Income Inequality and Population Health: A Global Gradient?

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Abstract

Cross-national empirical research on the link from income inequality to population health produces a range of conflicting conclusions. Income inequality sometimes improves, sometimes harms, and often has no effect on population health. We reconcile these mixed findings by proposing that economic development moderates the relationship between income inequality and health. We estimate fixed effects models with multiple measures of income inequality and population health to examine the degree to which the relationship between income inequality and population health varies with economic development. Consistent with our intervention, we find that development moderates the association between income inequality and two measures of population health, which closely track distinct channels through which inequality is thought to harm population health. Our findings produce two broad generalizations. First, we observe a *global gradient* in the relationship between income inequality and population health whereby the former has worse impacts on the latter in poor countries than in rich ones. Income inequality has a 139.7 to 374.3% more harmful effect on health in poorer than richer countries, a significantly harmful effect in 2.1 to 53.3 percent of countries and 6.6 to 67.6% of the world's population, but no significantly harmful effect in richer countries. Second, our results are consistent with income inequality playing either a *proximate* or *conditional* cause of lower population health, and with both psychological and neo-material mechanisms. Thus, we suggest future research to identify specific material mechanisms operating at the macro-level, and whether or not these mechanisms interact with psychological processes at the level of individuals.

Keywords

cross-national, economic development, 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 find such a relationship with deleterious health effects (e.g., Lynch and Kaplan 1997; Kawachi, et al. 1997; Ram 2006) while others do not (e.g., Mellor and Milyo 2001; Deaton 2003; Beckfield 2004). While many studies follow Wilkinson's focus on wealthy countries, others examine both developed and less developed countries with similarly mixed results (e.g., Gravelle, et al. 2002; Babones 2008; Pop, et al. 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 income inequality to population health. Social integrationist theories posit that psychosocial factors, such as status comparisons, link inequality to poor health outcomes (e.g., Kawachi, et al. 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; Muntaner and Lynch 1999; Lynch, et al. 2004). Thus, neo-materialist perspectives suggest that inequality should have more harmful effects in poor countries where poor health infrastructure concentrates health care 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., Mellor and Milyo 2001; Beckfield 2004; Pop, et al. 2013). Using a sample of countries covering fifty-three years (1960-2013) with wider income inequality coverage than the previous literature, we estimate fixed effects models with interaction terms between income 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 more closely tap the psychosocial mechanisms proposed by Wilkinson and others, years lived with disability (YLD) per 100,000 due to non-communicable diseases and due to 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, income inequality has a significant deleterious impact on life expectancy. At the highest levels of economic development, we observe either a positive (life expectancy) or null (non-communicable disease YLD rate) association 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. We observe a significant coefficient on income inequality indicating a harmful effect in 2.1% to 53.3% of countries and 6.6% to 67.6% of the world's population. In none of our analyses do we observe a harmful effect in more developed countries (e.g., countries with per capita GDP above the 54th percentile). While the pattern of these relationships suggests that material mechanisms may play an important role in the relationship between income inequality and health, our concluding discussion suggests the need for more research. We contend that research that differentiates between income inequality as a *proximate* or truly conditional cause for poor population health will further the literature. We also suggest research examining neo-material mediators and moderators operating at the macro-level and the role of psychosocial mechanisms in poorer countries, and we propose strategies to examine these more directly.

BACKGROUND

A recent review of studies suggests a causal link between income inequality and health (Pickett and Wilkinson 2015). Several researchers have suggested intervening mechanisms, including low social status (Wilkinson and Pickett 2009a; 2009b; Wilkinson 1999), underinvestment in public goods (Lynch and Kaplan 1997), and erosion of social cohesion and trust (Wilkinson 1997; Kawachi, et al. 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 which 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). Furthermore, these processes erode trust and social cohesion through the focus on individualism, which has important implications for population health (Kawachi, et al. 1997; Kawachi, et al. 1999; Wilkinson and Pickett 2017). These 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 material ones, resulting in a neo-materialist theory of income inequality and health. 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 that support health (e.g., health services, environmental regulation, welfare-states, etc.) (Lynch, et al. 2004; Singh, et al. 2016; Bor, Cohen, and Galea 2017). The consequences to underinvestment in medical services, education, cultural events, and environmental protections impact the poor disproportionately in countries with high income inequality, which worsens population health (Lynch and Kaplan 1997; Muntaner and Lynch 1999; Bhandari, Newton, and Bernabé 2015).

As we elaborate below, another variant holds that income inequality harms population health only when there is a significant deficit between median incomes and the average cost for effective health care. In this scenario, income inequality matters differently in poor than in rich countries because *relatively* poor individuals in rich countries earn incomes closer to the cost of effective health care than do *relatively* poor individuals in poor countries. Thus, income inequality is either a proximate cause of poor population health, or depends on the absolute incomes of the relatively poor in relation to the average costs of effective health care. 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 income inequality and health (Pickett and Wilkinson 2015; Elgar 2010; Layte 2012).

While recent work makes strong causal claims regarding the health effects of inequality (see Pickett and Wilkinson 2015), the cross-national empirical track record of these effects is mixed in both research design and findings. One meta-analysis finds 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 displays considerable variation 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 Mellor and Milyo 2001; Beckfield 2004; Babones 2008 for a discussion).[1] More recent work takes steps to ameliorate these problems. Results from these studies are not conclusive. Some offer no support (Avedano 2012), others offer qualified support (Pop, et al. 2013; Torre and Myrskylä 2014) and still others suggest contrarian evidence (Herzer and Nunnencamp 2015).

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

Development and the Inequality-Health Effect

We propose a partial explanation for varied findings in the literature—inequality may have different effects 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 contend that the link between income 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 for a discussion). Therefore, one might expect income 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; Pickett and Wilkinson 2010; 2015; Lago, et al. 2018). Thus, we might observe even larger relative differences in the effect of income inequality and population health between rich and poor countries when considering these types of health outcomes. That is, the integrationist approach suggests:

H_1*: Income Inequality harms population health more in rich than in poor countries.*

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

Second, poor*er* individuals in poor countries possess far fewer economic resources than do poor*er* individuals in rich countries (Korzeniewicz and Moran 2009). Thus, even in the presence of minimal health infrastructure, poorer individuals in poor countries will have fewer surplus resources to spend on health care than their counterparts in rich countries. In this scenario, the relationship between income inequality and population health is a conditional one. Income inequality only harms population health when the incomes of the relatively poor are inadequate in relation to the average cost of effective health care. In short, neo-materialists suggest income inequality is related to disinvestment in public goods, the lack of democratic institutions, or the deficit between surplus incomes and effective health care 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; Muntaner and Lynch 1999; Lynch, et al. 2004). That is, the neo-materialist perspective suggests that:

H_2*: Income Inequality harms population health more in poor than in rich countries.*

While little empirical work makes a strong case for a conditional effect of inequality on health, some results suggest as much. For example, some researchers divide countries into developmental groups and estimate regressions separately. These scholars then make descriptive comparisons of the association between income inequality and health across these developmental groups. But 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 Javad 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 significantly 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 significantly 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 income inequality and life expectancy in high-income countries and a negative association between income inequality and life expectancy for low-income countries.[3]

While the practice of dividing samples of countries into income thresholds can provide suggestive evidence for variation in the association between inequality and health across developmental strata, it has several limitations. First, the income group classifications themselves vary, with some employing their own thresholds and others employing pre-determined (e.g., World Bank) thresholds. Some make a distinction between less-developed and more-developed (Ram 2006; Herzer and Nunnencamp 2015). Others divide the sample into three components—low-income, middle-income, or high-income (Pop, et al. 2013). Still others estimate regressions on samples of low- and middle-income countries (Pulok 2012; Hajebi and Javad Razmi 2014) or on samples of high-income countries (Beckfield 2004; Torre and Myrskylä 2014). Unsurprisingly, results vary considerably across these classificatory systems.

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

Our 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: 319-320), 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 concluding sections. 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 income inequality and 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 rich 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 on population health 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 all disability due to non-communicable diseases and the mental and substance abuse disorder YLD, which includes all disability owing to mental illness and substance abuse.

The non-communicable illness YLD measure captures 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, et al. 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 (Ribeiro, et al. 2017; Pabayo, Kawachi, and Gilman 2014; Patel, et al. 2018). Thus, if psychosocial mechanisms are the primary pathways through which income inequality may impact health, we may observe a significant, positive relationship between mental and substance abuse disorder YLD and income inequality; particularly in high-income countries.

DATA AND METHODS

Dependent Variables – Population Health

The dependent variables are life expectancy at birth, infant mortality, and years lived with two types of disability (YLD). The first two measures are commonly used in previous cross-national research about income inequality and health (Wilkinson 1992; Mellor and Milyo 2001; Beckfield 2004; Babones 2008). 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 1000 live births at the country-level. It is logged to ensure normality. The life expectancy variable covers a maximum of 170 countries and 53 years (1960-2013), while the infant mortality variable covers a maximum of 169 countries and 53 years (1960-2013). These variables are drawn from population estimates or from country vital records. There are no self-reported health elements. We utilize linear interpolation to fill in missing values within countries between years. For the life expectancy at birth variable, interpolated data accounts for 1% of cases, while for the infant mortality variable, it accounts for .01% of cases.

We utilize YLD data from the Global Burden of Disease study (GBD 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 are generated by multiplying prevalence (based on systematic reviews) by the disability weight (based on population-based surveys) for each sequela (GBD 2015). The

YLD variables contain no self-reported elements. We utilize 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 YLD variables cover a maximum of 165 countries and 23 years (1990-2013). The Global Burden of Disease study generates data for each country at five year intervals (i.e., 1990, 1995, 2000, etc.). Thus, we perform linear interpolation to fill in missing values within countries between years. The data interpolation accounts 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. We follow the recommendations of Solt (2009) and account for this variability by estimating multiple imputation (MI) models. This procedure incorporates uncertainty in the Gini estimates into the coefficients and standard errors (for details, see Rubin 1996 and Jenkins 2105).

To improve comparability and coverage, we use post-tax and transfer (or “net”) income inequality data from the SWIID (Solt 2009). Because they are benchmarked with LIS data (see Solt 2009 for a detailed discussion), incomes are adjusted for household size to produce inequality in equivalent household incomes. The Gini variable covers 173 countries and 53 years (1960-2013).

Independent Variable – Economic Development

We measure economic development with gross domestic product per capita (GDP per capita) in current US dollars from the World Bank Development Indicators (World Bank 2016). The GDP per capita variable covers 166 countries and 53 years (1960-2013). To alleviate biases in estimated coefficients and standard errors owing to extreme skew, we log GDP per capita. We utilize 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 are similar but slightly higher than those presented in previous cross-national works (e.g., Beckfield 2004; Babones 2008).[5]

Multivariate Fixed Effects Models

Heterogeneity bias is an important issue in cross-national income inequality and health research (Beckfield 2004). To remedy this problem, we use a fixed-effects estimator in both approaches. 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 correct for heteroscedasticity and arbitrary forms auto-correlation within clusters (Rogers 1993).

Conceptually, we estimate 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 refers to the interaction of income inequality and GDP per capita. α 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 $\beta x_{jt}\gamma_{jt}$ is equal to zero.

The data creates unbalanced panels, where countries contribute different numbers of observations. The final sample for the life expectancy models includes 4243 observations, 163 countries, and 53 years. For the infant mortality models, the final sample has 4155 observations, 162 countries, and 53 years. For the years lived with disability (YLD) models, the final samples have 2894 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 analyze alternative sources of data on income inequality, life expectancy, and GDP per capita. In addition, we employ varying lags of income inequality, and alternative econometric corrections for heteroskedastic and serially-correlated errors, and unobserved period effects. Our multiple analyses allow 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 estimate 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. The results for the infant mortality and life expectancy models are presented in Table 2. 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 in keeping with previous research, and is 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. Model 3 reveals a small increase in the effect of income inequality on infant mortality as development increases; however, it is non-significant.

As has been noted elsewhere, 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 income 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 (Politt, et al. 2005; Pavalko and Caputo 2013). Thus, the interaction between income inequality and economic development is positive and significant in the interactive model of life expectancy (Model 4). This finding provides some support the argument that economic development attenuates the association between income inequality and life expectancy (H1).

[Figure 2 about here]

When countries undergo epidemiological transition, communicable illnesses decline and life expectancy increases; however, life expectancy gains slow among more developed/healthy countries. Therefore, the significant interaction term in Model 4 should be read with some caution. However, non-communicable illnesses do not follow this pattern, and in fact become a larger concern for population health among countries with greater life expectancy (GBD 2015). Figure 2 plots several measures of population health against economic development. A comparison of the scatter plot for life-expectancy (top left) to that for YLD due to communicable diseases (top right) bears this out. In both cases, there is much less variability in population health at higher levels of development. 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). More importantly, the variation in both non-communicable diseases and mental health and substance abuse disorders 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 non-communicable disease YLD rate and mental and substance use disorders YLD rate. The basic and interactive models are presented in Table 3. In Model 1, income inequality has a significantly 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 H1, economic development attenuates the relationship between income inequality and the non-communicable disease YLD rate. However, economic development plays no moderating role in the relationship between income inequality and mental and substance use disorders YLD. Thus, the significant interaction term in Model 4 of table 2 is not an artifact of low variability in life expectancy in rich countries. Economic development appears to attenuate 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 inequality-health link for two reasons. First, they allow us to assess whether or not we observe a moderating effect of economic development in 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. This replication also *addresses* spatial (i.e., country) and temporal composition.

[Table 4 about here]

Table 4 reports the results in a manner identical to Tables 2 and 3. 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, the there is a significant, positive interaction between inequality and economic development when life expectancy is the dependent variable.

Additional Concerns

We conduct five additional analyses. First, the World Bank's life expectancy estimates come from a variety of sources using a variety of methods. Beckfield (2004) 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 (234). Second, to maximize sample size above, 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 address the potential for heteroskedastic and serially-correlated errors with the clustered sandwich estimator from Rogers (1993), but these 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 period-specific fixed effects.

[Table 5 about here]

Thus, Table 5 reports 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 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 auto regressive 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 Tables 2-6, suggesting our previous estimates are overly conservative owing to the bias of clustered standard errors with unbalanced panels.

Finally, some literature suggests the impacts of inequality on health are cumulative and lagged (Zheng 2012; c.f. Lillard et al. 2015; Shi et al. 2004). One anonymous reviewer suggested that such lags should be shorter for infectious diseases that are more important in poor countries and longer for degenerative diseases more prevalent in rich countries. If our data evinces this varied lag process, we should expect (a) lagged effects to be larger than contemporaneous ones and (b) lagged effects to peak at shorter intervals with respect to life expectancy than the non-communicable 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 1-10 year lags (see Kim, et al. 2008) for both life expectancy and non-communicable YLD rate. The interaction terms that we obtain from these models are reported in Figure 2. We find a linear (though not exactly monotonic) decrease in the size of the interaction term for each lag from years 1-10. 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 years lived with disability due to non-communicable diseases varies significantly with the level of development and has more harmful effects on poorer countries. To examine the substantive importance of this variation, we examine the marginal effects of inequality on life expectancy and years lived with disability (non-communicable diseases) as they vary by GDP per capita. Each panel shows the marginal effects across the analyses in Tables 2-5.

[Figure 3a and 3b, about here]

The first panels of Figures 3a and 3b illustrates the analysis from Model 4 of Table 2. The second panel comes from Model 4 of Table 4. The results in the third panel 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 on Figure 3b illustrates the percent of the population. 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 percent more deleterious in poorer countries (Panel 3). At the high end, we estimate that inequality's impact on population health is as much as 220.67 percent more deleterious in poorer countries (panel 1).[7]

In all panels, the effect of inequality on health is significantly negative at lower levels of 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, however, because most of the world's population lives in the developing world. 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 over the period. Panels 1 and 3 in each figure also show that we estimate a significantly *positive* impact of inequality in extremely rich countries, though the share of cases is similarly 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 YLD (non-communicable disease). Panel 1 comes from Model 3 of Table 3; panel two comes from Model 2 of Table 5. Panels 3 and 4 are identical to 1 and 2 except 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 inequality's impact on population health is significantly deleterious at lower levels of 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 therefore includes middle-income countries like Paraguay and Thailand. These analyses also suggest an even larger gradient in the impact of income inequality and 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 percent more deleterious in poorer countries (panel 1). At the high end, the impact is as much as 374.3 percent more deleterious (panel 2).

Taken together, the results presented in Figure 2 and 3 tell a clear, if varied, substantive story. Inequality harms population health among countries at the lowest developmental strata. Countries in the middle experience either a harmful (years lived with disability) or null (life expectancy) health impact 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 income inequality on population health, though we are skeptical of the life expectancy results among richer countries for the reasons discussed above. In short, our results reveal a *global* gradient in the relationship between income inequality and population health, and the magnitude of this macro-gradient is relatively large (139.7 to 374.3% more deleterious in poor countries).

DISCUSSION

Theories linking income inequality to poorer health are intuitive and provide varied causal mechanisms, yet the empirical literature is mixed. While some of this owes to differences in methodology, sample composition, data sources, etc., 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 test the hypothesis directly in a systematic fashion. 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. Income inequality worsens population health in poorer countries, but has no significant harmful effects in richer countries.

While it is beyond the scope of the present paper to parse out the precise mechanisms underlying the partial associations we observe, we do provide some conjecture to motivate future research. First and foremost, both the more deleterious impact of inequality in poor countries and the null results on YLD from mental disorders and substance abuse align with previous research emphasizing mechanisms drawn from neo-materialist perspectives. That is, our results highlight neo-material mechanisms underlying the relationship between income inequality and health. We imagine three types of neo-material processes that may matter (and co-vary across time and space), but 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 poor countries with high inequality, health care, adequate sanitation, nutrition and health education are enjoyed by a small and rich proportion of the population, which produces poor average population health outcomes. Contrarily, relatively poor individuals living in high-income countries with high income inequality enjoy vastly superior health care, sanitation, nutrition and health education than their counterparts in poor countries. While health gradients exist even in rich countries with high inequality (e.g., Beckfield, Olafsdottir, and Bakhtiari 2013), these public goods are less concentrated among the rich than they are in poor countries with high inequality (Anand and Ravallion 1993; Elo 2009; Pop, et al. 2013).

Another type involves less robust political institutions in less-developed inegalitarian countries. 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 (Kaufman and Segura-Ubiergo 2001; Beckfield and Krieger 2009).

Both of these 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 impact differential exposure to material factors that impact health. Income inequality may be more strongly correlated with inequality in access to health care in poor countries where health infrastructure is less developed. Similarly, income inequality may be more strongly correlated with spending on health-enhancing social services in poor countries for which there is a shallow history of democracy and political inclusion. As such, the deleterious association between income inequality and health in poor countries may be the result of confounding factors such as public goods infrastructure or political institutions (c.f. 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 could consider the degree to which the relationship between income inequality and health is driven by its correlation with this larger constellation of processes directly. Scholars could also investigate the degree to which *income* inequality is a proximate cause of poor health when compared with other forms of inequality.

However, a third possible mechanism involves the *minimum resources necessary to obtain adequate health care*, which are more widely distributed in rich countries than in poor ones, even in the context of high income inequality. In this scenario, the average cost for minimally-adequate health care is at or below the median income in rich countries, but well above the median income in poor 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/households (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 health care even further below the median income in high-income countries.[8] If such a structural relationship between health care costs and median incomes holds across developmental hierarchies, 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 poorer countries. Some recent research suggests that psychosocial pathways are also important for health in less-developed countries (Walker, Kyomuhendo, Chase, and Choudhry 2013). Walker, et al. (2013) 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" (215).

Thus, our results may suggest that psychosocial factors interact with material ones to produce a negative effect of inequality on population health in poorer countries. That is, social comparisons and status positions underling the stress, shame, and anxiety-mediated health effects may be worse in poorer countries. In the absence of a robust healthcare or health insurance infrastructure, for example, individuals have fewer resources with which to mitigate the health effects of stress, shame and anxiety. Thus, a fruitful merger between the integrationist and neo-materialist approaches would be to consider the intervening role of material resources in the health effects of psychosocial processes.

This question could be answered at both the macro and micro levels. For example, a parallel analysis to that performed here might be to consider an interaction of inequality with macro-level covariates capturing the prevalence of healthcare and health infrastructure.

Alternatively, there are logical reasons to consider socioeconomic status (SES) as a moderator of the proposed psychological 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 we would expect that inequality would have a larger effect on individual health among those in the bottom of the income distribution. In such an analysis, we would expect that SES has a stronger moderating effect in countries with weaker healthcare systems and/or health infrastructure. In the individual analyses envisioned here, researchers should consider the lag structure of inequality's effects.

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., Gravelle 1998; c.f. Subramanian and Kawachi 2004; Ellison 2002). 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 (Wolfson, et al. 1999; Babones 2008).

2. Pop, et al. (2013) use the hybrid model of Allison (2009), 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 thus potentially biased by) unobserved time-invariant covariates in the hybrid model, while the deviated covariates are perfectly uncorrelated (and thus unbiased) with these unobservables.

3. Herzer and Nunnencamp's (2015) design requires balanced panels and thus 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 akin to 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 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.

REFERENCES

Allison, Paul. 2009. *Fixed effects regression models*. Los Angeles: Sage Publications

Anand, Sudhir and Martin Ravallion. 1993. “Human development in poor countries: On the role of private incomes and public services.” *Journal of Economic Perspectives,* 7, 133–150.

Avendano, Mauricio. 2012. “Correlation or causation? Income inequality and infant mortality in fixed effects models in the period 1960-2008 in 34 OECD countries.” *Social Science and Medicine*, 75(2012): 754-760.

Babones, Salvatore J. 2008. “Income inequality and population health: correlation and causality.” *Social Science and Medicine,* 66(7): 1614-1626.

Beckfield, Jason. 2004. ‘‘Does Income Inequality Harm Health? New Cross-National Evidence.’’ *Journal of Health and Social Behavior*, 45:231–248.

Beckfield, Jason and Nancy Krieger. 2009. “Epi + demos + cracy: Linking Political Systems and Priorities to the Magnitude of Health Inequities—Evidence, Gaps, and a Research Agenda.” *Epidemiologic Reviews,* 31: 152-177.

Beckfield, Jason, Sigrun Olafsdottir, and Elyas Bakhtiari. 2013. “Health Inequalities in Global Context.” *American Behavioral Scientist*, 57(8):1014–1039.

Bhandari, Bhesh, J. T. Newton,, and Eduardo Bernabé. 2015. “Income Inequality and Use of Dental Services in 66 Countries.” *Journal of Dental Research*, 94(8): 1048-1054.

Bor, Jacob, Gregory H. Cohen, and Sandro Galea. 2017. “Population health in an era of rising income inequality: USA, 1980–2015.” *The Lancet*, 389(10077): 1475-1490.

Cutler, David M., Angus Deaton, and Adriana Lleras-Muney. 2006. “The Determinants of Mortality.” *Journal of Economic Perspectives*, 20: 97-120.

Davey Smith, George. 1996. “Income Inequality and Mortality: Why Are They Related?” *British Medical Journal*, 312:987–88.

Deaton, Angus. 2003. “Health, Inequality, and Economic Development .” *Journal of Economic Literature*, 41(1): 113-158.

Deininger, Klaus and Lyn Squire. 1996. “A New Data Set Measuring Income Inequality.” *World Bank Economic Review*, 10:565–91.

Elgar, Frank J., 2010. “Income inequality, trust, and population health in 33 countries.” *Am. J. Public Health,* 100, 2311-2315.

Elgar, Frank J., Geneviève Gariépy, Torbjørn Torsheim, and Candace Currie. 2017. “Early-life income inequality and adolescent health and well-being.” *Social Science and Medicine,* 174: 197-208.

Ellison, George T. H. 2002. “Letting the Gini out of the bottle? Challenges facing the relative income hypothesis.” *Social Science and Medicine*, 54(2002): 561-576.

Elo, Irma T. 2009. “Social class differentials in health and mortality: Patterns and explanations in comparative perspective.” *Annual Review of Sociology*, 35, 553–572.

Feenstra, Robert C., Robert Inklaar, and Marcel P. Timmer. 2013. “The Next Generation of the Penn World Table,” NBER Working Paper no. 19255. http://cid.econ.ucdavis.edu/pwt.html

Global Burden of Disease Study Collaborators (GBD). 2015. “Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013.” *The Lancet*, 386(9995):743–800.

Gravelle, Hugh. 1998. “How much of the relation between population mortality and unequal distribution is a statistical artefact?” *British Medical Journal*, 316, 382–385.

Gravelle, Hugh, John Wildman, and Matthew Sutton. 2002. “Income, income inequality and health: what can we learn from aggregate data?” *Social Science and Medicine*, 54(4): 577-589.

Hajebi, Elnaz and Mohammad Javad Razmi. 2014. “Effect of Income Inequality on Health Status in a Selection of Middle and Low Income Countries.” *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 9(3):133-152.

Hansen, Christian. B. 2007. “Generalized Least Squares Inference in Panel and Multilevel Models with Serial Correlation and Fixed Effects.” *Journal of Econometrics* 140(2): 670-694.

Herzer, Dierk and Peter Nunnencamp. 2015. “Income Inequality and Health: Evidence from Developed and Developing Countries.” *Economics: The Open-Access, Open-Assessment E-Journal*, 9 (2015-4): 1—57.

Jenkins, Stephen P. 2015. “World income inequality databases: an assessment of WIID and SWIID.” *Journal of Economic Inequality,* 13: 629-671.

Kaufman, Robert R. and Alex Segura-Ubiergo. 2001. “Globalization, Domestic Politics, and Social Spending in Latin America: A Time-Series Cross-Section Analysis, 1973-97.” *World Politics*,53(4): 553-587.

Kawachi, Ichiro, Bruce P. Kennedy, Kimberly Lochner, and Deborah Prothrow-Stith. 1997. “Social Capital, Income Inequality, and Mortality.” *American Journal of Public Health*, 87:1491–9.

Kawachi, Ichiro, Bruce P. Kennedy, and Richard G. Wilkinson, eds. 1999. *Income Inequality and Health: A Reader.* New York: New Press.

Kim, Daniel, Ichiro Kawachi, Steven Vander Hoorn, and Majid Ezzati. 2008. "Is inequality at the Heart of it? Cross-Country associations of income inequality with cardiovascular diseases and risk factors." *Social Science and Medicine*, 66, 1719-1732.

Klomp, Jeroen and Jakob de Haan. 2009. "Is the political system really related to health?" *Social Science and Medicine*, 69:36-46.

Korzeniewicz, Patricio and Timothy Patrick Moran. 2009. *Unveiling Inequality: A World-Historical Perspective*. New York: Russel Sage

Lago, Santiago, David Cantarero, Berta Rivera, Marta Pascual, Clara Blázquez-Fernández, Bruno Casal, and Francisco Reyes. 2018. "Socioeconomic status, health inequalities and non-communicable diseases: a systematic review." *J Public Health* 26(1): 1-14. https://doi.org/10.1007/s10389-017-0850-z

Layte, Richard, 2012. "The association between income inequality and mental health: testing status anxiety, social capital, and neo-materialist explanations." *Eur. Sociol. Rev.*, 28, 498-511.

Lillard, Dean R., Richard V. Burkhauser, Markus H. Hahn, and Roger Wilkins. 2016. "Does early-life income inequality predict self-reported health in later life? Evidence from the United States." *Social Science and Medicine* 128: 347-355.

Link, Bruce and Jo Phelan. 1995. "Social Conditions As Fundamental Causes of Disease." *Journal of Health and Social Behavior*, 1995 (Extra Issue):80-94.

Lynch, John and George A. Kaplan. 1997. "Understanding How Inequality in the Distribution of Income Affects Health." *Journal of Health Psychology*, 2:297–314.

Lynch, John, George Davey Smith, Sam Harper, Marianne Hillemeier, Nancy Ross, George A. Kaplan, and Michael Wolfson. 2004. "Is income inequality a determinant of population health? Part 1. A systematic review." *The Milbank Quarterly*, 82(1): 5–99.

Mellor, Jennifer M. and Jeffrey Milyo. 2001. "Reexamining the evidence of an ecological association between income inequality and health." *J Health Polit Policy Law*, *26*(3):487-522.

Mills, Anne 2014. "Health care systems in low- and middle-income countries." *The New England Journal of Medicine*, 370(6):552-557.

Muntaner, Charles and John Lynch. 1999. “Income Inequality, Social Cohesion, and Class Relations: A Critique of Wilkinson’s Neo-Durkheimian Research Program.” *International Journal of Health Services,* 29:59–81.

Muntaner, Charles, Carme Borrell, Edwin Ng, Haejoo Chung, Albert Espelt, Maica Rodriguez-Sanz, Joan Benach, and Patricia O’Campo. 2011. “Review article: Politics, welfare regimes, and population health: controversies and evidence.” *Sociology of Health and Illness,* 33(6): 946-964.

Nichols, Austin and Mark Schaffer. 2007. “Clustered Errors in Stata,” Working Paper. http://repec.org/usug2007/crse.pdf

Pabayo, Roman, Ichiro Kawachi, and Stephen E. Gilman. 2014. “Income inequality among American states and the incidence of major depression.” *Journal of Epidemiology and Community Health,* 68(2), 10.1136/jech–2013–203093. http://doi.org/10.1136/jech-2013-203093

Patel, Vikram, Jonathan K. Burns, Monisha Dhingra, Leslie Tarver, Brandon A. Kohrt, and Crick Lund. 2018. “Income inequality and depression: a systematic review and meta-analysis of the association and a scoping review of mechanisms.” *World Psychiatry*, 17(1), 76–89. http://doi.org/10.1002/wps.20492

Pavalko, Eliza K. and Jennifer Caputo. 2013. “Social Inequality and Health across the Life Course.” *American Behavioral Scientist*, 57:1040–1056.

Pickett, Kate E. and Richard G. Wilkinson. 2010. “Inequality: an underacknowledged source of mental illness and distress.” *Br J Psychiatry.* 197(6):426-8. doi: 10.1192/bjp.bp.109.072066.

Pickett, Kate E. and Richard G. Wilkinson. 2015. “Income inequality and health: A causal review.” *Social Science and Medicine*, 128C: 316-326.

Pollitt, Ricardo A., Kathryn M. Rose, and Jay S. Kaufman. 2005. “Evaluating the evidence for models of life course socioeconomic factors and cardiovascular outcomes: a systematic review.” *BMC Public Health,* 5:7.

Pop, Ioana, Erik van Ingen, and Wim van Oorschot.2013. “Inequality, Wealth and Health: Is Decreasing Income Inequality the Key to Create Healthier Societies?” *Social Indicators Research,* 113:1025–1043.

Pritchett, Lant and Lawrence H. Summers. 1996. “Wealthier is Healthier.” *The Journal of Human Resources,* 31(4): 841-868.

Pulok, Mohammad H. 2012. “Revisiting Health and Income Inequality Relationship: Evidence from Developing Countries.” *Journal of Economic Cooperation and Development*, 33(4): 25-62.

Ram, Rati. 2006. “Further examination of the cross-country association between income inequality and population health.” *Social Science and Medicine*, 62, 779–791.

Regidor, Enrique, David Martinez, Juana M. Santos, María E. Calle, Paloma Ortega, and Paloma Astasio. 2012. “New findings do not support the neomaterialist theory of the relation between income inequality and infant mortality.” *Social Science and Medicine,* 75:752-753

Ribeiro, Wagner S., Annette Bauer, Mário C. Rezende Andrade, Marianna York-Smith, Pedro M. Pan, Luca Pingani, Martin Knapp, Evandro S. F. Coutinho, and Sara Evans-Lacko. 2017. “Income inequality and mental illness-related morbidity and resilience: a systematic review and meta-analysis.” *The Lancet Psychiatry*, 4(7): 554-562. https://doi.org/10.1016/S2215-0366(17)30159-1.

Rogers, William H. 1993. “Regression standard errors in clustered samples.” *Stata Technical Bulletin*, 13: 19–23.

Rubin, Donald B. 1996. “Multiple Imputation After 18+ Years.” *Journal of the American Statistical Association,* 91(434): 473-489.

Shi, Leiyu, James Macinko, Barbara H. Starfield, Jiahong Xu, Jerri Regan, Robert L. Politzer, and J. T. Wulu. 2004. “Primary Care, infant mortality, and low birth Weight in the states of the USA.” *Journal of Epidemiology and Community Health*, 58(5), 374-380.

Singh, Ankur, Jane Harford, Helena S. Schuch, Richard G. Watt, and Marco A. Peres. 2016. “Theoretical basis and explanation for the relationship between area-level social inequalities and population oral health outcomes – A scoping review.” *SSM - Population Health*, 2: 451-462. https://doi.org/10.1016/j.ssmph.2016.06.001.

Solt, Frederick. 2009. “Standardizing the World Income Inequality Database.” *Social Science Quarterly,* 90: 231-242.

Subramanian, S. V. and Ichiro Kawachi. 2004. “Income Inequality and Health: What Have We Learned So Far?” *Epidemiologic Reviews,* 26: 78–91.

Torre, Roberta and Mikko Myrskylä. 2014. “Income inequality and population health: An analysis of panel data for 21 developed countries, 1975–2006.” *Population Studies,* 68:11-13.

Walker, Robert, Grace Bantebya Kyomuhendo, Elaine Chase, and Sohail Choudhry. 2013. “Poverty in global perspective: is shame a common denominator?” *Journal of Social Policy* 42: 215-233.

Wilkinson, Richard G. 1992. "Income Distribution and Life Expectancy." *BMJ*, 304(6820): 165–168.

Wilkinson, Richard G. 1996. *Unhealthy Societies: The Afflictions of Inequality*. London: Routledge.

Wilkinson, Richard G. 1997. "Income, inequality and social cohesion." *American Journal of Public Health,* 87: 104-106.

Wilkinson, Richard G. 1999. "Health, hierarchy, and social anxiety." *Annals New York Academy of Sciences*, 896: 48–63.

Wilkinson, Richard G. and Kate E. Pickett. 2006. "Income inequality and population heath: A review and explanation of the evidence." *Social Science and Medicine*, 62:1768–1784.

Wilkinson, Richard G. and Kate E. Pickett. 2009a. *The Spirit Level: Why More Equal Societies Almost Always Do Better.* Bloomsbury Press.

Wilkinson, Richard G. and Kate E. Pickett. 2009b. "Income inequality and social dysfunction." *Annual Review of Sociology*, 35: 493–511.

Wilkinson, Richard G. and Kate E. Pickett. 2017. "The enemy between us: The psychological and social costs of inequality." *European Journal of Social Psychology*, 47: 11-41.

Wolfson, Michael, George Kaplan, John Lynch, Nancy Ross, and Eric Backlund. 1999. "Relation between income inequality and mortality: Empirical demonstration." *British Medical Journal*, 319, 953–957.

World Bank. 2016. "World Bank Development Indicators." Retrieved from http://data.worldbank.org/ on August 26, 2017.

Zheng, Hui. 2012. "Do people die from income inequality of a decade ago?" *Social Science and Medicine*, 75: 36-45.

TABLE 1: Descriptive Statistics

		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
	S.D.	1.606	1.068	9.788	9.538	1687.232	298.712

Note: *Natural logarithm.

TABLE 2: Multiple Imputation Fixed-effects Regressions of Infant Mortality (Log) on Income Inequality and Life Expectancy on Income Inequality

	Basic Models		Full Models	
	(1)	(2)	(3)	(4)
	Log Infant Mortality	Life Expectancy	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 x 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, *** p<.001, ** p<.01, * p<.05.

TABLE 3: Multiple Imputation Fixed-effects Regressions of Years Lived with Disability per 100,000 on Income Inequality

	Basic Models		Full Models	
	(1)	(2)	(3)	(4)
	Years Lived with Disability, NCD	Years Lived with Disability, M-SA	Years Lived with Disability, NCD	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 x 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, *** p<.001, ** p<.01, * p<.05. NCD refers to Non-Communicable Diseases. M-SA refers to Mental or Substance Abuse Disorders.

TABLE 4: Fixed-effects Regressions of Infant Mortality and Life Expectancy on Alternative Gini

	Basic Models		Full Models	
	(1)	(2)	(3)	(4)
	Infant Mortality	Life Expectancy	Infant Mortality	Life Expectancy
Income Inequality	.0003	-.040	.001	-0.478*
	(.003)	(.053)	(.014)	(.205)
Log GDP per Capita	-.239***	.695	-.240**	-1.460
	(.037)	(.754)	(.074)	(1.105)
Gini x 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

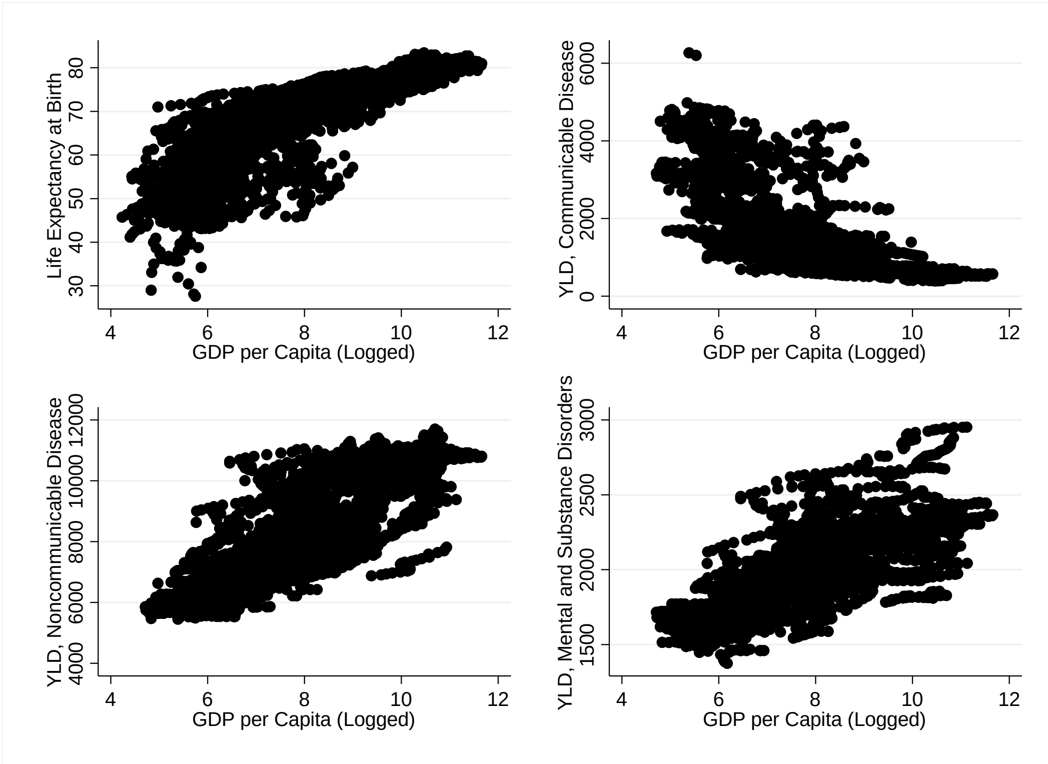
Note: Serial correlation and heteroscedasticity consistent standard errors in parentheses, *** *p*<.001, ** *p* <.01, * *p* <.05. Controls for data source utilized in the model, but not reported here.

Table 5: Multiple Imputation Fixed Effects Regression of Life Expectancy and Years Lived with Disability per 100,000, Non-Communicable Diseases on Income Inequality

	(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 x Log Real GDP per capita	.150***	-1.409*
	(.036)	(.677)
Constant	86.713***	4193.874***
	(13.023)	(242.118)
Observations	542	2682

Note: NCD refers to Non-Communicable Diseases. 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 *** *p* <.001, ** *p* <.01, * *p* <.05.

Figure 1: Scatterplots of Life Expectancy by GDP per Capita versus Years Lived with Disability per 100,000 by GDP per Capita



Note: Abbreviation YLD refers to Years Lived with Disability per 100,000.

Figure 2: Interaction Terms When Gini is Lagged 1-10 Years

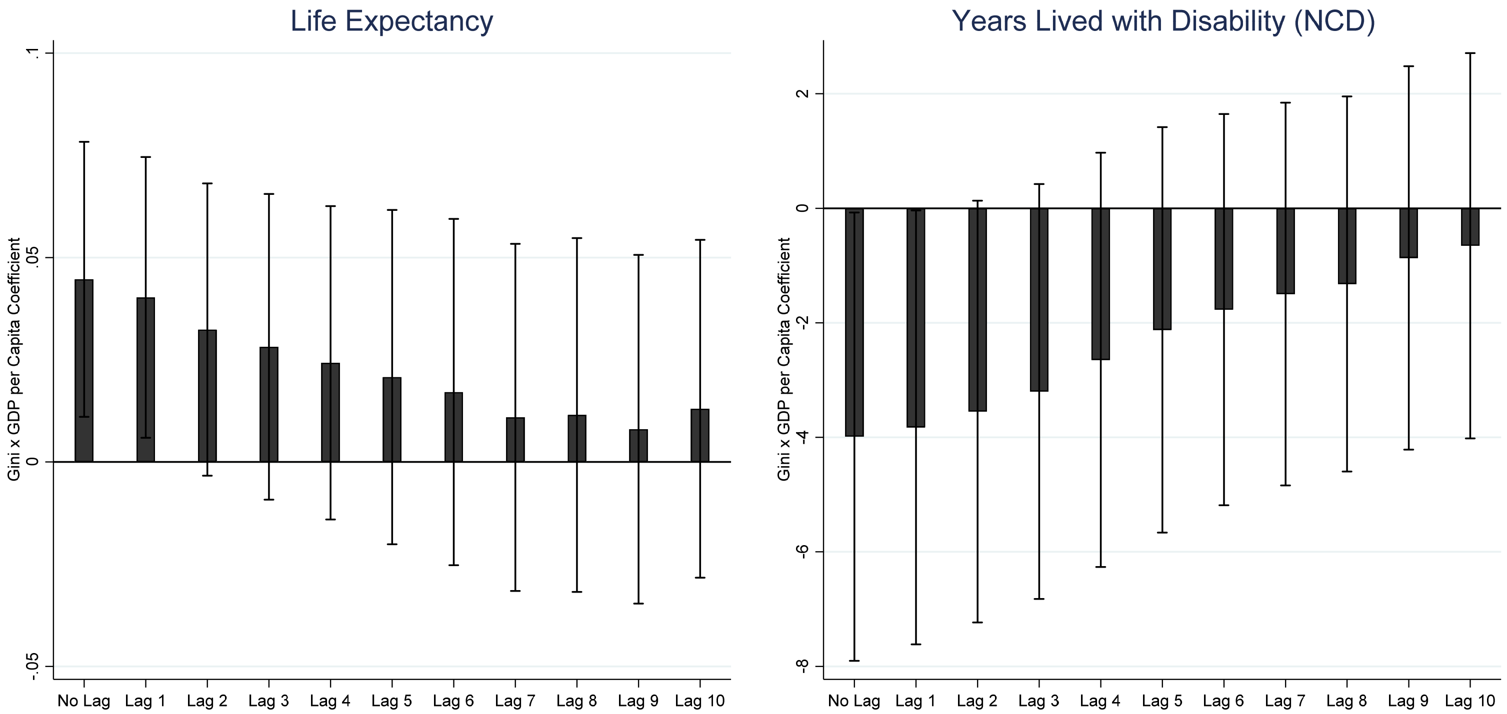


Figure 3a: Marginal Effects of Gini on Life Expectancy at Birth across Observed Range of Economic Development

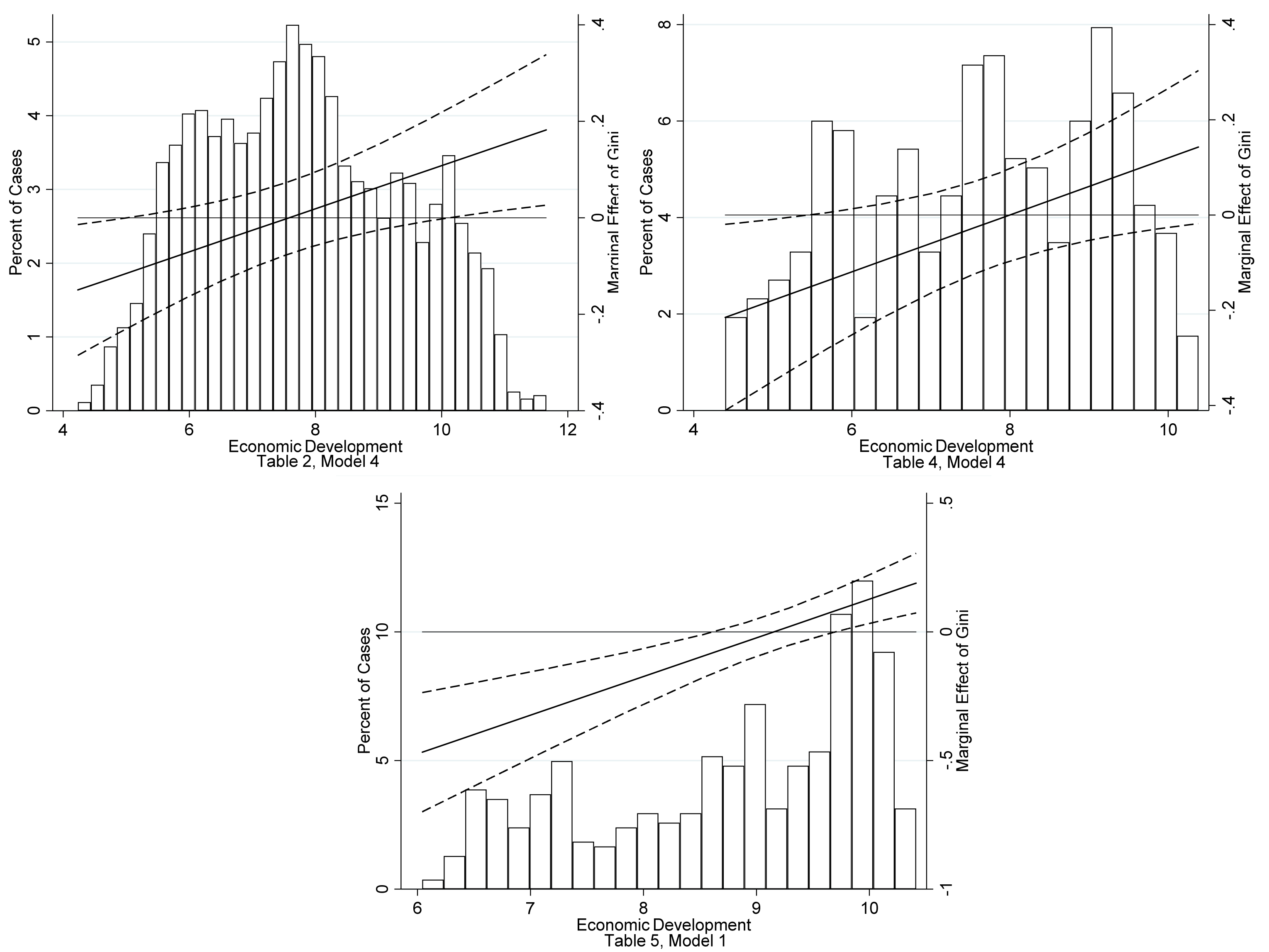


Figure 3b: Marginal Effects of Gini on Life Expectancy at Birth across Observed Range of Economic Development, Population-Weighted

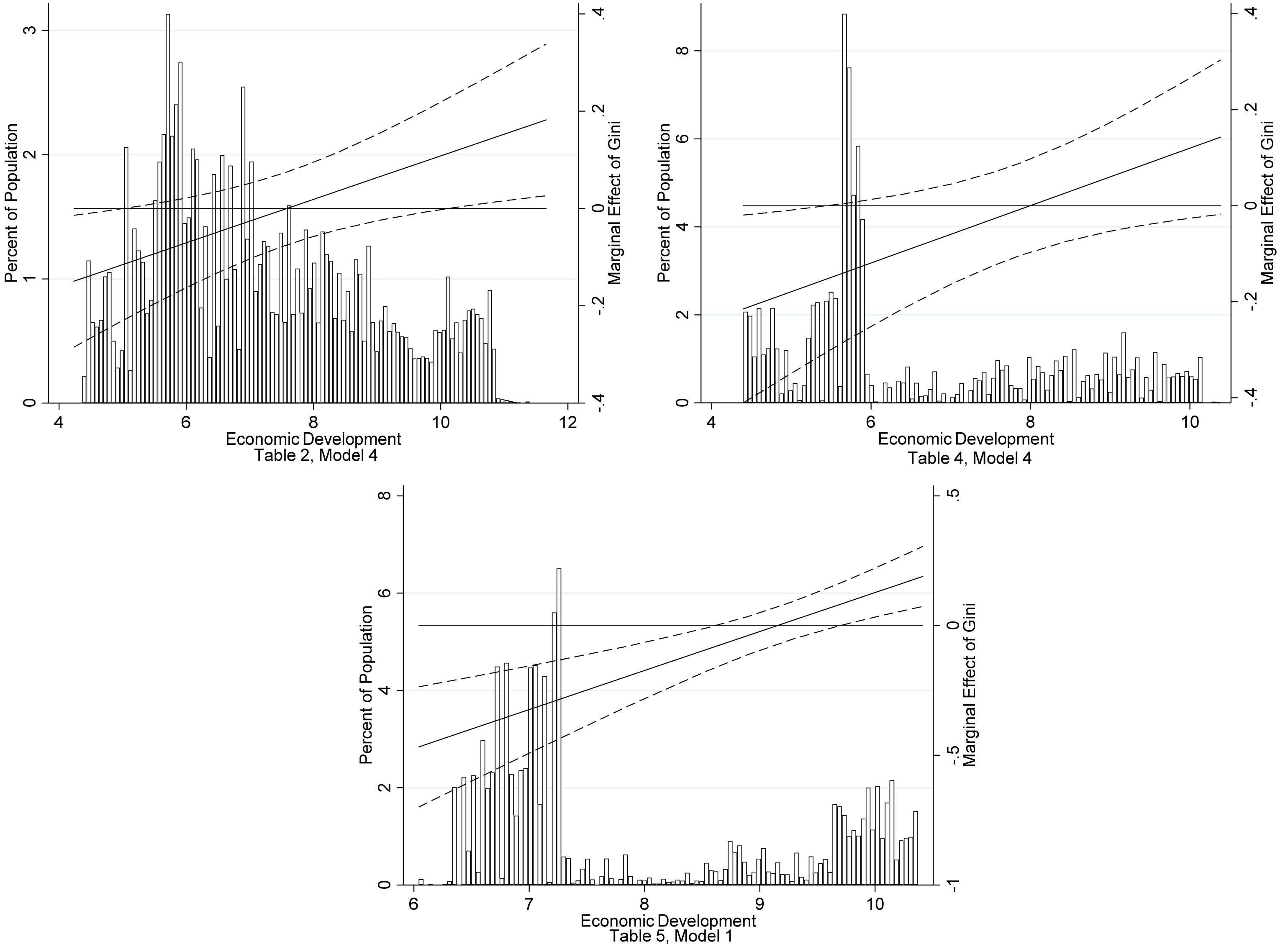


Figure 4: Marginal Effects of Gini on Years Lived with Disability per 100,000, Non-Communicable Diseases across Observed Range of Economic Development, Unweighted (top) and Population Weighted (bottom)