gained less from the overall trajectory of improving health than others. The stronger negative impact of income inequality on health for disadvantaged groups may help explain why SES and racial/ethnic health disparities have widened over the past decade despite overall increases in population health.

Hypotheses

In this study, we examine whether temporal trends in income inequality are accompanied by or lead to temporal trends in health and health disparities within a geographical unit, as this temporal approach can clearly portray the causal effect from income inequality to health (Subramanian & Kawachi, 2004) and minimize the possible confounding factors and incomparability of data problems prevalent in cross-national comparisons (Zheng, 2009). More specifically, we test the effects of national level income inequality, measured by the Gini coefficient, on physical functioning and activity limitations in the U.S. from 1984 to 2007 with a variety of individual-level SES and demographic characteristics statistically controlled. We also test the interactions of income inequality with individual SES indicators and demographic variables that represent bases of stratification/disadvantage. Our specific hypotheses are:

Hypothesis 1. Increasing income inequality over time is associated with increasing poor physical functioning and activity limitations.

This hypothesis is compatible with much previous research, but time rather than geo-political areas is the unit of analysis.

Hypothesis 2. Increasing income inequality will interact with SES (income, education, and employment status) and with gender, race/ethnicity, and marital status such that income inequality has stronger effects for the disadvantaged than for the advantaged.

The SES and demographic variables all measure forms of social advantage/disadvantage. We expect increasing income inequality to exacerbate the effects of disadvantage on physical functioning and activity limitations.

Methods

Data

The analysis focuses on the U.S. population from 1984 to 2007, examining how the gradient of socioeconomic status on physical functioning and activity limitations changes in the context of increasing income inequality. This analysis requires a multilevel dataset. The individual-level data come from the National Health Interview Survey (NHIS), conducted by the National Center for Health Statistics (NCHS). The macro-level data come from the U.S. Census Bureau (www.census.gov). Ethics approval was not required since this paper used secondary data lacking personal identifiable information.

The NHIS has been conducted annually since 1957. The NHIS involves a household survey, administered to a national probability sample of noninstitutionalized U.S. residents. One key dependent variable in this study, physical functioning, is a combination of the need for help with personal care and routine needs, and activity limitations. The 1984 survey was the first to include questions about the need for help with personal care and routine needs. Thus we use 24 waves of NHIS data from 1984 to 2007. Because of concerns about the accuracy and reliability of proxy reports, the sample is restricted to the primary respondent from each household although inclusion or exclusion of proxy reports do not yield significantly different findings. The average sample size, after excluding missing data and respondents under age 18, is roughly 25,332 people per year, yielding a total sample size of 607,959. Sampling weights are used throughout the analyses to account for the complex multistage cluster sampling design. We obtained data about income inequality (Gini coefficient and ratios of income deciles) from the U.S. Census Bureau.

Measures

Outcome variables

Physical functioning is a combination of two health measures: (1) need for help with personal care and routine needs and (2) activity limitations.

The question about the need for help with routine tasks asks respondents if they are able to perform instrumental activities of daily living (IADLs), including everyday household chores, necessary business, shopping, and getting around for other purposes. The question about personal care needs asks respondents if they are able to perform activities of daily living (ADLs), including eating, bathing, dressing, using the toilet, and getting around inside the home. Before 1997, the question about routine needs was combined with the question about personal care needs; response options were: 1. unable to perform personal care needs, 2. limited in performing other routine needs, 3. not limited in performing personal or routine needs. We recoded this variable as “0” unable to perform personal care needs or limited in performing other routine needs and “1” not limited in performing personal or routine needs. Since 1997, the routine needs question is asked separately from the personal care question; response options for each question are: 1. yes, need help, 2. no, do not need help. Because routine needs cannot be separated from personal care needs before 1997, we combined IADL and ADL information into one variable for data after 1997. Respondents who need help for any personal care or routine need were coded 0, otherwise, 1, yielding a comparable variable across all waves of data.

In terms of activity limitations, respondents were asked if they had any activity limitation. Those who were limited in any way were coded 0, otherwise, 1. Thus, consistent with the coding of the integrated variable ADL/IADL, a higher score represents better health or functioning.

Physical functioning was constructed based on these two health measures. Respondents who need help with personal care or routine needs, or have activity limitations, were coded 0 (i.e., poor physical functioning), otherwise 1 (i.e., good physical functioning). Another complication concerns the age ranges of respondents asked about personal care and routine needs. Prior to 1997, the ADL and IADL questions were asked of sample members age 18–69; after 1997, they were asked of all respondents. The activity limitations question, however, was asked of all age groups at all times of measurement. To maximize the number of cross-sectional surveys included in the analysis, we restricted the sample to individuals age 18–69. The percentage of respondents aged 18–69 reporting good physical functioning increased from 82.6% in 1984 to 86.4% in 2007.

Activity limitations. As described above, prior to 1997, questions about personal care and routine needs were asked only of respondents under 70 years of age. In order to include the oldest sample members, separate analyses based on all sample members aged 18 and older were performed using activity limitations as the dependent variable. In this sample, the percentage of respondents aged 18 and older having no activity limitations increased from 79.8% in 1984 to 82.6% in 2007.

Contextual variable

Income inequality. Income inequality can be measured in multiple ways (Allison, 1978). The most commonly used measure is the Gini coefficient, which is based on the Lorenz curve that displays the cumulative distribution function of total income that accrues across successive income intervals. If there is no income inequality, the curve is a straight line at a 45-degree angle. When there is income inequality, the curve falls below that line and the greater the inequality, the deeper the depth of the curve. The Gini coefficient ranges from 0 to 1, with higher values indicating higher levels of income inequality. The Gini coefficient for U.S. family income increased from .383 in 1984 to .432 in 2007. We also use ratios of income deciles to measure income inequality: 50th/20th, 80th/50th, 95th/50th, 95th/80th and 95th/20th. (In the NHIS, income is measured as family income, rather than household income. In line with U.S. Census Bureau guidelines, we use the above income ratios.)

Compositional variables

Family income. In the NHIS, income was measured using ordinal income categories that varied across times of measurement. We first calculated the mid-point of each income category and then converted the mid-point incomes to 2007 U.S. dollars. For example, the mid-point for income category $1000–$2000 was $1500, which was then adjusted to the appropriate value based on the 2007 Consumer Price Index. We also controlled the squared term of income because some research suggests that income inequality may only have a compositional effect, resulting from the simple cumulation of individual-level nonlinear relationships between income and health (Gravelle, 1998). In addition to using family income as a continuous variable, we also collapsed family income into three categories: below the 20th percentile, 20th–50th percentile, and above the 50th percentile. We had hoped to define more fine-grained categories at the top of the income distribution but were unable to do so because the highest income category is large and open-ended (e.g., $75,000 and higher).

Education. Before 1997, education was measured as years of formal education and ranged from 0 to 18. Since 1997, education has been measured as the highest level of formal schooling completed. To achieve a consistent metric, we converted level of schooling since 1997 to years of education: never attended/kindergarten only = 0, grades 1–11 = 1–11, 12th grade/high school graduate/GED or equivalent = 12, some college with no degree = 13, AA degree: technical or vocational/AA degree: academic program = 14, bachelor's degree (BA, AB, BS, BBA) = 16, Master's degree/Professional degree/Doctoral degree = 18. We also constructed a three-category measure of education: college graduate (16 or more years of formal schooling completed), high school graduate (12–15 years of schooling), and less than high school (fewer than 12 years of schooling) (Goesling, 2007). These alternate measures allow us to determine whether education's effect on health is specific to the way education is measured.

Work Status is a binary variable in which 1 = full/part time job and 0 = not employed.

Gender is a binary variable (1 = male). *Race* also is coded dichotomously (1 = white, 0 = non-white). *Marital Status* is a binary variable in which 1 = married. *Age* was coded in years. *Age squared* was included to capture the non-linear component of the relationship between age and the outcome variables.

We also created a dummy variable named "post-1997" (1984–1996 = 0, 1997–2007 = 1) to adjust the regression model estimates for any effects of changes in question framing and response options.

Statistical procedures

As noted above, the age ranges for the outcome variables differed across survey years. To ensure that the analyses are not biased by this issue, we examine two outcome variables: physical functioning (age 18–69) and activity limitations (age 18 and over). Because physical functioning and activity limitations are binary variables, we used a binary logit model with robust cluster technique to conduct the analysis (Jain & Dubes, 1988). This estimation allows corrections of error terms to account for correlated observations within years.[1]

Equation (1) presents the empirical model used for studying physical functioning and activity limitations using the binary logit model, where socioeconomic status indicators, race, sex, and marital status are interacted with the Gini coefficient:

$$\log[p/(1-p)] = \beta_0 + \beta_1(\text{Gini}) + \beta_2(\text{Year}) + \beta_3(\text{Age}) + \beta_4(\text{Age}^2) + \beta_5(\text{Male}) + \beta_6(\text{White}) + \beta_7(\text{Married}) + \beta_8(\text{Education}) + \beta_9(\text{Work}) + \beta_{10}(\text{Income}) + \beta_{11}(\text{Gini*Education}) + \beta_{12}(\text{Gini*Work}) + \beta_{13}(\text{Gini*Income}) + \beta_{14}(\text{Gini*Male}) + \beta_{15}(\text{Gini*White}) + \beta_{16}(\text{Gini*Married}) \quad (1)$$

The results present unstandardized logistic regression coefficients for the explanatory variables. Prior research suggests that (1) β_1 should be negative (i.e., income inequality harms health) and (2) β_6, β_7, β_8, β_9, and β_{10} should be positive (i.e., white race, being married, and higher socioeconomic status are associated with better physical health). We also hypothesize that β_{11}, β_{12}, β_{13}, β_{15}, and β_{16} will be positive; that is, rising income inequality will increase the protective effects of socioeconomic status, white race and being married on physical health. An exception to this pattern is gender. Because women have longer life expectancy and less harmed by income inequality than men, we would expected negative β_5 and β_{14}.

Results

Trends of income inequality, 1984–2007

Fig. 1 portrays the trends of income inequality in the U.S. from 1984 to 2007. Generally, all the measures of income inequality indicate that income inequality increased over time, especially for the 95th/20th ratio, the 95th/50th ratio, and the Gini coefficient. The 95th/50th ratio reflects the trend in overall inequality

[1] We do not use a multilevel model in which year is treated as a random effect because we need to treat year as a fixed effect to capture the temporal trends of physical functioning and activity limitations. Robust cluster technique can account for the correlation among observations within years without compromising the fixed effect of years.

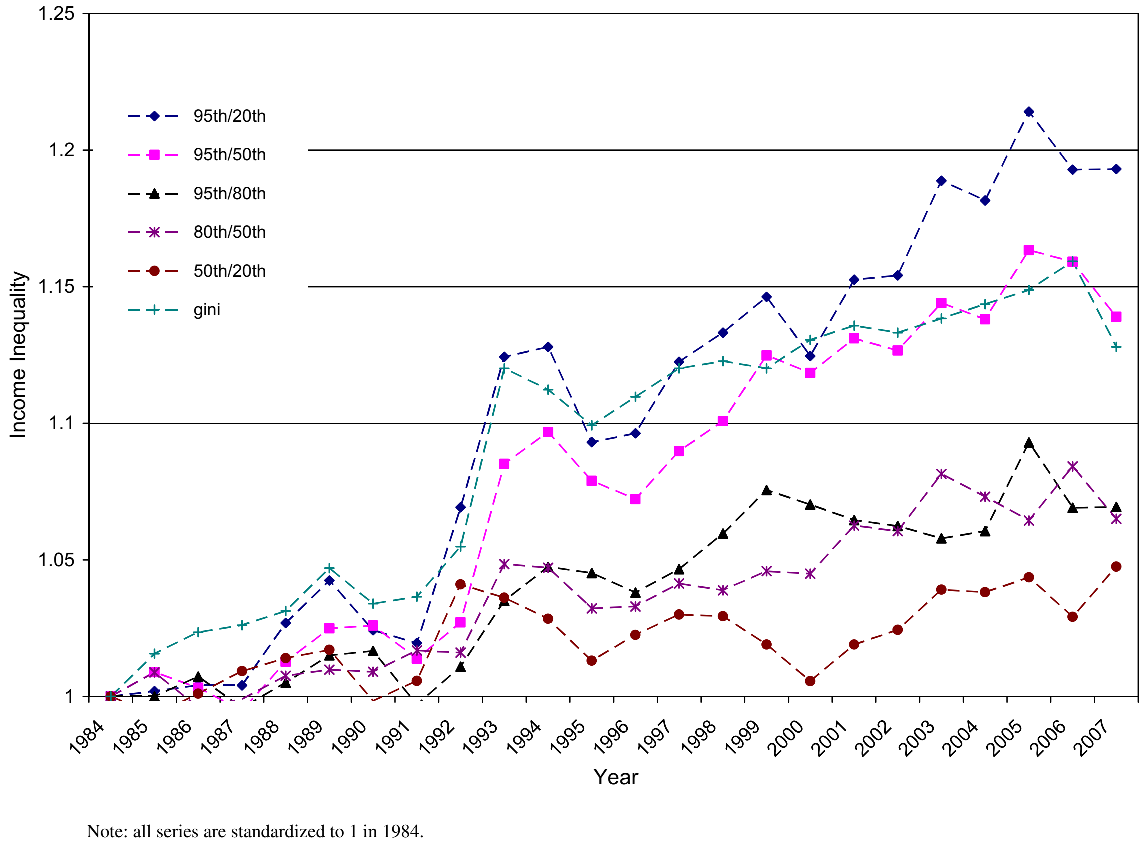

Fig. 1. Trends in Gini coefficient and ratios of income deciles for families, 1984–2007. *Source*: U.S. Census Bureau (www.census.gov).

measured by the Gini coefficient. Families at the 95th percentile pulled away from those at the 80th percentile at a similar rate at which families at the 80th percentile pulled away from those at the 50th percentile. In contrast, the middle class (at the 50th percentile) did not improve as much as other groups. As a result, the 50th/20th ratio increases only slightly over time. These trends indicate that affluent families' rising incomes largely propelled the growing income inequality observed since 1984 (Western, Bloome, & Percheski, 2008).

Increasing protective effects of SES

The results in Table 1 demonstrate how changing income inequality affects the gradient of individual-level risk factors on physical functioning. Model 1 includes only the Gini coefficient and year and shows that the log odds of having good physical functioning increase over time, but this trend is suppressed to some extent by increasing income inequality. Every .01 unit increase in the Gini coefficient substantially decreases the odds of good physical functioning by 4.99% ($(1 - e^{-5.12*.01})*100$). The dramatic increase in the Gini coefficient from 1984 to 2007 decreases the odds of good physical functioning by 22.2% overall ($(1 - e^{-5.12*.049})*100$).[2] The log odds ratios for other models in this and subsequent tables can be similarly interpreted.

Models 2 and 3 control for individual-level risk factors. Model 2 adds age, age squared, sex, race, and marital status to the equation. Increasing age is significantly and negatively related to good physical functioning. Both white race and being married significantly increase the log odds of good physical functioning. Gini coefficient and year remain significant countervailing predictors.

In Model 3 the SES indicators are added to the model. The effects of Gini coefficient, year, age, and marital status remain significant and in the same direction as in Model 2. Age squared also is significant in this model, indicating that the negative relationship between age and good physical functioning levels off or reverses slightly at older ages. This pattern likely reflects the effects of selective survival of the most robust members of the older cohorts. The direction of the coefficient for race changes across Models 2 and 3. In Model 2, white race was associated with better physical functioning; in Model 3, white race is associated with poorer physical functioning. This change suggests that were it not for the benefits of higher SES, whites would have poorer physical functioning than non-whites. Gender becomes a significant predictor when SES indicators are included in the model, with men less likely to report good physical functioning. Being a man significantly decreases the odds of good physical functioning by about 23% ($(1 - e^{-.261})*100$). The change in statistical significance between Model 2 and Model 3 suggests that men's higher average socioeconomic status was suppressing the negative relationship between sex and the dependent variable. All four SES indicators are significant predictors of good physical functioning. As expected, education, family income, and work status are positively related to good physical functioning. Regarding education, each year of additional education is associated with a statistically significant 2%

[2] As indicated in Model 1, every unit increase in the Gini coefficient decreases the odds of good physical health by 99.4% ($(1 - e^{-5.12})*100$). The Gini coefficient is .432 in 2007 and .383 in 1984, so the change between 1984 and 2007 is .049. The .049 unit increase in the Gini coefficient decreases the odds of good physical health by ($1 - e^{-5.12*.049}$) (Long, 1997). Multiplying by 100 is for ease of interpretation.

Table 1
Unstandardized coefficients for binary logit regression of physical functioning on Gini coefficient, SES and other explanatory variables (respondents aged 18–69).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Gini	−5.120* (2.611)	−6.660** (2.569)	−5.066* (2.557)	−10.833*** (2.118)	−9.651*** (1.552)	−13.189*** (1.713)
Year	.034*** (.008)	.041*** (.008)	.037*** (.007)	.040*** (.007)	.013** (.004)	.018*** (.004)
Age		−.057*** (.006)	−.202*** (.006)	−.201*** (.006)	−.200*** (.006)	−.195*** (.006)
$Age^2/100$		.003 (.006)	.175*** (.007)	.173*** (.007)	.172*** (.007)	.168*** (.007)
Male		.013 (.014)	−.261*** (.017)	.647*** (.192)	.323 (.171)	.393* (.180)
White		.163*** (.010)	−.175*** (.012)	−.334 (.245)	−.433 (.242)	−.378 (.212)
Married		.586*** (.039)	.242*** (.040)	−2.994*** (.459)	−3.205*** (.462)	−3.356*** (.467)
Education			.020*** (.003)	.178*** (.039)	.187*** (.036)	
Income/1000			.030*** (.001)	.001 (.005)	.006 (.004)	
$(Income/1000)^2$			−.0001*** (.000)	−.0001*** (.000)	−.0001*** (.000)	
Employed			1.427*** (.043)	−1.389** (.513)	−1.558** (.509)	−1.557** (.514)
Gini*education				−.380*** (.093)	−.400*** (.084)	
Gini*income				.070*** (.012)	.060*** (.011)	
Gini*employed				6.811*** (1.284)	7.232*** (1.270)	7.329*** (1.286)
Gini*male				−2.084*** (.465)	−1.273** (.412)	−1.451*** (.432)
Gini*white				.383 (.598)	.621 (.597)	.523 (.523)
Gini*married				7.784*** (1.153)	8.321*** (1.161)	8.822*** (1.172)
High school						1.752*** (.269)
College						.236 (.309)
20th–50th income group						.219 (.171)
Above 50th income group						.202 (.285)
Gini*high school						−3.916*** (.648)
Gini*college						.296 (.732)
Gini*20th–50th						.955* (.416)
Gini*above 50th						1.903** (.695)
Post-1997					.369*** (.032)	.440*** (.038)
Constant	−63.530*** (15.391)	−76.245*** (14.086)	−66.230*** (13.008)	−69.716*** (13.493)	−16.519* (7.714)	−25.503*** (7.896)
Pseudo R^2	.003	.090	.192	.194	.195	.193

***$p < .001$, **$p < .01$, *$p < .05$.
Note: Numbers in parentheses are robust standard errors.

($(e^{.02} - 1)*100$) increase in the odds of good physical functioning. Having a job is associated with a statistically significant 3 times ($e^{1.427} - 1$) increase in the odds of good physical functioning. Finally, every $1000 increase in family income is associated with a statistically significant 3% ($(e^{.03} - 1)*100$) increase in the odds of good physical functioning. But the effect of family income on health is curvilinear and peaks at approximately $150,000 as the coefficient for income squared is negative. After including income squared in the model, the Gini coefficient still exerts a significant negative effect on good physical functioning, which suggests that income inequality has a contextual rather than compositional effect on health.

Model 4 includes the interaction terms of the SES indicators and demographic characteristics with the Gini coefficient. The main effects of the Gini coefficient, year, age, age squared, education, and income squared remain significant and in the same direction as in Model 3. The coefficient for white race remains negative, but is no longer statistically significant. The previously positive main effects of family income and work status are now non-significant or negative. But the positive coefficients for the interactions of income and work status with the Gini coefficient are significant, indicating that the positive effects of family income and work status on physical functioning increase as income inequality increases. At first glance, the significant and negative effect of the interaction of education with the Gini coefficient appears anomalous. It is often the case, however, that the effects of education or income will be counter to expectations when both variables are in the same model. The main effect of marital status also has reversed. The interaction of marital status with the Gini coefficient is positive and significant, however, suggesting that the protective effects of being married increase during conditions of high income inequality. The coefficient for sex has reversed direction. But the interaction of sex and the Gini coefficient is significant and negative, indicating that men are especially disadvantaged in physical functioning when income inequality is high. Model 5 adjusting for "post-1997" does not yield substantial different findings.

Model 6 includes the interactions between education and income categories and the Gini coefficient. The main effects of the Gini coefficient, year, age, age squared, being male, being married, and employment status remain significant and in the same directions as in Model 5. The interactions of the Gini coefficient with employment status, sex, race, and marital status also are the same as those in Model 5 in direction and significance. With regard to education, the main effect of a high school degree, as compared to less than a high school degree is significant and positive. The main effect of a college degree or more, however, is not significant. The interaction of the Gini coefficient with a high school degree is significant and, unexpectedly, negative suggesting that the advantage of having a high school degree over less than a high school degree in physical functioning decreases when income inequality increases. The interaction of the Gini coefficient with a college degree or higher is non-significant. The main effects of the two income groups are not significant. The interactions of both income groups with the Gini coefficient, however, are significant and positive. These interactions suggest that the health disparities between these two groups and the reference group (Below 20th) become significantly larger under conditions of high income inequality.

Given the difficulty of explaining the coefficients of interaction terms in logistic regression models, we plot the predicted probabilities to visually describe how rising income inequality affects the gradients of socioeconomic status on physical functioning – which also sheds light on the increasing health inequality observed in the U.S. over the past two decades. Based on Model 6 in Table 1, the predicted probabilities were calculated by letting the Gini coefficient linearly rise from .383 to .432, constraining the explanatory variable to a certain value (e.g., Employed = 1), while keeping other variables constant at their means. Figs. 2 and 3 show the predicted

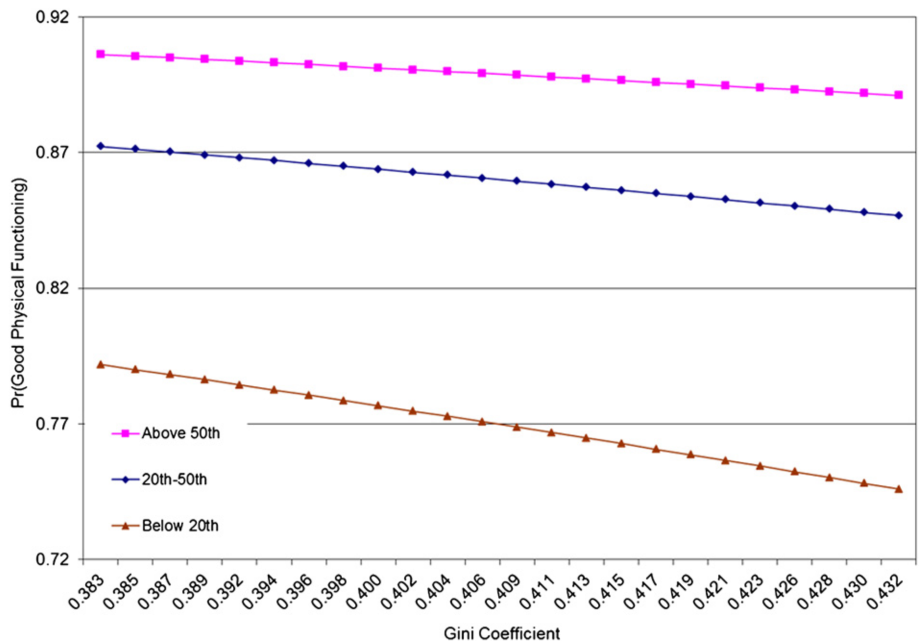

Fig. 2. Predicted probabilities for good physical functioning for people with different family income levels in the context of rising income inequality from 1984 to 2007.

probabilities of having good physical functioning for people with different levels of family income and different employment status in the context of rising income inequality from 1984 to 2007. People at all income levels and employment statuses are negatively affected by rising income inequality – i.e., probabilities of good physical functioning are lower under conditions of high income inequality. At the same time, however, the protective effects of income and being employed are larger under conditions of high income inequality. Consequently, income inequality is especially harmful for people with lower incomes and the unemployed, producing larger overall health disparities.

In contrast, the negative coefficient for the interaction between education and Gini in Model 5 suggests that the positive effect of education on physical functioning decreases with increasing income inequality. In other words, increasing income inequality has reduced the magnitude of education's protective effects for health. Model 6 differentiates education on the basis of highest degree (less than high school, high school, college degree or higher) rather than years of schooling. The significant negative coefficient for "Gini*High School" and non-significant positive coefficient for "Gini*College" suggest that high school's protective effect on health decreases when the Gini coefficient increases, while college's

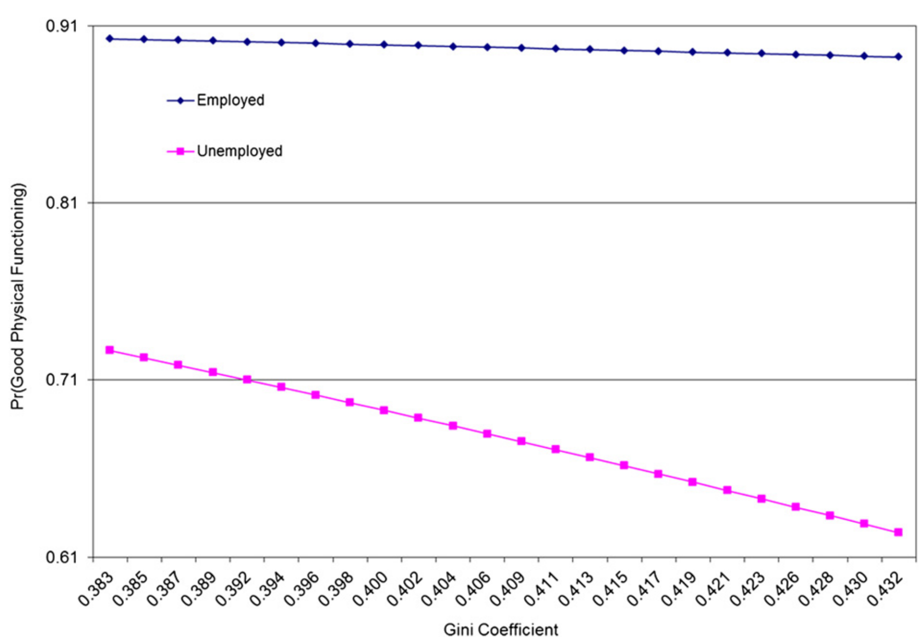

Fig. 3. Predicted probabilities for good physical functioning for people employed and unemployed in the context of rising income inequality from 1984 to 2007.

protective effect does not (although the latter also doesn't increase with rising income inequality). The top panel of Fig. 4 clearly portrays these two changing effects. The health gap between high school graduates and people without high school degrees narrows over time, while the gap between college graduates and people without high school degrees slightly widens.

Table 1 was based on respondents aged 18–69. To examine whether the results in Table 1 are applicable to the entire age range of American adults, in Table 2 we present the same explanatory models as in Table 1 for activity limitations. The dependent variable is coded such that higher scores represent the absence of activity limitations. Consistent with Table 1, (1) the Gini coefficient, being a man, white and older decrease the log odds of having no activity limitation, while being highly educated, married, having a job and higher income are positively related to "no activity limitation;" (2) the protective effects of income, employment, and being married increase with rising income inequality; and (3) the negative effect of being a man on "without any activity limitation" becomes stronger with increasing income inequality. The interaction terms "Gini*High School" and "Gini*-College" suggest that a college degree or higher's protective effect against activity limitations significantly increases as income inequality increases, but being a high school graduate does not. Fig. 4b clearly illustrates these two effects.

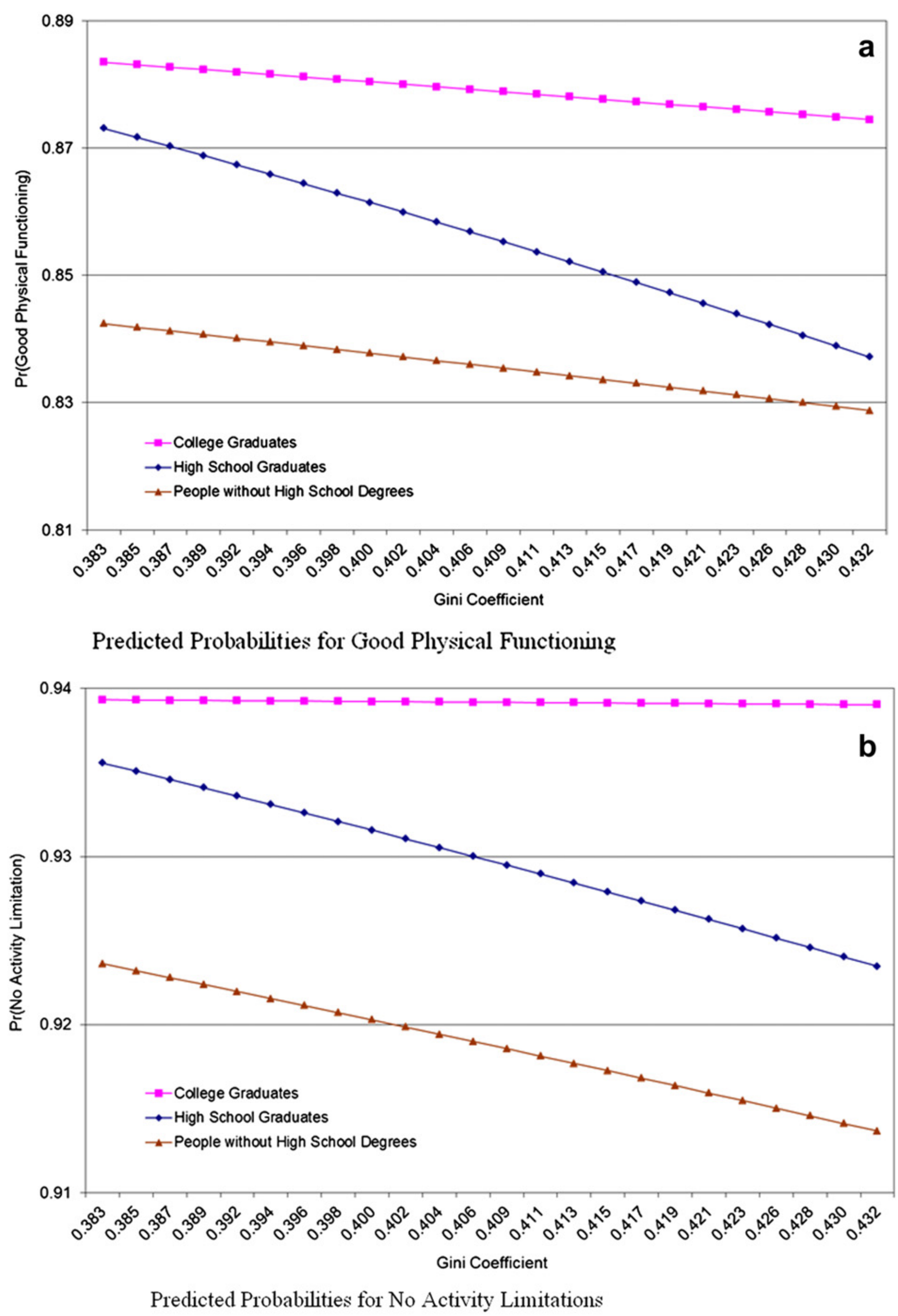

Fig. 4. Predicted probabilities for good physical functioning or no activity limitations for people with different educational levels in the context of rising income inequality from 1984 to 2007.

Table 2
Unstandardized coefficients for binary logit regression of absence of activity limitations on Gini coefficient, SES and other explanatory variables (respondents aged 18 and older).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Gini	−4.137* (2.098)	−4.958** (1.823)	−4.061* (1.719)	−12.883*** (1.233)	−12.040*** (1.784)	−13.167*** (1.715)
Year	.025*** (.006)	.029*** (.005)	.023*** (.005)	.026*** (.005)	.008* (.004)	.014*** (.004)
Age		−.077*** (.002)	−.143*** (.002)	−.144*** (.002)	−.143* (.002)	−.140*** (.001)
$Age^2/100$		.030*** (.002)	.112*** (.002)	.113*** (.002)	.113*** (.002)	.110*** (.002)
Male		−.011 (.011)	−.212*** (.014)	.598*** (.176)	.412* (.165)	.472** (.174)
White		.185*** (.008)	−.104*** (.010)	.117 (.188)	.045 (.198)	.172 (.181)
Married		.505*** (.035)	.219*** (.036)	−3.103*** (.435)	−3.201*** (.436)	−3.292*** (.430)
Education			.022*** (.002)	.041 (.035)	.050 (.034)	
Income/1000			.028*** (.001)	−.0002 (.004)	.003 (.004)	
$(Income/1000)^2$			−.0001*** (.000)	−.0001*** (.000)	−.0001*** (.000)	
Employed			1.294*** (.035)	−2.461*** (.643)	−2.550*** (.639)	−2.492*** (.647)
Gini*education				−.044 (.082)	−.065 (.081)	
Gini*income				.066*** (.010)	.062*** (.009)	
Gini*employed				9.088*** (1.586)	9.313*** (1.577)	9.279*** (1.596)
Gini*male				−1.847*** (.425)	−1.383*** (.397)	−1.529*** (.418)
Gini*white				−.530 (.459)	−.355 (.484)	−.612 (.440)
Gini*married				7.994*** (1.094)	8.245*** (1.098)	8.589*** (1.082)
High school						.587** (.208)
College						−.756* (.325)
20th–50th income group						−.026 (.191)
Above 50th income group						−.187 (.238)
Gini*high school						−1.055* (.494)
Gini*college						2.619*** (.779)
Gini*20th–50th						1.329** (.459)
Gini*above 50th						2.520*** (.581)
Post-1997					.236*** (7.725)	.290*** (.037)
Constant	−45.978*** (11.367)	−51.307*** (9.390)	−40.878*** (8.971)	−41.8461*** (9.559)	−8.165 (7.725)	−17.549* (8.010)
Pseudo R^2	.001	.109	.185	.187	.188	.186

***$p < .001$, **$p < .01$, *$p < .05$.
Note: Numbers in parentheses are robust standard errors.

Sensitivity analyses

Different measures of income inequality

In addition to examining the effect of the Gini coefficient on the gradients of individual characteristics on health, we also checked the robustness of the results by replacing the Gini coefficient with several ratios of income deciles. Results in Appendix I show similar patterns to Tables 1 and 2, which suggest that our findings are robust to different measures of income inequality.

Different functions of time period

We also tried different functions of time period to minimize the possible temporal-related confounders that may contribute to the direct and indirect contextual effects of income inequality. First, we included quadratic and cubic functions of time periods which however were removed from estimation due to multicollinearity problems. Second, we created time dummies based on either presidential cycle or economic recession cycle. Appendix II shows that these two types of time dummies do not change the findings.

Accounting for macro globalization trend

Some research suggests the rising income inequality in the U.S. in recent decades may be a result of globalization (e.g., outsourcing, international trade) (Krugman, 2008; Miller, 2001) although other researchers reject this argument (e.g., Irwin, 2008; Katz, 2008). Our study does not intend to unfold the relationship between globalization and income inequality, but it is still important to account for this macro globalization trend. This is important because if macro globalization affects both income inequality and individual health, ignoring this factor may yield a spurious correlation between income inequality and health. Appendix III presents the significant direct and indirect contextual effects of the Gini coefficient after controlling for four indicators of globalization (exports of goods and services as % of GDP, trade as % of GDP, FDI (foreign direct investment) net inflows as % of GDP, and FDI net outflows as % of GDP) and one indicator of the impact of globalization: unemployment rate.

Discussion

Using National Health Interview Survey data and U.S. Census Data, this study examined the extent to which income inequality, as an indicator of social context, affects the gradient of socioeconomic status on physical functioning and activity limitations in the U.S. from 1984 to 2007. The results of binary logit models with clustering technique indicate that increasing income inequality strengthens the protective effects of family income, employment, college education, and marriage on physical functioning and the absence of activity limitations. In contrast, high school education's positive effect weakens in the context of increasing income inequality. In addition, we found that increasing income inequality exacerbates men's disadvantage in physical functioning and activity limitations.

Significant interactions between income inequality and individual income were also found in some extant studies (e.g., Kahn, Wise, Kennedy, Kawachi & et al, 2000). In addition, a significant interaction was observed in one study in which the main effect of income inequality was non-significant (Mansyur et al., 2008). All the significant interactions indicated that the effects of income inequality on health were stronger among the lower income subgroup except one study, which reported that income inequality led to worse mental health among the most affluent individuals, but that the opposite was true for lowest income individuals (Weich, Lewis, & Jenkins, 2001). Overall, our results are compatible with the majority of previous research. In addition, however, we examined five other status characteristics – education, employment status, sex, race, and marital status – and generally observed similar patterns of wider health disparities under conditions of high income inequality.

We can only speculate on the mechanisms by which increasing income inequality amplifies the effects of income, college education, and employment status on health. One possibility is that income inequality results in underinvestment in human resources and social goods, while intensifying social comparisons and subsequent psychological stress and frustration. As increasing income inequality exacerbates these disadvantageous social conditions, personal resources, especially socioeconomic status, increase in importance as tools for accessing social and health resources.

The results also indicate that increasing income inequality exacerbates men's disadvantage in physical functioning and activity limitations. A possible explanation for this pattern may be gender differences in social networks and social positions in society (Zheng, 2009). First, men may be embedded in more competitive settings than women. Consequently, feelings of relative deprivation may be stronger for men than for women. Rising income inequality may increase feelings of relative deprivation, thus harming health more for men than for women. Second, income inequality may generate gender-specific stressors that are more harmful for men than for women. Some research finds that women are more likely to encounter and are more vulnerable to interpersonal stressors or "network" events (i.e., life events that happen to significant others rather than the respondent), e.g., illness and death of friends or family members (Kessler & McLeod, 1984; Maciejewski, Prigerson, & Mazure, 2001). In contrast, men are more likely to encounter and are more vulnerable to legal and work-related stressful life events, e.g., job loss, legal problems, robbery, and work problems (Kendler, Thornton, &Prescott, 2001; Siegler & George, 1983). Income inequality is positively associated with higher rates of violence, imprisonment, and unemployment (Kaplan, Pamuk, Lynch, Cohen, & Balfour, 1996), all of which involve more men than women. Therefore, it is possible that increasing income inequality is more likely to generate work-related and legal stressors than interpersonal stressors and, thus, harm men's health more than women's.

In addition, we found that the positive effect of being married on physical functioning and the absence of activity limitations strengthens in the context of higher income inequality. It is possible that the effects of social support on health may be stronger under conditions of relatively high income inequality. Another possible mechanism, compatible with the findings reported here, is that rising income inequality increases the importance of family income for health. Married persons usually have higher family income than non-married persons. Note, that in this study, however, the effects of marital status were significant net of family income.

This study tests the direct and indirect contextual effects of national level income inequality. Theoretically, it is arguable whether income inequality at the national level is the best way to investigate these effects although some research suggests national income inequality matters more than local social hierarchies (Wilkinson & Pickett, 2006) as people tend to compare themselves with the rest of society, e.g., "rural person comparing themselves with a Wall Street banker" (Kondo et al., 2012) than with their neighbors. And this societal comparison is especially "toxic". Empirically, focusing on national level rather than state level should not yield significantly different findings as we examine how the temporal trend of income inequality may be related to the temporal trend of health outcomes and the overall trends of Gini coefficient are remarkably similar across states (see Appendix IV).

Although this study provides strong support for the hypothesis that individual resources increase in importance as income inequality increases, several important issues need to be resolved in future research. First, due to data limitations, we could not have a fine-grained top category of income. The top category ends at $75,000 and higher. It is likely that income inequality may have only a trivial impact on the richest, which would further enlarge the health disparities between the richest and poorest. Second, the potential mechanisms by which income inequality affects health need strong empirical tests. Given the limitations of the data available, we can only speculate about possible explanations. Third, although physical functioning and activity limitations are widely-used and reliable measures of general health status, the contextual effects of income inequality on the relationship between individual factors and other specific health outcomes should be examined in future research. Fourth, the health outcomes examined in this paper were dichotomous and, thus, relatively crude. It would be informative to include continuous measures of health in future research. Fifth, cross-national studies also are an important priority for future research. The Gini coefficient is much higher in the U.S. than in other developed countries where it is usually lower than .4. Further research is needed to determine whether temporal changes in income inequality in other societies have effects similar to those observed in this study. It also would be valuable to test opposite trends in income inequality – that is whether decreasing income inequality has positive effects on health and/or changes the effects of individual-level characteristics and resources. Sixth, this study is based on pooled cross-sectional data. Replicating the analyses with longitudinal data would be informative.

This study has made four significant contributions to the literature. First, our findings demonstrate the utility of studying the links between income inequality and health over time in the same country. This research design avoids the problems of historical and cultural differences that affect cross-national studies. Second, our results emphasize that although socioeconomic status is a fundamental cause of health or disease (Link & Phelan, 1995), its effect is not fixed across different social contexts, especially varying levels of income inequality. Our contextual effect approach suggests that we need to determine the social conditions or social context under which the SES-health association exists or changes. This approach is consistent with sociologists' essential idea that the macro social environment influences individual-level correlations. Third, the results indicate that income inequality, as a social context, has an interactive contextual effect, which determines the significance of individual-level risk factors – including income, education, employment status, gender, and marital status – on two health outcomes. Fourth, the findings shed light on research about growing health disparities in the U.S. in the last several decades. A series of demographic and epidemiological studies have documented the increasing socioeconomic inequality in health, disability, mortality, and life expectancy in the U.S. in the past several decades (e.g., Feldman et al., 1989; Goesling, 2007; Hummer et al., 1998; Meara et al., 2008; Pappas et al., 1993; Preston & Elo, 1995; Schoeni et al., 2005). Our findings indicate rising income inequality may contribute to the widening health disparities.

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Appendix

Appendix I
Unstandardized coefficients for binary logit regression of physical functioning on ratios of income deciles, SES and other explanatory variables (respondents aged 18–69).

	Model 1	Model 2	Model 3	Model 4	Model 5
95/20 ratio	−.637*** (.192)				
50/20 ratio		−3.709*** (1.093)			
80/50 ratio			−3.848* (1.854)		
95/50 ratio				−1.043 (.671)	
95/80 ratio					−2.186 (1.362)
Year	.052** (.013)	.036*** (.004)	.041** (.013)	.038* (.017)	.029** (.009)
Ratio*education	−.015*** (.005)	−.166** (.674)	−.132*** (.038)	−.038*** (.011)	−.120** (.039)
Ratio*20th–50th	.041 (.022)	.220 (.399)	.328 (.180)	.094 (.056)	.269 (.201)
Ratio*above 50th	.133*** (.037)	1.459** (.516)	1.146*** (.342)	.327*** (.095)	.993*** (.300)
Ratio*employed	.356*** (.056)	2.779** (1.069)	3.138*** (.561)	.949*** (.142)	3.066*** (.456)
Ratio*male	−.100*** (.029)	−.563 (.389)	−.831** (.308)	−.288*** (.083)	−1.017*** (.281)
Ratio*white	.020 (.025)	.250 (.257)	.056 (.255)	.043 (.067)	.221 (.201)
Ratio*married	.399*** (.050)	2.833** (1.003)	3.461*** (.484)	1.076*** (.123)	3.527*** (.440)
Pseudo R^2	.191	.190	.191	.191	.191

***$p < .001$, **$p < .01$, *$p < .05$.
Notes:
1. Numbers in parentheses are robust standard errors.
2. The "Ratio" in the interaction terms between "Ratio" and SES and demographic characteristics refers to 95/20 ratio in Model 1, 50/20 ratio in Model 2, 80/50 ratio in Model 3, 95/50 ratio in Model 4, and 95/80 ratio in Model 5.
3. All models controlled for age, age squared, gender, race, marital status, education, income group dummies, and employment status. To save space, the coefficients of these covariates are omitted.

Appendix II
Accounting for different time functions.

		Model 1	Model 2
Presidential cycle	1984 (reference)		
	1985–1989	−.032 (.022)	
	1989–1993	−.048 (.041)	
	1993–1997	−.105 (.088)	
	1997–2001	.278** (.091)	
	2001–2005	.320** (.107)	
	2005–2007	.373*** (.110)	
Recession cycle	1984–1989 (reference)		
	1990–1991 recession		.019 (.021)
	1992–2000		−.012 (.022)
	2001 recession		−.025 (.042)
	2002–2007		.079 (.044)
	Gini	−4.743* (2.228)	−6.474*** (1.304)
	Gini*education	−.400*** (.084)	−.420*** (.035)
	Gini*income	.060*** (.011)	.062*** (.011)
	Gini*employed	7.232*** (1.270)	7.278*** (1.276)
	Gini*male	−1.273** (.412)	−1.214** (.418)
	Gini*white	.621 (.597)	.598 (.587)
	Gini*married	8.321*** (1.161)	8.329*** (1.161)
Pseudo R^2		.195	.195

***$p < .001$, **$p < .01$, *$p < .05$.
Notes:
1. Numbers in parentheses are robust standard errors.
2. Both models controlled for age, age squared, gender, race, marital status, education, income, income squared, employment status, and "post-1997". To save space, the coefficients of these covariates are omitted.

Appendix III
Accounting for macro globalization trend.

	Model 1	Model 2	Model 3	Model 4	Model 5
Unemployment rate	.009 (.009)				
Exports of goods and services (% of GDP)		−.022*** (.007)			
Trade (% of GDP)			−.004 (.009)		
Foreign direct investment, net inflows (% of GDP)				.006 (.015)	
Foreign direct investment, net outflows (% of GDP)					−.014 (.011)
Year	.013*** (.004)	.016*** (.003)	.015* (.006)	.013** (.004)	.013*** (.004)
Gini	−9.547*** (1.448)	−9.028*** (1.515)	−9.672*** (1.528)	−9.749*** (1.587)	−9.540*** (1.574)
Gini*education	−.403*** (.085)	−.416*** (.085)	−.401*** (.086)	−.399*** (.085)	−.401*** (.084)
Gini*income	.060*** (.011)	.061*** (.011)	.060*** (.011)	.060*** (.011)	.061*** (.011)
Gini*employed	7.241*** (1.270)	7.266*** (1.276)	7.235*** (1.270)	7.229*** (1.270)	7.238*** (1.273)

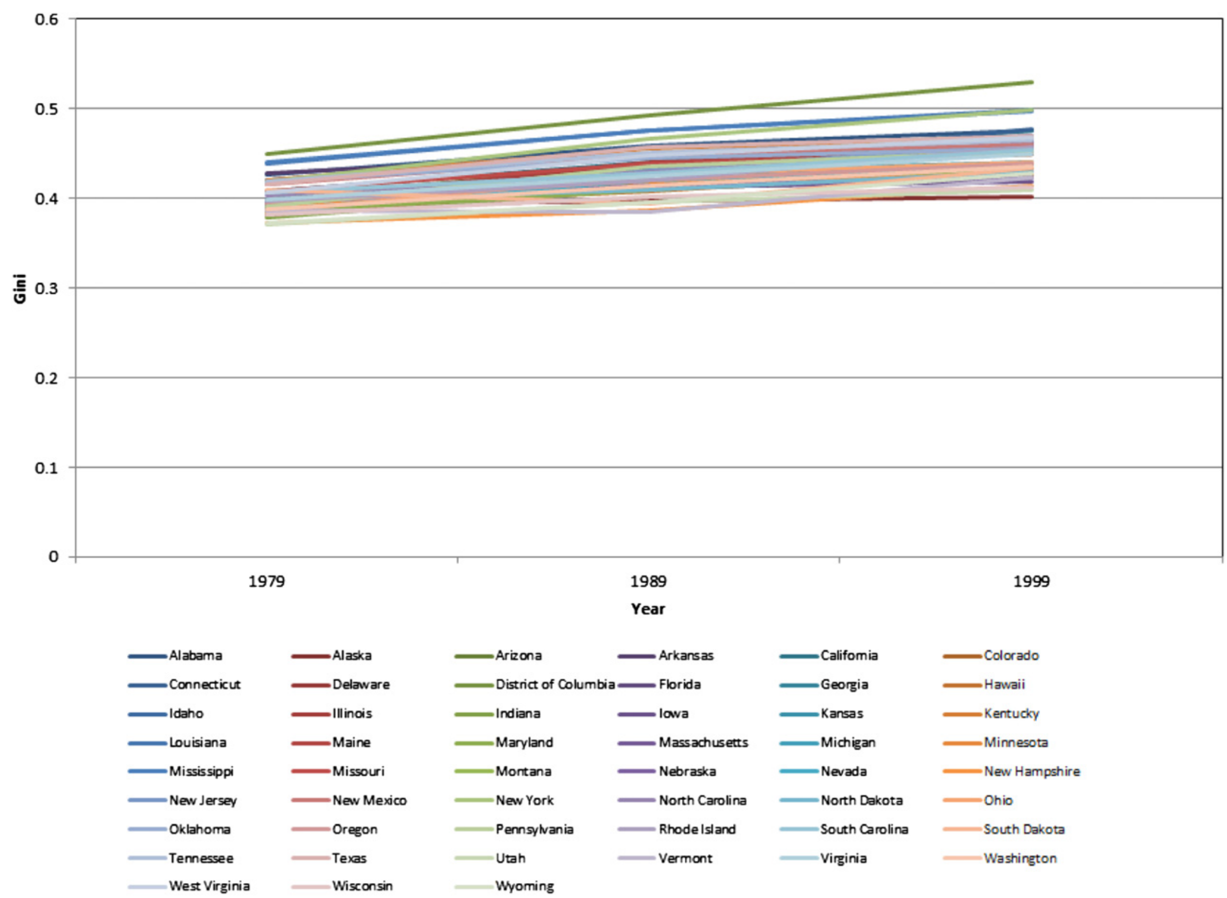
Appendix III (*continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5
Gini*male	−1.259** (.418)	−1.212** (.415)	−1.270** (.413)	−1.278** (.414)	−1.262** (.414)
Gini*white	.629 (.596)	.595 (.596)	.612 (.590)	.624 (.595)	.615 (.596)
Gini*married	8.331*** (1.160)	8.344*** (1.166)	8.324*** (1.162)	8.318*** (1.159)	8.327*** (1.163)
Pseudo R^2	.195	.195	.195	.195	.195

***$p < .001$, **$p < .01$, *$p < .05$.

Notes:

1. Numbers in parentheses are robust standard errors.
2. All models controlled for age, age squared, gender, race, marital status, education, income, income squared, employment status, and "post-1997". To save space, the coefficients of these covariates are omitted.



Note: Census website only provided state-level Gini coefficient for three time points.

Appendix IV. Trends in Gini coefficient across U.S. states, 1979–1999. From U.S. Census Bureau.

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