Income Inequality and Population Health: A Global Gradient?

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Abstract

Cross-national empirical research about the link between income inequality and population health produces conflicting conclusions. We address these mixed findings by examining the degree to which the income inequality and health relationship varies with economic development. We estimate fixed effects models with different measures of income inequality and population health. Results suggest that development moderates the association between inequality and two measures of population health. Our findings produce two generalizations. First, we observe a global gradient in the relationship between income inequality and population health. Second, our results are consistent with income inequality as a proximate or conditional cause of lower population health. Income inequality has a 139.7% to 374.3% more harmful effect on health in poorer than richer countries and a significantly harmful effect in 2.1% to 53.3% of countries in our sample and 6.6% to 67.6% of the world's population, but no significantly harmful effect in richer countries.

Keywords

cross-national, economic development, fixed effects, income inequality, population health

Since Wilkinson's (1992) influential study about the deleterious effects of income inequality on health, researchers have continued to investigate the harmful health effects of inequality, with varied and contentious results. Some studies support Wilkinson's contention that inequality has deleterious health effects (e.g., Kawachi et al. 1997; Lynch and Kaplan 1997; Ram 2006) while others do not (e.g., Beckfield 2004; Deaton 2003; Mellor and Milyo 2001). Many of these studies follow Wilkinson's focus on wealthy countries; however, some examine this relationship in both developed and less developed countries with mixed results (e.g., Babones 2008; Gravelle et al. 2002; Pop, van Ingen, and van Oorschot 2013).

In this article, we advance the inequality–health debate by contending that income inequality has different health effects in rich and poor countries. We support this argument by testing for a moderating role of economic development. Based on previous literature, we identify two types of mechanisms linking inequality to population health. Social integrationist theories posit that psychosocial factors, such as status comparisons, connect inequality to poor health outcomes (e.g., Kawachi, Kennedy, and Wilkinson 1999; Layte 2012; Pickett and Wilkinson 2015). These theories imply that inequality should have more harmful effects in rich countries where status comparisons are more salient. By contrast, neo-materialist theories propose that material resources like health infrastructure account for inequality's negative relationship with health (e.g., Davey Smith 1996; Lynch et al. 2004; Muntaner and Lynch 1999). Thus, neo-materialist perspectives suggest that inequality should have more harmful effects in poor countries where inadequate health infrastructure concentrates healthcare and healthy behavior among a small elite.

An existing cross-national literature points to our intervention, but leaves unanswered the key empirical question about the role of economic development in the income inequality-health link (e.g., Beckfield 2004; Mellor and Milyo 2001; Pop et al. 2013). Using a sample of countries covering 53 years (1960 to 2013) with wider income inequality coverage than the previous literature, we estimate fixed effects models with interaction terms between inequality and economic development. In addition to the two standard health outcomes employed in previous literature (infant mortality and life expectancy at birth), we introduce two variables that address problems related to low variation in population health among rich countries and that better reflect psychosocial mechanisms proposed by social integrationist theories: years lived with disability (YLD) per 100,000 due to (a) non-communicable diseases and (b) mental health disorders and substance abuse (1990–2013).

Our results suggest that economic development moderates the relationship between income inequality and two of the measures of health: life expectancy at birth and non-communicable disease YLD rate. At the lowest levels of economic development, inequality has a significant deleterious impact on life expectancy. At the highest levels of economic development, we observe either a positive association (life expectancy) or a null association (non-communicable disease YLD rate) between inequality and health, but auxiliary analyses show that the former is untenable.

Because we employ alternative sources of Gini, alternative measurements of development and population health, and alternative econometrics, we observe variation in the size of this global gradient across models. For example, comparing the estimated effect of income inequality at the lowest to the highest level of development, we observe a 139.7% to 374.3% more harmful effect on health at the lowest level of development. This harmful effect impacts 2.1% to 53.3% of countries and 6.6% to 67.6% of the world’s population. We fail to observe a harmful effect in high-income countries (e.g., countries with per capita gross domestic product [GDP] above the 54th percentile). While the pattern of these relationships suggests that material mechanisms may play an important role in the relationship between inequality and health, we recommend further research. Research that investigates income inequality as a *proximate* or conditional cause for poor population health will further the literature. We also propose strategies for examining neo-material mechanisms operating at the macro-level and potential psychosocial mechanisms in poorer countries.

BACKGROUND

A recent review of studies implies a causal link between income inequality and health (Pickett and Wilkinson 2015). Proposed intervening mechanisms include low social status (Wilkinson 1999; Wilkinson and Pickett 2009a; Wilkinson and Pickett 2009b), underinvestment in public goods (Lynch and Kaplan 1997), and erosion of social cohesion and trust (Kawachi et al. 1997; Wilkinson 1997). These narratives fall into two primary categories: integrationist and neo-materialist.

Social integration mechanisms are rooted in comparisons that arise when people consider their relative status positions. Due to factors like conspicuous consumption, individuals readily discern their relative status, and the subsequent comparisons result in stress and anxiety that harms health (Wilkinson 1999; Wilkinson and Pickett 2009a; Wilkinson and Pickett 2017). In more unequal societies, less capability for social mobility exists; therefore, status differentiation becomes more important (Wilkinson and Pickett 2017). These processes also erode social cohesion through a focus on individualism, which has important implications for population health (Kawachi et al. 1997; Kawachi 1999; Wilkinson and Pickett 2017). Social integration pathways focus on the psychosocial experience of inequality in the form of depression, shame, and anxiety, and how these experiences impact health behaviors, such as smoking or drinking (Lynch et al. 2004). They have a neo-Durkheimian character in that their ultimate focus is on social disintegration and its relationship to health (Muntaner and Lynch 1999).

The second narrative minimizes the psychosocial pathways in favor of neo-material ones. In one variant, income inequality is the result of historical, cultural, and political-economic processes that influence individuals' access to resources (e.g., access to technological innovation, medical care, etc.) and shape the availability of public goods (e.g., health services, environmental regulation, welfare-states, etc.) that support health (Bor, Cohen, and Galea 2017; Lynch et al. 2004; Singh et al. 2016). The consequences to underinvestment in medical services, education, and environmental protections disproportionately impact the poor in countries with high income inequality, which worsens population health (Bhandari, Newton, and Bernabé 2015; Lynch and Kaplan 1997; Muntaner and Lynch 1999).

Another variant holds that income inequality harms population health only when there is a significant deficit between median incomes and the average cost of effective healthcare. In this scenario, *relatively* poor individuals in rich countries earn incomes closer to the cost of effective healthcare than do *relatively* poor individuals in poor countries. Thus, income inequality is either a proximate cause of poor population health or the inequality–health link depends on the absolute incomes of the poor in relation to the average costs of effective healthcare. While neo-material theorists presume that the psychosocial and material pathways are reciprocal (see Lynch and Kaplan 1997), material concerns, rather than the emotional experience of inequality, are paramount in these pathways. Neo-materialists critique psychosocial approaches as downplaying the structural causes of inequality (Muntaner and Lynch 1999), while integrationists argue that distribution of material resources, such as public health expenditures, play little or no mediating role in the relationship between inequality and health (Elgar 2010; Layte 2012; Pickett and Wilkinson 2015).

While recent work makes strong causal claims regarding the health effects of income inequality (see Pickett and Wilkinson 2015), results from prior cross-national empirical research about these effects are mixed. One meta-analysis contends that 83% of international-level studies support the income inequality–health link (Wilkinson and Pickett 2006); while another concludes that there is little evidence of a direct effect (Lynch et al. 2004). Previous cross-national work varies considerably in terms of methodologies, data sources, and control variables, such that comparing findings across these studies is not a straightforward exercise (Torre and Myrskylä 2014). Furthermore, many of these studies are limited by inadequate data, small sample sizes, and selection and heterogeneity biases (see Babones 2008; Beckfield 2004; Mellor and Milyo 2001 for a discussion).[1] Recent work takes steps to ameliorate these problems but their results are not conclusive; some offer no support (Avedano 2012), others offer qualified support (Pop et al. 2013; Torre and Myrskylä 2014), and others provide contradictory evidence (Herzer and Nunnencamp 2015).

A key to these mixed findings may be that income inequality has different effects on population health in countries at different levels of development. Economic resources play an important role in health outcomes (Deaton 2003; Pritchett and Summers 1996). Thus, one might expect to observe no effect in studies that combine countries at various levels of economic development (e.g., Babones 2008; Beckfield 2004; Gravelle et al. 2002). Depending on how the effect of inequality varies by development, one might expect to observe positive, negative, or null effects in studies that focus on countries at particular levels of development (e.g., Hajebi and Razmi 2014; Herzer and Nunnencamp 2015; Torre and Myrskylä 2014). Therefore, a crucial part of the story may be that a country's economic resources impact the relationship between inequality and health.

Economic Development and the Income Inequality–Health Link

To account for these varied findings in the literature, we propose that income inequality may have different effects on population health in poor and rich countries. Indeed, both integrationist and neo-materialist approaches suggest as much, but reach very different conclusions with respect to direction. Narratives that focus on social integration imply that the link between inequality and health may be stronger in high-income countries. Here, social factors are presumed to become stronger determinants of health after countries undergo an epidemiological transition. When basic human needs are met, individuals are more likely attend to status comparisons that erode health (see Wilkinson 1996). Therefore, one might expect inequality to have more harmful effects on population health in rich countries. Moreover, psychosocial mechanisms have implications for both non-communicable diseases and mental illnesses (Kawachi et al. 1999; Lago et al. 2018; Pickett and Wilkinson 2010; 2015). One might observe even larger relative differences in the effect of inequality on population health between rich and poor countries when considering these types of health outcomes. Thus, the integrationist approach suggests:

> **Hypothesis 1:** Income inequality harms population health more in high-income than in low-income countries.

By contrast, neo-materialist perspectives suggest that income inequality may have a more serious effect on population health in poorer countries. Poor residents of high-income countries may experience less severe impacts of inequality on health for several reasons. First, they enjoy larger and more efficient provisions for public services, on average, than do the poor in lower income countries (Anand and Ravallion 1993; Elo 2009; Pop et al. 2013). Poorer countries with high inequality may invest less in public goods; however, unlike high-income countries with high inequality, they lack the economic and administrative resources to maintain infrastructure for all. Most of the healthcare cost burden falls on the household in low- and middle-income countries, as public spending on health is often incomplete or absent (Mills 2014). In these countries, only the rich have access to resources that improve health because no safety nets exist for the poor.

Second, poor*er* individuals in lower income countries possess far fewer economic resources than do poor*er* individuals in high-income countries (Korzeniewicz and Moran 2009). Even with minimal health infrastructure, poorer individuals in poor countries will have fewer surplus resources to spend on healthcare than their counterparts in rich countries. In this scenario, the relationship between income inequality and population health is a conditional one. Inequality only harms population health when the incomes of the poor are inadequate in relation to the average cost of effective healthcare. In short, neo-materialists suggest that inequality is related to disinvestment in public goods, the lack of democratic institutions, or the deficit between surplus incomes and effective healthcare among the poor rather than psychosocial factors. In each case, one would expect a more harmful impact of inequality on population health in poor than in rich countries (e.g., Davey Smith 1996; Lynch et al. 2004; Muntaner and Lynch 1999). Thus, the neo-materialist perspective suggests that:

> **Hypothesis 2:** Income inequality harms population health more in low-income than in high-income countries.

Previous research suggests that there may be a conditional effect of income inequality on population health; however, few works make a strong case for this effect or test it directly. For example, some researchers divide countries into income groups and estimate regressions separately. These scholars then make descriptive comparisons of the association between inequality and health across these groups. However, even these suggestive results are mixed. When only low- and middle-income countries are considered in the analysis, the results illustrate either a positive relationship (e.g., Pulok 2012) or a negative one (e.g., Hajebi and Razmi 2014). Pop et al. (2013) find conflicting results in a hybrid model where Gini enters as both a country-mean and a country-mean-deviated covariate. The former produces a significant, negative association between inequality and life expectancy in low- and middle-income countries, but no significant impact in high-income countries. The latter produces a significant, positive effect in poor countries, but no effect in middle and high-income countries.[2] Herzer and Nunnencamp (2015) find evidence of a positive association between inequality and life expectancy in high-income countries and a negative association between inequality and life expectancy for low-income countries.[3]

Analyzing income groups yields suggestive evidence that the relationship between income inequality and population health may vary according to economic development, but this strategy has several limitations. First, the income group classifications vary, with some researchers employing their own thresholds and others employing pre-determined (e.g., World Bank) thresholds. Some make a distinction between less-developed and more-developed countries (Herzer and Nunnencamp 2015; Ram 2006). Others divide the sample into three components: low-income, middle-income, or high-income countries (Pop et al. 2013). Still others estimate regressions on samples of low- and middle-income countries (Hajebi and Razmi

2014; Pulok 2012) or on samples of high-income countries (Beckfield 2004; Torre and Myrskylä 2014). Results vary considerably across these classificatory systems.

Second, this approach reduces the asymptotic power of any statistical tests. The typical cross-national comparative dataset may include up to 180 countries, but this number shrinks considerably when dividing across two or three categories. Third, none of these studies focus extensively on *testing* the null hypothesis that inequality effects are invariant across the entire observed range of GDP per capita. Qualitative differences between coefficients across groups of countries in different income classifications may not be significantly different from zero.[4]

Analytical Strategy

Following recent programmatic statements in this literature (Pickett and Wilkinson 2015), we propose an alternative modeling strategy to test the moderation hypothesis: an interaction of GDP per capita with income inequality in the fixed effects framework with minimal controls as originally employed by Beckfield (2004). Our approach is strategic for several reasons. First, this strategy allows for maximum variation for economic development, which maximizes statistical power. Second, following Beckfield (2004) and advice from Pickett and Wilkinson (2015:319–20), we include no time-varying controls outside of a linear time trend. When combined with our fixed effects approach, this allows us to eliminate unmeasured time-invariant country characteristics without “controlling” for covariates on the causal path from inequality to health, a discussion to which we return in the conclusion. Third, our approach involves time-varying measures of both Gini and population health (see Pickett and Wilkinson 2015:320). Fourth, our approach does not require income thresholds and allows for a direct test of the null hypothesis that the association between inequality and population health operates in the same manner at all levels of development (i.e., the coefficient on the interaction term is zero).

We also address one other problem that may plague previous research: the low variability in life expectancy and infant mortality in high-income countries (Avendano 2012; Pop et al. 2013; Regidor et al. 2012). This problem makes it quite difficult to evaluate the assertion that income inequality has different implications for population health in wealthier countries because any observed differences could be due as much to low variability in these two measures as to different inequality effects. To address this problem, we employ an additional measure of population health: years lived with disability (YLD) per 100,000. We utilize the non-communicable disease YLD, which includes disability due to non-communicable diseases, and the mental and substance abuse disorder YLD, which includes disability due to mental illness and substance abuse.

The non-communicable illness YLD measure summarizes the population health effect of illnesses for which there is greater variation among middle- and high-income countries. In these countries, life expectancy is higher, and better infrastructure limits the transmission of communicable diseases (Anand and Ravallion 1993; Cutler, Deaton, and Lleras-Muney 2006; Elo 2009). Previous work suggests a link between income inequality and greater prevalence, incidence, and risk of mental illness in high-income countries owing to reduced social capital, status hierarchy, and feelings of shame (Pabayo, Kawachi, and Gilman 2014; Patel et al. 2018; Ribeiro et al. 2017). Thus, if psychosocial mechanisms are the primary pathways through which income inequality may impact health, one may observe a significant, positive relationship between the mental and substance abuse disorder YLD and income inequality; particularly in high-income countries.

DATA AND METHODS

The dependent variables were life expectancy at birth, infant mortality, and years lived with two types of disability (YLD) rate. The first two measures are commonly used in previous cross-national research about income inequality and health (Babones 2008; Beckfield 2004; Mellor and Milyo 2001). We obtained the life expectancy and infant mortality measures from the World Bank Development Indicators (World Bank 2016). Life expectancy at birth refers to the combined male and female life expectancy at the country-level. Infant mortality rate refers to the number of infants dying before reaching one year of age, per 1,000 live births at the country-level. Both variables were drawn from population estimates or from country vital records, with no self-reported health elements. We logged infant mortality to ensure normality. We utilized linear interpolation to fill in missing values within countries between years. Interpolated data accounted for 1% cases for the life expectancy at birth variable and 0.1% of cases for the infant mortality variable.

We obtained YLD data from the Global Burden of Disease (GBD) study (2015) to test the hypothesis that past a certain level of economic development, life expectancy may no longer adequately capture how income inequality harms health. Years lived with disability (YLDs) are a measurement of the burden of disease that accounts for the short- or long-term loss of health due to a disability. They were created by multiplying prevalence (based on systematic reviews) by the disability weight (based on population-based surveys) for each sequela (GBD 2015). The YLD variables contained no self-reported health elements. We utilized variables for the rate of YLDs per 100,000 for non-communicable diseases and mental and substance use disorders, which is a subcategory of non-communicable diseases. The Global Burden of Disease study contained data for each country at five-year intervals (i.e., 1990, 1995, 2000, etc.). Thus, we performed linear interpolation to fill in missing values within countries between years. The data interpolation accounted for about half of the cases for both sets of YLD variables.

Independent Variable: Income Inequality

Limited numbers of observations and lack of comparability are major issues in cross-national research involving income inequality (Solt 2009). The Standardized World Income Inequality Database (SWIID) maximizes cross-national and temporal comparability by drawing on the largest possible sample of countries and years from several data sources, including the World Income Inequality Database (WIID) and the high-quality estimates from the Luxembourg Income Study (LIS). However, complete comparability is not possible as cross-national surveys vary in terms of units of observation, income definitions, and quality. The SWIID allows users to account for uncertainty in Gini estimates that arise from residual incomparability. Because they are benchmarked with LIS data, incomes are adjusted by household size to produce a measure of inequality in equivalent household incomes.

To improve comparability and coverage, we used post-tax and transfer (or “net”) income inequality data from the SWIID (Solt 2009). We followed the recommendations of Solt (2009) by estimating multiple imputation (MI) models. This procedure incorporated the uncertainty from residual incomparability in the Gini estimates into the coefficients and standard errors (see Jenkins 2015; Rubin 1996).

Independent Variable: Economic Development

We measured economic development with gross domestic product per capita (GDP per capita) in current U.S. dollars from the World Bank Development Indicators (World Bank 2016). To alleviate biases in estimated coefficients and standard errors owing to extreme skew, we logged

GDP per capita. We utilized linear interpolation to fill in about 1% of missing values within countries between years.

[Table 1 about here]

Table 1 reports descriptive statistics for each variable. Bivariate correlations between income inequality and the health variables were similar but slightly higher than those presented in previous cross-national works (e.g., Babones 2008; Beckfield 2004).[5]

Multivariate Fixed Effects Models

Heterogeneity bias is an important issue in cross-national income inequality and population health research (Beckfield 2004). To remedy this problem, we used a fixed effects estimator. While the fixed effects estimator does not address biases arising from omitted time-varying variables, it eliminates biases owing to unobserved time-invariant country-specific variation. In addition to correcting the standard errors for uncertainty in Gini with the MI regressions, we also corrected for heteroscedasticity and arbitrary forms of auto-correlation within clusters (Rogers 1993).

Conceptually, we estimated the following equation for each indicator of population health:

$$(1)\ Y_{jt} = a_j + \beta x_{jt} + \beta \gamma_{jt} + \beta x_{jt} \gamma_{jt} + \beta year_{jt} + \varepsilon_{jt}$$

In equation 1, Y refers to the health outcome (life expectancy, infant mortality, or years lived with disability per 100,000) for country j at time t. X and γ are income inequality and GDP per capita, respectively. The fourth term, $\beta x_{jt} \gamma_{jt}$, refers to the interaction of income inequality and GDP per capita. a contains the country-specific intercepts that net out any unobserved time-invariant, country-specific effects. *Year* is a linear time trend and ε is the error-term. The strength of this approach is three-fold. First, it both eliminates unmeasured time-invariant factors and maximizes statistical power. Second, it maximizes cross-national and temporal variation in GDP per capita. Third, it enables a direct test of the null hypothesis that inequality does not have different effects at different levels of development, which is the null-hypothesis that $\beta x_{jt} y_{jt}$ is equal to zero.

The data create unbalanced panels, where countries contribute different numbers of observations. The final sample for the life expectancy models includes 4,243 observations, 163 countries, and 53 years. For the infant mortality models, the final sample includes 4,155 observations, 162 countries, and 53 years. For the YLD models, the final samples cover 2,894 observations, 162 countries, and 20 years.

Alternative Data and Econometrics

As with any cross-national analyses, the data described above have both advantages and disadvantages that impact our estimates of the association between income inequality and health. Thus, we also estimated models using alternative sources of data on income inequality, life expectancy, and GDP per capita. In addition, we employed varying lags of inequality and alternative econometric corrections for heteroskedastic and serially correlated errors and unobserved period effects. These multiple analyses allowed us to report a range of estimates for the association between income inequality and health that, *in toto*, provides a more balanced assessment of the association to inform the literature than any single analysis (see Pickett and Wilkinson 2015).

RESULTS

[Table 2 about here]

We present results for two fixed effects models per dependent variable: a basic model including Gini, GDP per capita, and year, and an interactive model that adds the product of Gini and GDP per capita. Table 2 presents the results for the infant mortality and life expectancy models. While the direct effect of economic development is not the focus of this article, we note that the insignificant effect of GDP per capita on life expectancy in Table 2 is similar to previous research, and consistent with our concerns about the low variability of life expectancy among richer countries (see Beckfield 2004; Cutler et al. 2006). The first panel reports the results from the basic models for infant mortality and life expectancy. Consistent with previous research, income inequality does not have a significant association with infant mortality. Similarly, income inequality does not have a significant impact on life expectancy in Model 2. The interaction term appears in Models 3 and 4 in the second panel. Model 3 reveals a small increase in the effect of income inequality on infant mortality as development increases; however, it is non-significant.

Income inequality's effect may be more salient for life expectancy because it captures cumulative advantages or disadvantages over an entire life course. Some evidence suggests that early-life inequality has health implications for people as they get older (Elgar et al. 2017). This impact may be even more apparent in the context of development, as early life poverty is associated with greater health disadvantages later in life (Pavalko and Caputo 2013; Pollitt, Rose, and Kaufman 2005). The interaction between inequality and economic development is positive and significant in the interactive model of life expectancy (Model 4). However, in the poorest countries, inequality has a significant, negative association with life expectancy. This finding provides some support for the argument that economic development attenuates the association between income inequality and life expectancy (Hypothesis 2).

[Figure 1 about here]

When countries undergo epidemiological transition, communicable illnesses decline and life expectancy increases; however, life expectancy gains diminish in more developed countries. Therefore, the significant interaction term in Model 4 should be read with some caution. But, non-communicable illnesses do not follow this pattern and become a larger concern for population health among countries with greater life expectancy (GBD 2015). Figure 1 plots several measures of population health against economic development. A comparison of the scatterplot for life expectancy (top left) to that for YLD due to communicable diseases (top right) reveals this fact. In both cases, there is much less variability in population health as economic development increases. By contrast, non-communicable illnesses and mental health/substance abuse disorders increase with development (due largely to longer life spans and more sophisticated diagnostic mechanisms). The variation in these two variables among high-income countries (top right of each graph) is similar in magnitude to that among lower income countries (bottom left of each graph).

[Table 3 about here]

To proceed, we calculate separate fixed effects models for the non-communicable disease YLD rate and the mental and substance use disorders YLD rate. The basic and interactive models are presented in Table 3. In Model 1, income inequality has a significant, positive impact on the non-communicable disease YLD rate. In Model 2, inequality has no significant effect on the mental and substance use disorders YLD rate. In Model 3, and consistent with Hypothesis 2, economic development attenuates the relationship between inequality and the non-communicable disease YLD rate. However, economic development plays no moderating role in the relationship between inequality and the mental and substance use disorders YLD. Economic development appears to diminish the link from inequality to both life expectancy and the non-communicable disease YLD rate.

Alternative Source of Income Inequality Data

The models in Table 4 replace the SWIID Ginis with those from Deininger and Squire (1996) as implemented by Beckfield (2004). These models provide a unique window into the income inequality–population health link for two reasons. First, they allow us to assess whether or not we observe a moderating effect of economic development on the inequality-health link across two sources of Gini. The second reason is that the Deininger and Squire (1996) dataset covers a different period of time (1947–1996) and set of countries than do the SWIID data, addressing spatial (i.e., country) and temporal composition.

[Table 4 about here]

Table 4 reports the results of this analysis. The results are substantively identical to those produced using Solt's (2009) SWIID data. Panel 1 does not support the income inequality–health link, as inequality is not associated with infant mortality or life expectancy. The interactive models indicate no significant interaction between inequality and economic development when infant mortality is the dependent variable. However, there is a significant, positive interaction between inequality and development when life expectancy is the dependent variable.

Additional Concerns

We conduct five additional analyses based on measurement and econometric concerns. First, the World Bank's life expectancy estimates come from a variety of sources that employ a variety of methods. Beckfield (2004:234) generated a measure of life expectancy that includes a control variable for one important difference in measurement: those based on estimates versus complete life tables. Second, to maximize sample size in the previous analyses, we used a measure of GDP per capita that does not account for differences in prices between countries (Purchasing Power Parity [PPP]). These “real” GDP data are available but on smaller samples. Third, we addressed the potential for heteroskedastic and serially-correlated errors with the clustered sandwich estimator from Rogers (1993). However, this estimator may be biased when panels are unbalanced or few in number and potentially less efficient than alternative generalized least squares estimators (e.g., Hansen 2007; Nichols and Schaffer 2007). Fourth, our previous models control for time effects with a linear time trend, which does not fully control for unmeasured case-invariant and period-specific fixed effects.

[Table 5 about here]

Table 5 reports these two replications. In Model 1, we replace the World Bank’s measure of life expectancy with that of Beckfield (2004) and his control (suppressed). In both models, we address the second, third, and fourth issues simultaneously by employing real (PPP-adjusted) GDP per capita from the Penn World Tables (Feenstra, Inklaar, and Timmer 2013), estimating and correcting for a first-order autoregressive process with a Prais-Winston transformation, employing a heteroscedasticity-consistent covariance matrix, and including the full set of T-1 time dummies. In each model, the interaction coefficient between inequality and GDP per capita is in the same direction as our previous models and statistically significant. The *t*-ratios are generally smaller in Table 5 than in Tables 2 through 4, suggesting that our previous estimates are overly conservative, owing to the bias of clustered standard errors with unbalanced panels.

Finally, some literature suggests that the impacts of income inequality on population health are cumulative and lagged (cf., Lillard et al. 2015; Shi et al. 2004; Zheng 2012). One anonymous reviewer suggested that such lags should be shorter for infectious diseases that are more important in low-income countries and longer for degenerative diseases more prevalent in high-income countries. If our data support this differential lag process, we might expect (a) lagged effects to be larger than contemporaneous ones, and (b) lagged effects to peak at shorter intervals for life expectancy *vis-à-vis* the non-communicable disease YLD rate. Because the SWIID data allow for the widest possible temporal range, we re-estimated the models from Tables 2 and 3 above with 1 to 10 year lags (see Kim et al. 2008) for both life expectancy and non-communicable disease YLD rate. The interaction terms that we obtain from these models are reported in Figure 2. We find a linear (though not quite monotonic) decrease in the size of the interaction term for each lag from years 1 to 10. The pattern is the same for both outcomes. Moreover, the overlapping confidence intervals suggest that none of these coefficients are significantly different from each other (see Torre and Myrskylä. 2014).[6]

[Figure 2 about here]

Substantive Significance

The results suggest that the impact of income inequality on life expectancy and non-communicable disease YLD rate varies significantly with the level of development and has more harmful effects in poorer countries. To examine the substantive importance of this variation, we examine the marginal effects of inequality on life expectancy and non-communicable disease YLD rate as they vary by GDP per capita. Each panel shows the marginal effects across the analyses in Tables 2 to 5.

[Figure 3a and 3b, about here]

The first set of panels for Figures 3a and 3b illustrate the analysis from Model 4 of Table 2. The second set of panels comes from Model 4 of Table 4. The results in the third set of panels come from Model 1 of Table 5. The left *y*-axis of Figure 3a displays the percent of cases at each level of development, while that axis on Figure 3b illustrates the percent of the population at each level of development. All panels suggest that variation in the effect of inequality across development is fairly large. At the low end, we estimate that inequality's impact on population health is as much as 139.7% more deleterious in poorer countries (Panel 3). At the high end, we estimate that inequality's impact on population health is as much as 220.7% more deleterious in poorer countries (Panel 1).[7]

In all panels, the effect of income inequality on population health is significantly negative at lower levels of economic development. However, the share of country-cases for which we observe this effect varies from small to moderate (2.1% to 38.6%). Countries in this range include Uganda, Sudan, India, Bangladesh, Ethiopia, Guatemala, and China. These percentages rise considerably when we factor in population size because most of the world's population lives in developing countries. We estimate that 6.6% to 66.2% of the world's population lived in countries that experienced a negative effect of inequality on health at some point during the period. Panels 1 and 3 in each figure also show that we estimate a significant, *positive* impact of inequality on health in the richest countries, though the share of cases is small. While this finding is consistent with those elsewhere (e.g., Herzer and Nunnencamp 2015), we are skeptical of this association because of the low variability in life expectancy among richer countries and because the finding lacks a theoretical rationale.

[Figure 4 about here]

Figure 4 presents the results for the non-communicable disease YLD rate. Panel 1 comes from Model 3 of Table 3, while Panel 2 comes from Model 2 of Table 5. Panels 3 and 4 are identical to Panels 1 and 2 except that they report the percent of the world's population on the first *y*-axis rather than country-cases. As with life expectancy, each panel shows that income inequality's impact on population health is significantly harmful at lower levels of economic development. Unlike our analysis of life expectancy, none of these figures imply that inequality *improves* population health in richer countries, as the confidence interval includes zero for the full range of positive coefficients we estimate. The share of cases (39.6% to 53.3%) and world population (53.4% to 67.6%) for which this association holds is much larger than for life expectancy, and includes middle-income countries like Paraguay and Thailand. These analyses also suggest a larger gradient in the impact of inequality on health across rich and poor countries than do our analyses of life expectancy. At the low end, inequality's impact on population health is as much as 246.2% more deleterious in low-income countries than in high-income countries (Panel 1). At the high end, the impact is as much as 374.3% more harmful (Panel 2).

Taken together, the results presented in Figures 3 and 4 tell a clear, if varied, substantive story. Income inequality harms population health among countries at the lowest developmental strata. Countries in the middle experience either a deleterious health impact (years lived with disability) or a null health impact (life expectancy) from inequality. At the highest end of the developmental strata, we observe either a *beneficial* impact (life expectancy) or no impact (years lived with disability) of inequality on health, though we are skeptical of the life expectancy results among high-income countries. In short, our results reveal a relatively large global gradient in the relationship between income inequality and population health (139.7% to 374.3% more deleterious in low- or middle-income countries than in high-income countries).

DISCUSSION

Theories linking income inequality to poorer population health are intuitive and provide compelling causal mechanisms, yet the empirical literature is mixed. While some of these mixed results are due to differences in methodology, sample composition, and data sources, we suggest that a conditional effect of inequality is also a plausible, if partial, explanation. That is, development is a key moderator in the relationship between inequality and health. While a few pieces of empirical work gesture toward this finding, none of them provide a direct, systematic test of the hypothesis. Our results hold across various analytical procedures including the source of Gini, country and temporal coverage, the measurement of population health, and econometric considerations. The relationship between income inequality and population health is best described by a global gradient. Inequality is linked to worse population health in low- and middle-income countries, but has no significant harmful effects in high-income countries.

While it is beyond the scope of this paper to parse out the exact mechanisms underlying these observed associations, we provide a few suggestions to motivate future research. Both the more harmful impact of income inequality on population health in lower income countries and the null results on mental disorders and substance abuse YLD rate align with previous research emphasizing mechanisms drawn from neo-materialist perspectives. Our results highlight potential neo-material mechanisms underlying the relationship between inequality and health. We imagine three types of neo-material processes that may matter (and co-vary across time and space), each with different implications for our understanding of a causal link from inequality to health.

One type involves less economic and administrative capacity to build robust systems of public health in poor countries. In lower income countries with high income inequality, healthcare, adequate sanitation, nutrition and health education are enjoyed by a small, rich proportion of the population, which produces poor average population health outcomes. By contrast, poor individuals living in high-income countries with high inequality enjoy vastly superior healthcare, sanitation, nutrition, and health education than their counterparts in low- and middle-income countries. While health gradients exist even in high-income countries with high inequality (e.g., Beckfield, Olafsdottir, and Bakhtiari 2013), these public goods are less concentrated among the rich than they are in lower income countries with high inequality (Anand and Ravallion 1993; Elo 2009; Pop et al. 2013).

Another type involves less robust political institutions in lower income countries with high income inequality. Evidence suggests that political institutions are tied to population health through mechanisms such as democracy and stability (Klomp and de Haan 2009) and welfare regimes (Muntaner et al. 2011). Transition to a capitalist economy, neoliberal restructuring, and trade openness also appear to have implications for health (Beckfield and Krieger 2009; Kaufman and Segura-Ubiergo 2001).

Both of these processes imply that the neo-material perspective treats income inequality as a *proximate* cause for lower population health, as it is part of a wider constellation of processes that influence differential exposure to material factors that impact health. Income inequality may be more strongly correlated with inequality in access to healthcare in lower income countries where health infrastructure is less developed. Similarly, income inequality may be more strongly correlated with less spending on health-enhancing social services in lower income countries that lack robust political institutions and political inclusion. As such, the deleterious association between inequality and health in poor countries may be the result of confounding factors such as public goods infrastructure or political institutions (cf., Pickett and Wilkinson 2015). Both explanations imply that changes to the domestic political and institutional context might improve health outcomes even if inequality remains constant. Future work might consider the degree to which the relationship between income inequality and health is driven by its correlation with this larger constellation of processes. Scholars could also investigate the degree to which *income* inequality is a proximate cause of poor health when compared with other forms of inequality.

A third possible mechanism involves the minimum resources necessary to obtain adequate healthcare, which are more widely distributed in high-income countries than in low-income ones, even in the context of high income inequality. In this scenario, the average cost for minimally adequate healthcare is at or below the median income in high-income countries, but well above the median income in low-income countries. The wider availability of health insurance (either public or private) in high-income countries may also contribute to this outcome. Health insurance spreads the real cost of healthcare across a pool of both healthy and sick individuals (Mills 2014). It also shifts a portion of the cost to the private or public sector. Both would move the average cost for minimally adequate healthcare even further below the median income in high-income countries.[8] If such a structural relationship between healthcare costs and median incomes holds across the entire range of economic development, then a fixed level of income inequality should produce greater health gradients in poor countries than in rich ones (see Beckfield, Olafsdottir, and Bakhtiari 2013).

Our finding of more deleterious health effects in poor countries is inconsistent with the notion that psychosocial mechanisms should produce bigger effects in richer countries (e.g., Wilkinson 1996; Wilkinson and Pickett 2009a). Nevertheless, future work should consider modes of analysis that could assess the degree to which psychosocial mechanisms operate in low-income countries. Some recent research suggests that psychosocial pathways are also important for health in lower income countries. Walker et al. (2013:215) find that poor people in diverse developmental contexts experience a common pattern of “pretence, withdrawal, self-loathing, ‘othering’, despair, depression, thoughts of suicide and…reductions in self efficacy.”

Thus, psychosocial factors may interact with material ones to produce a negative effect of inequality on population health in poorer countries. Social comparisons and status positions underling the stress-, shame-, and anxiety-mediated health effects may be worse in lower income countries. In the absence of a robust healthcare infrastructure, individuals have fewer resources with which to mitigate the health effects of stress, shame, and anxiety. A fruitful merger between the integrationist and neo-materialist approaches may consider the intervening role of material resources on the health effects of psychosocial processes.

This question could be answered at both the macro and micro levels. For example, researchers might consider an interaction of income inequality with macro-level covariates capturing the prevalence of healthcare and health infrastructure. Alternatively, socioeconomic status (SES) may be a moderator of the proposed psychosocial pathways linking inequality to health. SES is considered to be a fundamental cause of health inequality in part because of the individual-level resources it provides (Link and Phelan 1995). If individuals in countries with high inequality experience stressors related to status comparisons, but can utilize economic resources to alleviate these stresses, then one might expect that inequality would have a larger effect on individual health among those in the bottom of the income distribution. In such an analysis, one would expect that SES has a stronger moderating effect in countries with weaker healthcare systems and/or health infrastructure. Researchers should consider the lag structure of inequality's effects, as well.

Notes

1. Some scholars have argued that the relationship between income inequality and health may be an artifact of the effect of individual income (e.g., Ellison 2002; Gravelle 1998; cf., Subramanian and Kawachi 2004). Evidence illustrates that the artefactual effect is not the entire story, as an independent effect of income inequality and health is observed even after accounting for it (Babones 2008; Wolfson et al. 1999).

2. Pop et al. (2013) use Allison's (2009) hybrid model, where time-varying, right-hand side covariates enter the model as both country-specific means and deviations from these means. The country-specific averages are perfectly correlated with (and potentially biased by) unobserved time-invariant covariates in the hybrid model, while the deviated covariates are perfectly uncorrelated (and unbiased) with these unobservables.

3. Herzer and Nunnencamp's (2015) design requires balanced panels and results in a small sample of countries.

4. The study coming closest to such a design is Pop et al. (2013), who include an interaction term between within-case deviated Gini and within-case deviated GDP per capita within each income group, and produce a null result.

5. We estimated models using non-interpolated variables to similar effect: estimates of the size of the global gradient and cases/population covered by significantly harmful effects were within the range reported below.

6. We do not suggest these findings contradict evidence for lagged inequality effects at the individual level (e.g., Zhang 2012). Macro-level population health data represent something like

a weighted average exposure rate to contextual effects like inequality, where the weights are historical trends in both inequality and the population age structure.

7. These percentages are based on the coefficients at the minimum and maximum GDP per capita.

8. This argument is distinct from those that suggest that the association simply reflects the fact that there are more poor people in countries with bad health. See Pickett and Wilkinson (2015) for an extended critique.

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Table 1. Descriptive Statistics, with Data from Solt (2009), Global Burden of Disease Study (2015), and World Bank (2016)

		1	2	3	4	5	6
1	GDP per capita*						
2	Infant mortality	–.914					
3	Gini coefficient	–.438	.535				
4	Life expectancy	.824	–.888	–.478			
5	Years lived with disability per 100,000, non-communicable diseases	.827	–.868	–.598	.768		
6	Years lived with disability per 100,000, mental and substance abuse disorders	.749	–.741	–.366	.686	.831	
	Mean	7.794	3.149	37.079	67.677	8246.269	1991.647
	Standard deviation	1.606	1.068	9.788	9.538	1687.232	298.712

Note: *Natural logarithm. GDP = Gross Domestic Product.

Table 2. Multiple Imputation Fixed Effects Regressions of Infant Mortality (Log) on Income Inequality and Life Expectancy on Income Inequality, with Data from Solt (2009) and World Bank (2016)

	Basic Models		Interactive Models	
	(1)	(2)	(3)	(4)
	Log Infant Mortality	Life	Log Infant Mortality	Life Expectancy
Income inequality	.001	–.036	–.006	–.339**
	(.003)	(.038)	(.009)	(.135)
Log GDP per capita	–.235***	.515	–.263***	–.905
	(.285)	(.424)	(.054)	(.807)
Gini × Log GDP per capita			.001	.045**
			(.001)	(.017)
Year	–.024***	.255***	–.025***	.241***
	(.002)	(.035)	(.002)	(.035)
Constant	53.233***	–444.152***	54.018***	–405.717***
	(4.204)	(66.807)	(4.189)	(66.377)
N	4155	4243	4155	4243

Note: Serial correlation and heteroscedasticity-consistent standard errors in parentheses. GDP = Gross Domestic Product.
* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3. Multiple Imputation Fixed Effects Regressions of Years Lived with Disability per 100,000 on Income Inequality, with Data from Solt (2009), Global Burden of Disease Study (2015), and World Bank (2016)

	Basic Models		Interactive Models	
	(1) Years Lived with Disability, NCD	(2) Years Lived with Disability, M-SA	(3) Years Lived with Disability, NCD	(4) Years Lived With Disability, M-SA
Income inequality	7.894**	–.515	35.146**	2.492
	(2.959)	(.692)	(13.978)	(2.848)
Log GDP per capita	139.876***	22.145***	286.354***	38.250*
	(29.884)	(6.096)	(76.119)	(15.479)
Gini × Log GDP per capita			–3.989*	–.440
			(1.981)	(.415)
Year	33.336***	5.031***	33.950***	5.010***
	(2.541)	(.616)	(2.596)	(.629)
Constant	–59880.430***	–8232.139***	–62128.190***	–8481.973***
	(4914.013)	(1194.732)	(5158.954)	(1255.708)
N	2894	2894	2894	2894

Note: Serial correlation and heteroscedasticity-consistent standard errors in parentheses. GDP = Gross Domestic Product; NCD = Non-Communicable Diseases; M-SA = Mental or Substance Abuse Disorders.
* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 4. Fixed Effects Regressions of Infant Mortality and Life Expectancy on Alternative Gini, with Data from Deininger and Squire (1996), Beckfield (2004), and World Bank (2016)

	Basic Models		Interactive Models	
	(1)	(2)	(3)	(4)
	Infant Mortality	Life	Infant Mortality	Life Expectancy
Income inequality	.000	–.040	.001	–0.478*
	(.003)	(.053)	(.014)	(.205)
Log GDP per capita	–.239***	.695	–.240**	–1.460
	(.037)	(.754)	(.074)	(1.105)
Gini × Log GDP per capita			.001	.060*
			(.002)	(.026)
Year	–.019***	.268**	–.019***	.267**
	(.004)	(.085)	(.004)	(.089)
Constant	43.461***	–469.191**	43.475***	–451.058**
	(7.398)	(162.386)	(7.554)	(171.436)
N	503	516	503	516
R^2	.900	.754	.900	.767

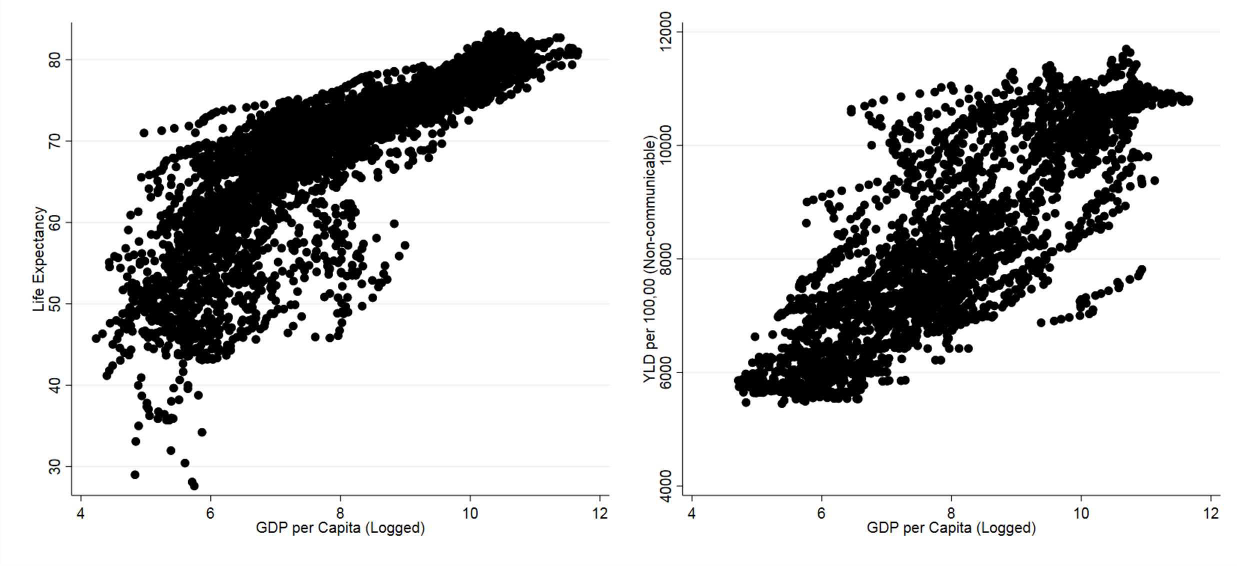
Note: Serial correlation and heteroscedasticity consistent standard errors in parentheses. Controls for data source utilized in the model, but not reported here. GDP = Gross Domestic Product.
* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 5. Multiple Imputation Fixed Effects Regression of Life Expectancy and Years Lived with Disability per 100,000, Non-communicable Diseases on Income Inequality with Data from Beckfield (2004), Solt (2009), Feenstra, et al. (2013), and Global Burden of Disease Study (2015)

	(1) Life Expectancy	(2) Years Lived with Disability, NCD
Gini	–1.376***	13.751*
	(.334)	(5.665)
Log real GDP per capita	–2.176	224.976***
	(1.385)	(31.074)
Gini × Log real GDP per capita	.150***	–1.409*
	(.036)	(.677)
Constant	86.713***	4193.874***
	(13.023)	(242.118)
Observations	542	2682

Note: Model 1 employs the life expectancy covariate from Beckfield (2004), along with its control (suppressed). All models include T-1 time dummies (suppressed). Serial correlation and heteroscedasticity-consistent standard errors in parentheses. GDP = Gross Domestic Product; NCD = Non-communicable Diseases.
* $p < .05$, ** $p < .01$, *** $p < .001$.

Figure 1. Scatterplots of Life Expectancy by GDP per Capita versus Years Lived with Disability per 100,000 by GDP per Capita, with Data from Global Burden of Disease Study (2015) and World Bank (2016)



Note: GDP = Gross Domestic Product; YLD = Years Lived with Disability per 100,000.

Figure 2. Interaction Terms When Gini Is Lagged by 1–10 Years, with Data from Solt (2009), Global Burden of Disease Study (2015), and World Bank (2016)

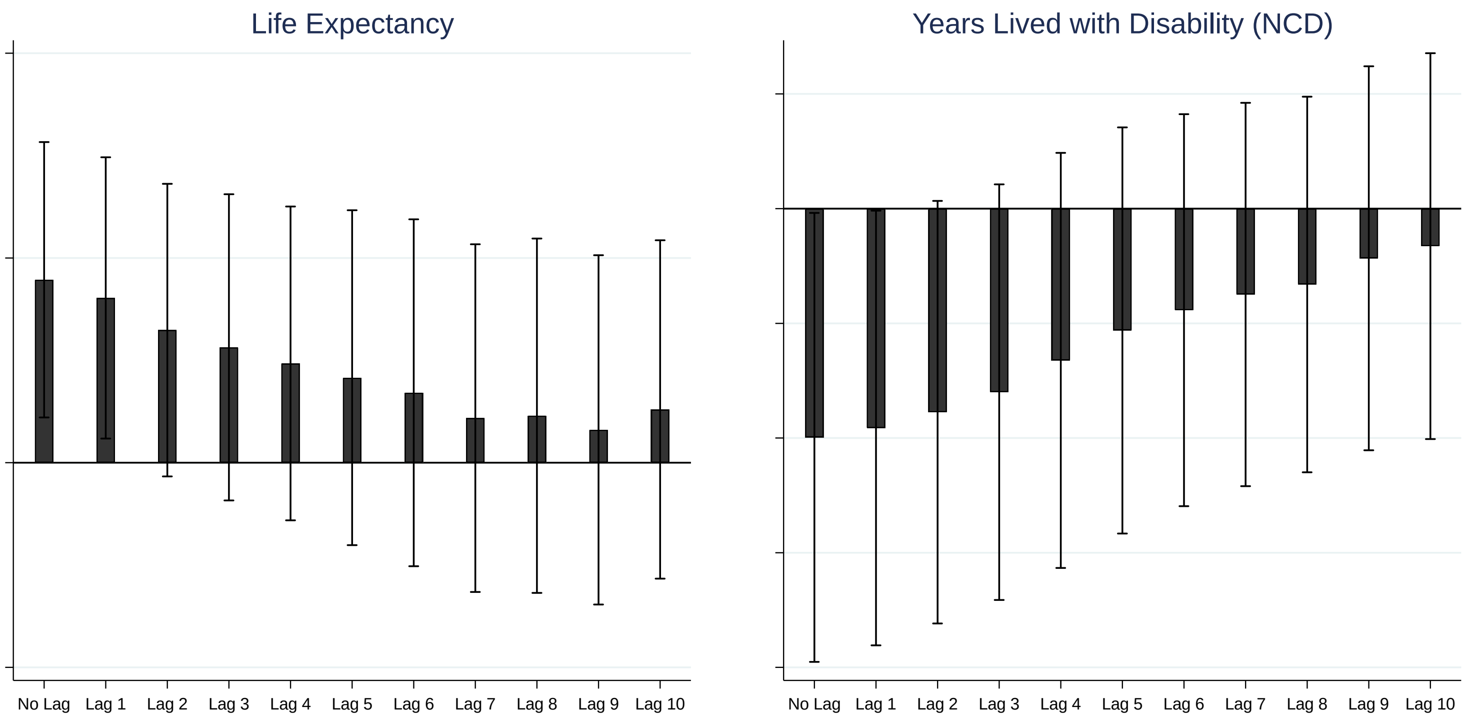


Figure 3a. Marginal Effects of Gini on Life Expectancy at Birth across Observed Range of Economic Development, with Data from Deininger and Squire (1996), Beckfield (2004), Solt (2009), Feenstra, et al. (2013), and World Bank (2016)

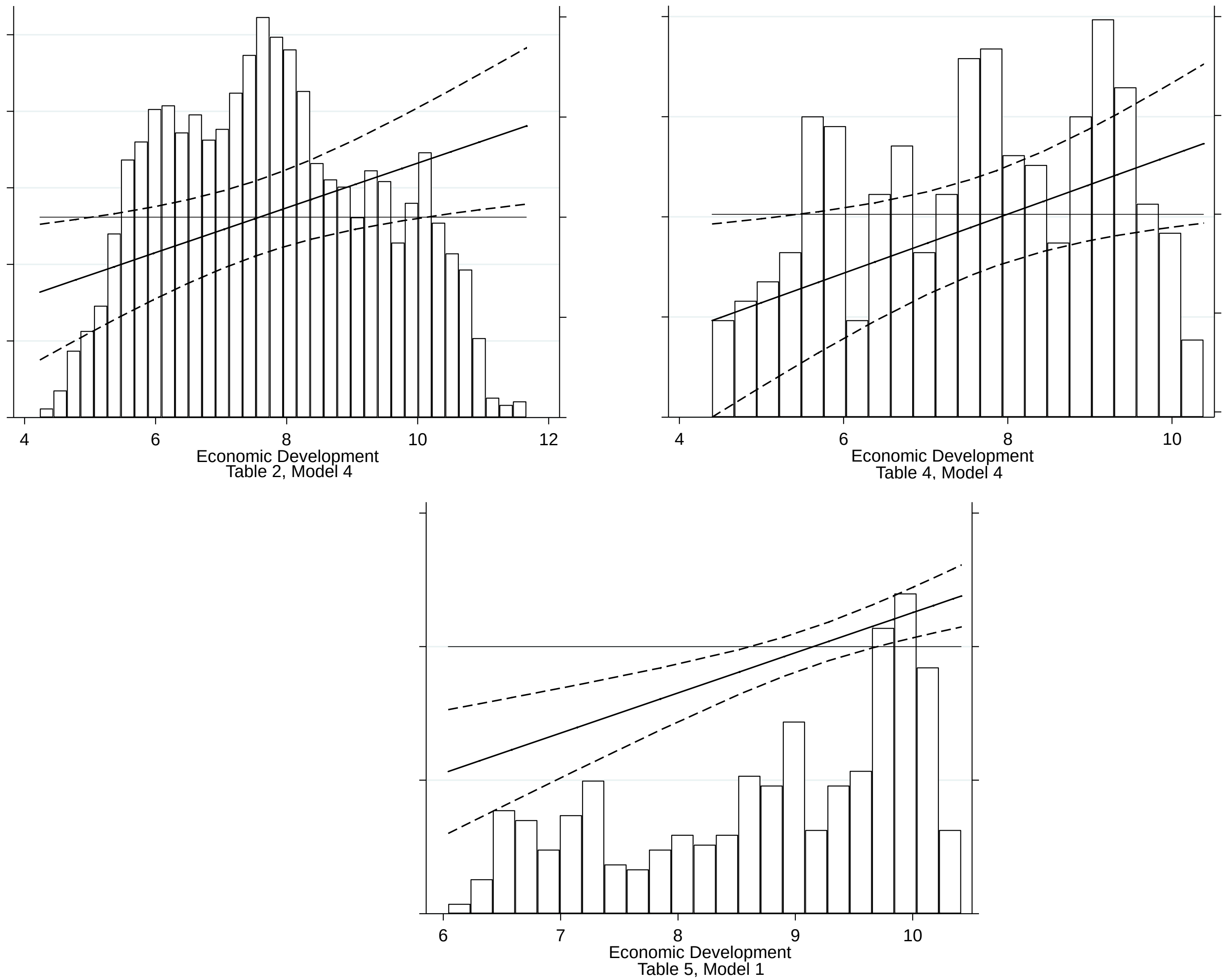


Figure 3b. Marginal Effects of Gini on Life Expectancy at Birth across Observed Range of Economic Development, Population-weighted, with Data from Deininger and Squire (1996), Beckfield (2004), Solt (2009), Feenstra, et al. (2013), and World Bank (2016)

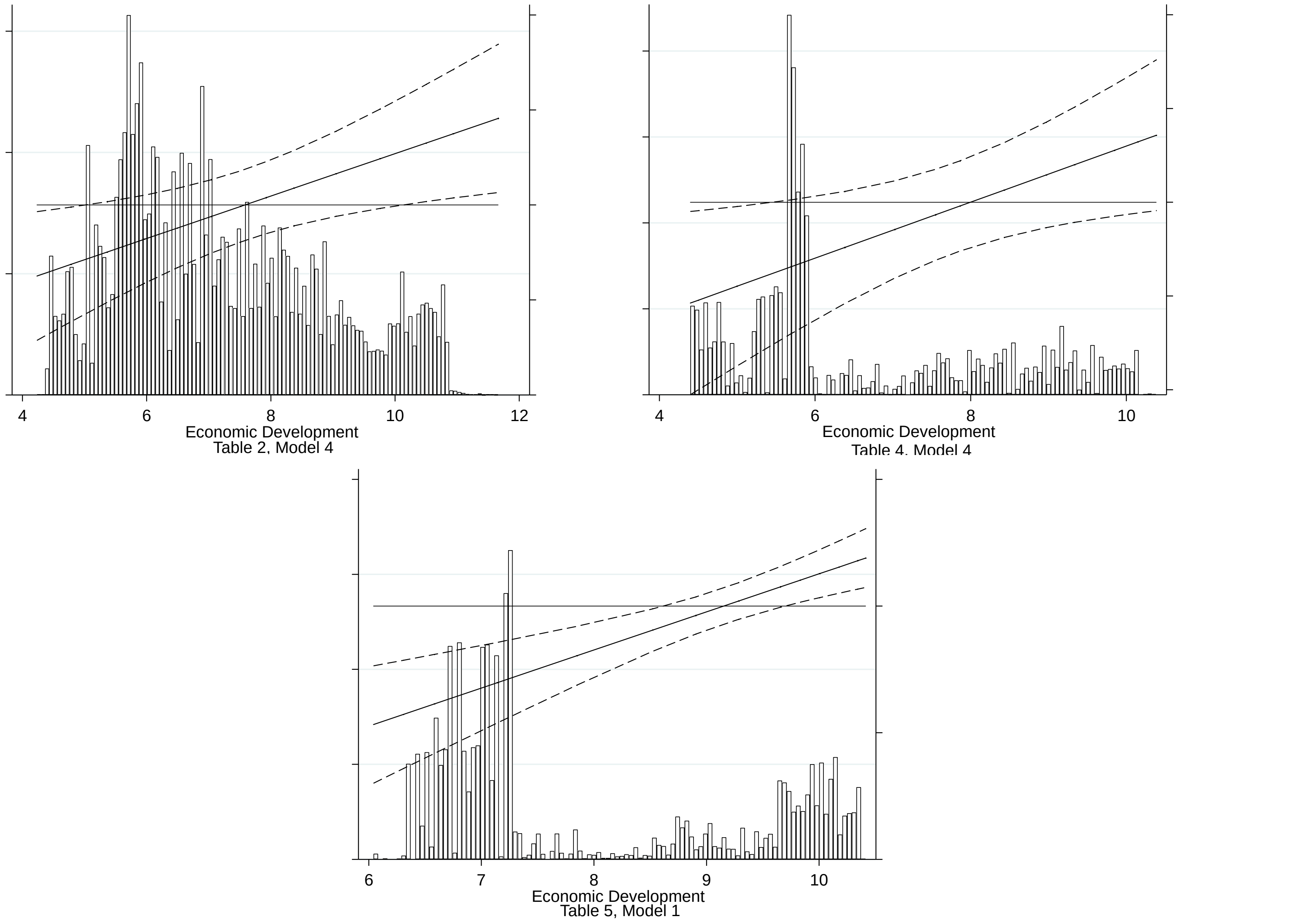


Figure 4. Marginal Effects of Gini on Years Lived with Disability per 100,000, Non-communicable Diseases across Observed Range of Economic Development, Unweighted (Top) and Population-weighted (Bottom), with Data from Solt (2009), Feenstra, et al. (2013), Global Burden of Disease Study (2015) , and World Bank (2016)