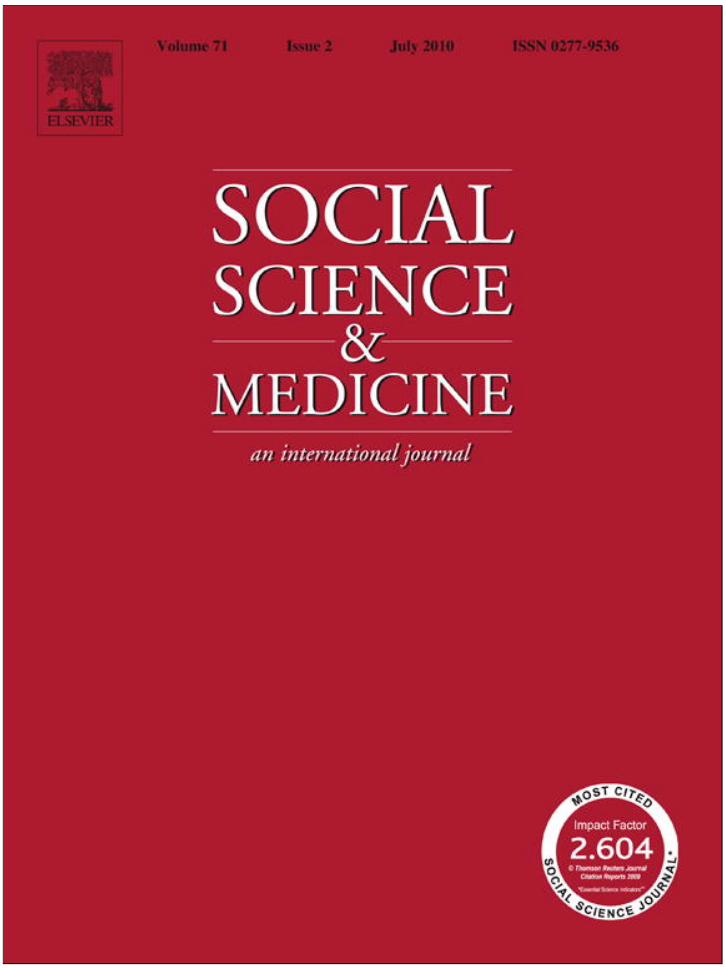

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Is wealthier always healthier? The impact of national income level, inequality, and poverty on public health in Latin America☆

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ABSTRACT

Despite findings indicating that both national income level and income inequality are each determinants of public health, few have studied how national income level, poverty and inequality interact with each other to influence public health outcomes. We analyzed the relationship between gross domestic product (GDP) per capita in purchasing power parity, extreme poverty rates, the gini coefficient for personal income and three common measures of public health: life expectancy, infant mortality rates, and tuberculosis (TB) mortality rates. Introducing poverty and inequality as modifying factors, we then assessed whether the relationship between GDP and health differed during times of increasing, decreasing, and decreasing or constant poverty and inequality. Data were taken from twenty-two Latin American countries from 1960 to 2007 from the December 2008 World Bank World Development Indicators, World Health Organization Global Tuberculosis Database 2008, and the Socio-Economic Database for Latin America and the Caribbean. Consistent with previous studies, we found increases in GDP have a sizable positive impact on population health. However, the strength of the relationship is powerfully influenced by changing levels of poverty and inequality. When poverty was increasing, greater GDP had no significant effect on life expectancy or TB mortality, and only led to a small reduction in infant mortality rates. When inequality was rising, greater GDP had only a modest effect on life expectancy and infant mortality rates, and no effect on TB mortality rates. In sharp contrast, during times of decreasing or constant poverty and inequality, there was a very strong relationship between increasing GDP and higher life expectancy and lower TB and infant mortality rates. Finally, inequality and poverty were found to exert independent, substantial effects on the relationship between national income level and health. Wealthier is indeed healthier, but how much healthier depends on how increases in wealth are distributed.

Introduction

A seminal piece by Pritchett and Summers (1996) found increases in per capita GDP had positive health effects. In their cross-national analysis they found that a 5% increase in GDP led to an average of 1% decrease in infant mortality rates. At the national level, as a country grows wealthier, it has more resources to spend on health-promoting social programs, such as public sanitation, potable water, and health awareness initiatives. At the individual level, individual consumers have more income that they can spend on healthy foods and medical care, which could plausibly translate into improved individual and, as a result, aggregate health statistics.

What role do poverty and inequality play in a potential wealth–health relationship? Is wealthier always healthier? At the national level, Deaton (2003) showed that the effect of each additional dollar on health is weaker among richer countries than for poorer countries. Anand and Ravallion (1993) suggested that much of the positive health effects from increases in GDP occur because economic growth decreases poverty. Thus, the relationship between increases in GDP and public health should be stronger for poorer countries, where growth lifts more people out of poverty (Dollar & Kraay, 2002). However, how poverty rates within a country affect public health has not been addressed. Additionally, we know of no studies offering empirical evidence on how poverty rates modify the relationship between national income level and health.

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The role of income inequality in determining public health has been hotly debated. Wilkinson's (1992) much-cited seminal article on income distribution and life expectancy found evidence that both increases in the share of income going to the poorest 60% of the population ($r = 0.80$, $p < 0.05$) and decreases in the level of relative poverty ($r = -0.73$, $p < 0.01$) were strongly correlated with increases in life expectancy. Since then, many studies have sought to investigate whether and how income inequality affects public health (Chiang, 1999; Kaplan, Pamuk, Cohen, & Balfour 1996; Kawachi, Kennedy, Lochner, & Prothrow-Stith, 1997; Lynch & Kaplan, 1997; Lynch et al., 1998; Lynch, Smith, Kaplan, & House, 2000; Marmot, 2002, 2005; Waldmann, 1992; Wilkinson, 1994). In their review of the literature on income inequality and population health, Wilkinson and Pickett (2006) found that over 70% of the 168 analyses reviewed report that health is worse in societies with greater income inequality.

Theories explaining the mechanisms through which income inequality affects public health broadly fall into three schools. First, the psychosocial interpretation contends that poor health stems from the perception of others above oneself in the social, and particularly income, hierarchy (Marmot, 2002). This perception in turn generates negative mental states such as stress and depression that have detrimental effects on health (Wilkinson, 1996). Lynch et al. (2000), however, criticized the psychosocial interpretation as being imprecise and fraught with conceptual and empirical problems. Instead, they advanced a "neo-materialist" interpretation, which contends that "health inequalities result from the differential accumulation of exposures and experiences that have their sources in the material world" (Lynch et al., 2000, p. 1202). Finally, the "social capital" interpretation – a synthesis of the psychosocial and neo-materialist interpretations – emphasizes the income inequality's role in preventing individuals from building and maintaining social capital, which in turn leads to poor health (Kawachi & Kennedy, 1999; Kawachi et al., 1997).

Research on inequality and health has been extended to the developing world, including Latin America, and has produced similar findings. Casas, Dachs, and Bambas (2001) presented a number of observations on income inequality and health within countries. For example, they noted that the child mortality rate was five times higher for families earning less than $50 USD per month than for families earning over $150 USD per month in Pelotas, Brazil. They also found in Peru in 1996 that the infant mortality rate for the poorest quintile of the population was almost five times larger than that of the richest quintile. Another study of Latin American indigenous peoples – disproportionately among the poor in every Latin American country – found that they had significantly higher mortality and morbidity rates than their non-indigenous counterparts (Montenegro & Stephens, 2006). Mexican men aged 50 and older from higher income brackets and socioeconomic backgrounds were reported to have better health than men from the same age group of lower income and socioeconomic positions (Smith & Goldman, 2007).

There is also a spatial dimension to income and health inequalities in Latin America, as Rojas (1998) and Orihuela-Egoavil (1993) noted. The Mexican municipality in the lowest decile of per capita income had an average of 2 hospital beds per 10,000 individuals between 1990 and 1996, as compared with 15 hospital beds per 10,000 individuals for the municipality in the highest decile of per capita income (Casas et al., 2001). Astraín, del Carmen Pría, and Ramos' (1998) study of differences in living conditions and mortality in the Cuban province of Camagüey found high mortality rates among the poorest areas of the province. Szwarcwald, Bastos, Viacava, and de Andrade (1999) showed that in Rio de Janeiro the highest homicide rates are found in municipalities with the greatest income inequality. Frank and Finch (2004) observed the importance of geographic and socioeconomic location in infant mortality rates in Mexico from 1986 to 1996, finding that poorer areas have higher infant mortality rates than more affluent areas. Consistent with evidence in high income countries, the descriptive research on Latin America indicates that both impoverished and highly unequal regions display greater health disadvantage.

Such evidence corroborates recent findings from developing countries. Salti (2010) found in South Africa that relative deprivation was a key predictor of mortality. Kondo et al. (2009) published their own meta-analysis on studies of inequality and health, including data from developing nations such as Chile and China. Consistent with the findings of Wilkinson and Pickett (2006), the authors found evidence linking income inequality with adverse health outcomes.

Methodological and empirical criticism of evidence linking income inequality and public health has emerged in recent years. Beckfield (2004) reproduced past studies with more data and found significant income inequality effects on infant mortality and life expectancy detected under ordinary least squares regression either disappeared or became markedly weaker under fixed effects regression, which controls for unobserved heterogeneity, or country-specific factors that could distort results. Similarly, Mellor and Milyo (2001, 2003) challenged evidence of the detrimental effects of income inequality on health in the United States by adding a variety of controls to their analysis and finding that income inequality has no significant effect on health. Pearce and Davey Smith (2003) presented examples where both income inequality and public health have been on the rise concurrently, such as New Zealand. In their analysis of Sweden, Gerdtham and Johannesson (2004) found evidence supporting the claim that increases in income improve health but none confirming that income inequality is detrimental to health. Finally, Lynch, Davey Smith, Harper, Hillemeier, Ross et al.'s (2004) and Lynch, Davey Smith, Harper, and Hillemeier's (2004) comprehensive studies found that, with the minor exception of a few studies of the United States, evidence showing a negative association between income inequality and public health is sparse and inconsistent. Deaton's (2003) comprehensive analysis concluded that "it is *not* true that income inequality itself is a major determinant of population health" (p. 151).

Despite the attention devoted to the relationship of GDP, poverty and inequality to public health, we are aware of no studies that examine whether the positive effects of economic development on health are modified by inequality or poverty. Does the impact of GDP on health depend on how it is distributed? That is, does the GDP-health association vary with levels of and changes in inequality and poverty? Pritchett and Summers (1996) claim that "wealthier is healthier," but is this always the case? It is plausible that the public health gains associated with increasing wealth crucially depend how that wealth is distributed, especially in view of evidence that the income has greater effects on health among resource-poor groups and countries.

Previous studies in this area have been primarily concerned with the developed world and have utilized cross-sectional data. Studies of developing countries that use longitudinal data rarely include the number of years this study considers (covering up to 513 country-years), relying on much smaller sample sizes of highly aggregated data, sometimes as few as 10–15 data points. This study, then, is unique in that it focuses on a less developed region of the world and employs longitudinal data and time series regression methods to examine the relationship between economic variables and public health over time, while also considering the interaction between national income level, poverty, and inequality.

The principle statistical tool used in this analysis is fixed effects regression modelling, or a 'within-country' analysis, following the

approach and recommendation of Beckfield (2004). GDP, poverty, and inequality are separately regressed on infant mortality, life expectancy, and tuberculosis (TB) mortality. Infant mortality and life expectancy are standard measures of public health and economic development. We use TB mortality as an example of infectious disease that is prevalent in Latin America that should disappear as countries become wealthier and undergo the epidemiological transition, and also because TB has long been viewed as an indicator of societal health (Stuckler, King, & Basu, 2008). Next, to test whether the wealth–health association depends on how income is distributed, GDP is regressed on each health variable, but this time the sample is stratified into periods of increasing, decreasing, or decreasing or constant inequality and poverty, providing a test of effect modification.

Data and methods

Data

Data on infant mortality and life expectancy come from the December 2008 World Bank World Development Indicators (WDI). We recognize that methodological problems have been raised concerning infant mortality data, such as changing mortality definitions, new monitoring methods, and the uneven spread of infant mortality across sections of the same region. Nevertheless, we examine infant mortality since it has been consistently used in studies on income inequality and public health. TB mortality data were obtained from the World Health Organization Global Tuberculosis Database 2008.

Per capita GDP in purchasing-power-parity is our measure of economic growth, retrieved from the December 2008 WDI. We use the income gini coefficient obtained from the World Income Inequality database as a measure of income inequality, constructed from survey estimates of individual incomes. Data on poverty come from the Socio-Economic Database for Latin America and the Caribbean. We use the national headcount of individuals in extreme poverty as defined by each country as our poverty measure. This measure has two advantages. By using the poverty line defined by each nation, we avoid purchasing-power-problems associated with using absolute poverty measures ($1 or $2 USD per day), providing a more complete picture than offered by varying regional (urban and rural) poverty measures. Moreover, looking only at the extreme, as opposed to moderate, poverty headcount will act as a more conservative, robust test of the poverty hypothesis since the number of individuals defined to be in poverty is smaller than in the extreme poverty headcount.

The analysis was conducted using Stata version 10.0. A three-year moving average procedure was applied to smooth data series with missing data points. This increased the effective sample size while leaving the means and standard deviations of the data essentially unchanged. To correct for positive skew in the distributions of TB mortality, infant mortality, and GDP, we took the natural logarithm of each of these variables. Table 1 presents summary statistics of the data.

Statistical models

To determine the magnitude and direction of the effect of the economic variables on our health indicators, we used panel regression techniques that accounted for the time- and country-dimensions of the data.

Hausman-tests were conducted to test for unobserved heterogeneity in the data that was affecting the results of the regressions. Results from the Hausman tests were mixed, with some regressions being completely unaffected by heterogeneity in the data while others were dramatically affected. For this reason, as well as the sensitivity of the study of inequality and health to the use of fixed-effects pointed out by Beckfield (2004), fixed-effects regression was chosen to prevent unobserved country-specific factors from biasing the estimated effects. Equation (1) is the fixed-effects estimator:

$$\widehat{H} = H_{i,t} - \overline{H}_i = \alpha + \beta\left(\varphi_{i,t} - \overline{\varphi}_t\right) + \varepsilon_{i,t} \quad (1)$$

where i and t specify country and year, respectively; $H_{i,t}$ is the health variable of interest; $\overline{H}_i$ represents the average value of that health variable; α is the constant term; β is coefficient on the independent variable; $\varphi_{i,t}$ is the economic variable of interest; $\overline{\varphi}_t$ represents the average value of that economic variable; and $\varepsilon_{i,t}$ is the residual.

Though we chose to use the fixed-effects estimator for our study, we acknowledge that its use in social epidemiology has recently been criticized. Clarkwest (2008) observed that the fixed-effects estimator, though controlling for unobserved heterogeneity in a population sample, might bar causal mechanisms implied by theoretical paradigms from entering the analysis. In his response to Clarkwest, Zimmerman (2008) pointed out that the fixed-effects estimator does not distinguish between the effects of income inequality as such and the effects of "confounding variables" that make the causal relationship between inequality and health spurious. Given that the fixed-effects estimator may eliminate key causal channels, it therefore makes it harder to detect a relationship between income inequality and health should one actually exist. In response to the latter, our principle goal is not to specify the mechanisms through which inequality – and, in addition, national income level and poverty – affects public health, but to test whether the distribution of wealth modifies effect of the relationship between GDP and health.

Another recent criticism of the fixed-effects estimator was advanced by Glymour (2008), who points to the importance of the specifying etiological period that could determine the relationship between inequality and health in particular and economic factors and health in general. Echoing Glymour's concern with etiological period, Blakely, Kennedy, and Kawachi (2001) found that it could take up to 15 years for income inequality to manifest itself in self-reported health. But, Preston (2007) found that health outcomes became increasing decoupled with economic level as access to health care and health care innovations improved over time. Similarly, Deaton (2006) offered evidence that increases in GDP had little to no effect on life expectancy and infant mortality. He also attributed the positive trend between growth and health outcomes to improved health care systems and institutional arrangements. Tapia Granados and Ionides (2008) found economic growth had a negative effect or no effect on population health in Sweden in the 20th century with some lag periods. Even in Latin America, there has been evidence of progressive dissociation between economics level and health (Eduardo & Kingsley, 1969; Stolnitz, 1965). To test for the existence of lagged effects, we lagged the dependent variables by 2, 5, 10, and 20 years (results not reported). A clear pattern was observable across the board: all of the results held, but GDP's impact grew stronger as lag periods increased. We also created 5 and 10-year averages in the dependent variables to see if the results held at periods larger than one year (results not reported). Again, all of our results were consistent.

We elect not to add any controls into the regression equation for three reasons. First, we want to capture the total effect, through any causal channel, of our economic variables on health (Subramanian, Blakely, & Kawachi, 2003). Since most co-determinants of health are influenced by economic level and/or inequality and/or poverty (e.g. education, quality and quantity of medical care, availability of clean water and sanitation, etc.) including them in the regression

Table 1
Summary statistics for economic and health variables.

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max	Source
Log GDP per capita	The logarithm of GDP per capita in purchasing power parity.	616	8.50	0.55	6.97	9.48	World Bank World Development Indicators (Dec. 2008)
Log infant mortality rate[a]	Logarithm of the annual number of deaths of infants under the age of one per 1000 live births.	862	3.86	0.70	1.71	5.11	World Bank World Development Indicators (Dec. 2008)
Life expectancy	Total life expectancy from birth in years.	454	66.33	7.79	42.41	78.66	World Bank World Development Indicators (Dec. 2008)
Extreme poverty rate[a]	National headcount of individuals living in extreme poverty as defined by that country as a percentage of total population.	293	18.47	11.85	1.38	56.0	Socio-Economic Database for Latin America and the Caribbean
Gini coefficient[a]	The gini coefficient represents how far a measured unit – in our case, countries – deviates from a perfectly equitable distribution of income among individuals or households. The coefficient ranges from 0, representing perfect income equality, to 100, representing perfect income inequality.	641	49.82	6.17	29.9	65.4	World Income Inequality Database 2008
Log TB mortality rate	The logarithm of total tuberculosis deaths per 100,000 individuals.	412	2.20	1.05	0	4.67	World Health Organization Global Tuberculosis Database 2008

[a] Variable smoothed with a three-year moving average procedure.

will soak up the effect of GDP/inequality/poverty on health (Pritchett & Summers, 1996; Wilkinson & Pickett, 2006). Second, we seek to avoid problems of multicollinearity between our economic variables and potential controls, as any controls would almost certainly correlate highly with national income level, inequality, and poverty. Finally, the heterogeneity between-countries in the sample that could potentially distort the results has been controlled for by using the fixed-effects estimator.

Testing modifying effects

Extending the investigation of the role of poverty, inequality, and national income level on public health, we consider the extent to which the potential beneficial effects of increases in per capita GDP are modified by both poverty and inequality. To do this we create a time-differenced variable for both poverty and inequality. For example,

$$\text{Inter}-\text{annual Poverty Change} = \left\{ \begin{array}{l} \text{Poverty Decreasing, if } \text{POV}_t - \text{POV}_{t-1} < 0 \\ \text{Poverty Constant, if } \text{POV}_t - \text{POV}_{t-1} = 0 \\ \text{Poverty Increasing, if } \text{POV}_t - \text{POV}_{t-1} > 0 \end{array} \right\}.$$

We then regressed GDP on each of our health indicators using equation (1) when poverty and inequality, individually, are increasing, declining, or declining and constant. By stratifying the dataset into these inter-annual change groups we can assess whether and how changes in poverty and inequality modify the potential wealth–health relationship.

Results

Pairwise correlations

Table 2 presents the pairwise correlations between the economic and health variables considered in the analysis. We observe that poverty has moderately strong and statistically significant associations with all of our health measures (log infant mortality: $r = 0.64$, $p < 0.01$; log TB mortality: $r = 0.59$; $p < 0.01$; life expectancy: $r = -0.61$, $p < 0.01$). Similarly, GDP also has strong and moderately strong associations with all variables (log infant mortality: $r = -0.67$, $p < 0.01$; log TB mortality: $r = -0.70$; $p < 0.01$; life expectancy: $r = 0.73$, $p < 0.01$). Inequality has only a weak, albeit statistically significant, association with log TB mortality ($r = 0.11$, $p < 0.05$).

Among the economic variables themselves, we see that poverty and GDP are moderately strongly correlated ($r = -0.61$, $p < 0.01$), suggesting that as GDP increases, poverty decreases. Inequality, on the other hand, is only moderately correlated with poverty ($r = 0.39$, $p < 0.01$) and weakly correlated with GDP ($r = -0.19$, $p < 0.01$).

Individual regressions

Table 3 presents the results of the individual regressions of the economic variables on health indicators using equation (1). Poverty had no effect on life expectancy or log TB mortality, and only a modest effect on log infant mortality ($\beta = 0.04$, $p < 0.05$). Inequality was shown to have a statistically significant effect on life expectancy ($\beta = 0.33$, $p < 0.05$), log TB mortality ($\beta = -0.03$, $p < 0.05$), and log infant mortality ($\beta = -0.03$, $p < 0.05$), but the coefficients are very small. Unexpectedly, all of the significant coefficients are in the "wrong direction"; that is, for example, the regression suggests that a one point increase in the gini coefficient would yield an increase in life expectancy of 0.33 years.

Income per capita is by far the most influential of our three economic variables. Each 1% higher GDP was associated with a reduction in infant mortality by 1.17% ($p < 0.01$) and an overall increase in life expectancy by 0.06 years ($p < 0.05$). Interestingly, per capita income level had no significant effect on log TB mortality rates.

It appears, at first glance, that the results of these regressions have vindicated the wealthier is healthier hypothesis: GDP, rather than poverty or inequality, appears to exert the strongest influence on population health.

Testing modifying effects of poverty and inequality

We next divided the dataset into periods of increasing, decreasing, and decreasing/constant levels of poverty and

Table 2
Pair-wise correlations between economic variables and health variables.

Variable	Poverty	Inequality	Income
Poverty	1	–	–
Inequality	0.39**	1	–
GDP	−0.61**	−0.19**	1
Life expectancy	−0.61**	−0.04	0.73**
Log TB mortality	0.59**	0.11*	−0.70**
Log infant mortality	0.64**	0.02	−0.67**

Notes: * Correlation is significant at $p < 0.05$; ** Correlation is significant at $p < 0.01$.

Table 3
Effects of income, poverty and inequality on health outcomes.

		Life expectancy	Log TB mortality	Log infant mortality
Poverty	β	−0.16 (0.10)	0.02 (0.01)	0.04* (0.01)
	Number of country-years	145	243	238
	Number of countries	20	20	20
	R^2	0.16	0.08	0.23
	95% C.I.	(−0.36, 0.05)	(−0.00, 0.05)	(0.01, 0.07)
Inequality	β	0.33* (0.12)	−0.03* (0.01)	−0.03* (0.02)
	Number of country-years	280	323	513
	Number of countries	22	22	22
	R^2	0.08	0.07	0.08
	95% C.I.	(0.07, 0.60)	(−0.05, −0.00)	(−0.07, −0.00)
Income	β	6.04* (2.50)	−0.93 (0.56)	−1.17** (0.26)
	Number of country-years	286	378	506
	Number of countries	22	22	22
	R^2	0.27	0.21	0.45
	95% C.I.	(0.84, 11.25)	(−2.08, 0.22)	(−1.71, −0.62)

Notes: * Coefficient is significant at $p < 0.05$; ** Coefficient is significant at $p < 0.01$; Fixed-effects regression controlling for country- and year-effects; R^2 for within-countries estimator reported; Robust standard errors clustered by country and in parenthesis; Constant term calculated but not reported. Income is log GDP per capita.

inequality to assess what effects fluctuations in these variables have on the relationship between national income level and public health. Table 4 presents the results of the regression, using equation (1), of GDP on our health variables during periods of rising, falling and no change in inequality.

When inequality was increasing, a 1% increase in GDP per capita was associated with a decrease in infant mortality rates of 0.92% ($p < 0.05$), and had no effect on log TB mortality rates or life expectancy. However, when inequality was decreasing or constant, the each 1% increase in GDP was associated with about a 64% larger effect, so that infant mortality rates fell by 1.51% ($p < 0.01$). The previously insignificant relationship with TB mortality and life expectancy also became statistically significant during periods characterised by falling inequality. Each 1% increase in GDP was associated with a reduction of TB mortality rates by 1.79% ($p < 0.01$) and life expectancy by 0.14 years ($p < 0.01$). Results for periods of decreasing inequality exhibited similar patterns.

Table 5 reports the same models for periods of changing poverty. The results were even stronger than for inequality. Increases in GDP during periods of increasing poverty had no statistically significant effect on life expectancy, TB mortality rates, or infant mortality rates. However, during periods of decreasing or constant poverty, national income level had a significant and substantial association with life expectancy ($\beta = 8.22$, $p < 0.01$), log TB mortality rates ($\beta = -2.50$, $p < 0.01$) and infant mortality rates ($\beta = -1.39$, $p < 0.01$). In periods of decreasing poverty only, the effects were marginally stronger across all three indicators.

In Appendix, we provide additional tests of multiple interactions among changes in poverty and inequality with the wealth–health relationship. All results are consistent with our basic findings. The strongest effect of wealth on health occurred when both inequality and poverty were falling.

Discussion and conclusion

Is wealthier always healthier according to our analysis? Our answer is: 'it depends'. During periods of increasing poverty or inequality, public health improved only marginally with increases in GDP. Conversely, when poverty or inequality was decreasing, there was a strong positive effect of GDP on infant mortality rates,

Table 4
Effects of income on health measures during periods of rising, falling and no change to inequality.

		Life expectancy	Log TB mortality	Log infant mortality
GDP with increasing inequality	β	3.03 (2.99)	−0.06 (0.69)	−0.92* (0.34)
	Number of country-years	163	212	305
	Number of countries	22	23	22
	R^2	0.03	0.00	0.24
	95% C.I.	(−3.18, 9.25)	(−1.50, 1.37)	(−1.62, −0.21)
GDP with decreasing inequality	β	8.53** (2.21)	−1.98** (0.29)	−1.46** (0.20)
	Number of country-years	70	98	111
	Number of countries	18	18	18
	R^2	0.34	0.65	0.53
	95% C.I.	(3.86, 13.21)	(−2.60, −1.37)	(−1.88, −1.04)
GDP with decreasing/constant inequality	β	10.41** (1.68)	−1.79** (0.35)	−1.51** (0.16)
	Number of country-years	123	166	201
	Number of countries	21	21	21
	R^2	0.29	0.48	0.46
	95% C.I.	(6.91, 13.91)	(−2.53, −1.06)	(−1.86, −1.20)
Overall	β	6.04* (2.50)	−0.93 (0.56)	−1.17** (0.26)
	Number of country-years	286	378	506
	Number of countries	22	22	22
	R^2	0.27	0.21	0.45
	95% C.I.	(0.84, 11.25)	(−2.08, 0.22)	(−1.71, −0.62)

Notes: *Coefficient is significant at $p < 0.05$; **Coefficient is significant at $p < 0.01$; Fixed-effects regression controlling for country- and year-effects; R^2 for within-countries estimator reported; Robust standard errors clustered by country and in parenthesis; Constant term calculated but not reported.

Table 5
Effects of income on health measures during periods of rising, falling and no change in poverty rates.

		Life expectancy	Log TB mortality	Log infant mortality
GDP with increasing poverty	β	2.00 (3.12)	0.20 (0.67)	−0.73 (0.35)
	Number of country-years	189	216	347
	Number of countries	22	21	22
	R^2	0.01	0.00	0.14
	95% C.I.	(−4.50, 8.49)	(−1.21, 1.60)	(−1.47, 0.01)
GDP with decreasing poverty	β	10.11** (1.80)	−2.56** (0.34)	−1.71** (0.33)
	Number of country-years	69	115	112
	Number of countries	14	15	15
	R^2	0.48	0.62	0.54
	95% C.I.	(6.22, 14.00)	(−3.30, −1.82)	(−2.42, −1.00)
GDP with decreasing/constant poverty	β	8.22** (2.81)	−2.50** (0.39)	−1.39** (0.25)
	Number of country-years	97	162	159
	Number of countries	19	20	20
	R^2	0.32	0.58	0.46
	95% C.I.	(2.32, 14.13)	(−3.32, −1.69)	(−1.92, −0.86)
Overall	β	6.04 (2.50)	-0.93 (0.56)	−1.17** (0.26)
	Number of country-years	286	378	506
	Number of countries	22	22	22
	R^2	0.27	0.21	0.45
	95% C.I.	(0.84, 11.25)	(−2.08, 0.22)	(−1.71, −0.62)

Notes: *Coefficient is significant at $p < 0.05$; **Coefficient is significant at $p < 0.01$; Fixed-effects regression controlling for country- and year-effects; R^2 for within-countries estimator reported; Robust standard errors clustered by country and in parenthesis; Constant term calculated but not reported.

TB mortality rates, and life expectancy at birth. In other words, the benefits of wealth to health strongly depend on how that wealth is distributed.

Consistent with recent research, we found inequality had no significant direct effect on public health. Similarly, we failed to detect a significant direct relationship between poverty and public health. Thus, our results seem to corroborate the claim that national income levels per capita is more important than both inequality and poverty in determining a population's overall health status. However, we found that while national income level exerted greater influence on public health than both poverty and inequality, it was unsatisfactory as a stand-alone explanation for variations in public health; at most explaining about 45% of the variance in a single health measure (infant mortality).

In our study we noted the methodological criticisms of past inequality–health research, and followed the recommendations made to rectify these problems (Beckfield, 2004). After doing so, we do found that the relationship between inequality and public health deteriorated or disappeared altogether, consistent with other research (Beckfield, 2004; Mackenbach, 2002; Mellor & Milyo, 2001; Preston, 2007).

Strengths and limitations

As with any statistical analysis, this study has several limitations. First, the study considered only one infectious disease (tuberculosis) and failed to consider any chronic diseases, reflecting the lack of surveillance in this region (Setel et al., 2007). Not considering chronic diseases – albeit deliberately – necessarily limits the scope of this study, particularly in addressing questions about the role of the "epidemiological transition" between countries at different levels of development within Latin America. Moreover, the absence of chronic diseases in this analysis may be why we failed to find a direct causal link between income inequality and public health, as Fuller, Shipley, Rose, Jarrett, and Keen (1980) in the Whitehall studies found evidence that inequality substantially affected mortality risk from heart disease. One variant of the inequality hypothesis holds that inequality effects public health via psycho-social mechanisms such as stress and depression. This being the case, one would expect to find a stronger association between inequality and chronic diseases, which have known links to negative psychosocial processes, than infectious diseases. However, life expectancy, which is the one health measure this study did consider that includes effects of chronic disease, was not appreciably more-affected by inequality than the other two measures, suggesting that inequality as such may not be an important determinant of health even for chronic disease.

Second, this paper only considers income inequality. However Latin America is a region fraught with inequality in many forms: gender, political, ethnic, and age inequality. By many measures, Latin America is one of the most unequal regions in the world. Although the principle aim of this study was to examine income inequality's relationship to public health, future studies would benefit from considering the numerous dimensions of inequality in Latin America.

Third, as with other papers in this literature, our results could be subject to ecological fallacy; that is, the aggregate effects we have found in this study may not apply to the population at the individual level. It is possible that the aggregate measures also mask differences within countries, obscuring the potential for reductions to health to be offset by benefits to health of others. Future research should attempt to assess how individual and neighbourhood inequalities relate to health status in Latin America. Furthermore, inequalities themselves are the results of specific policies, such as in Chile the decision to pursue rapid market-driven reforms such as privatization and trade liberalization under Pinochet. Future work should seek to evaluate the specific health effects of specific inequality-generating economic policies.

Finally, the study does not specify the mechanisms through which the GDP-health transfer occurs and how inequality and poverty modify this transfer; we only assert that the transfer and modifying effects exist. Future studies could build upon our findings to determine whether psychosocial states, material conditions, social capital stock, or a combination of all three causal pathways produce our results.

While our study focused on income, there remains wider debate and continued scope for research about the relationships among free

trade, economic growth, inequality, poverty, health and health inequalities (Bloom, Canning, & Sevilla, 2004; Dollar & Kraay, 2002, 2004). For example, recent work by Deaton (2006) found no effect of economic growth on health, adding to a growing body of literature about the cyclicality of mortality (Ruhm, 2000, 2003, 2007; Stuckler, Basu, Suhrcke, Coutts, & McKee, 2009a, 2009b; Tapia Granados 2005a, 2005b, 2008). These studies have found that the effects of short-term growth and long-run income can differ considerably, and, in particular, that in circumstances when social protections are high that the health risks of recessions could be offset by rapid decreases in mortality rates (Stuckler et al., 2009a).

Overall, our findings have important policy implications. It is often said that wealth is the most powerful determinant of a society's health, especially in resource-poor settings. Here, we find that greater wealth does not guarantee health. If policymakers wish to improve health, they should consider seeking equitable ways to achieve rises in living standards so as to address underlying challenges of poverty and inequality.

Appendix

In this appendix we report tests of interactions of wealth and health in joint periods of change in inequality and poverty. The first table reports the interactive associations of wealth–health with poverty when inequality is rising. The second table reports similar associations but when inequality is falling. All results are consistent with our basic findings. However, they must be viewed with caution, as the reduction in sample size makes it harder to detect a finding should one actually exist (risking a so-called type-II error).

Table A1
Effect of income on health outcomes during periods of change in poverty and rising inequality.

		Life expectancy	Log TB mortality	Log infant mortality
GDP with Increasing Poverty and Increasing Inequality	β	0.42 (3.47)	−0.69 (0.75)	−0.58 (0.42)
	Number of country-years	122	145	241
	Number of countries	22	21	22
	R^2	0.00	0.08	0.11
	95% C.I.	(−6.79, 7.62)	(−0.88, 2.25)	(−1.47, 0.31)
GDP with decreasing poverty and increasing inequality	β	11.12** (1.58)	−1.88** (0.37)	−1.60** (0.25)
	Number of country-years	27	54	54
	Number of countries	11	13	14
	R^2	0.54	0.37	0.52
	95% C.I.	(7.60, 14.64)	(−3.33, −0.44)	(−2.13, −1.07)
GDP with decreasing/constant poverty and increasing inequality	β	4.03 (5.69)	−1.92** (0.52)	−1.27** (0.35)
	Number of country-years	34	67	64
	Number of countries	15	17	18
	R^2	0.08	0.40	0.36
	95% C.I.	(−8.17, 16.24)	(−3.03, −0.81)	(2.01, −0.53)
Overall	β	6.04* (2.50)	−0.93 (0.56)	−1.17** (0.26)
	Number of country-years	286	378	506
	Number of countries	22	22	22
	R^2	0.27	0.21	0.45
	95% C.I.	(0.84, 11.25)	(−2.08, 0.22)	(−1.71, −0.62)

Notes: *Coefficient is significant at $p < 0.05$; ** Coefficient is significant at $p < 0.01$; Fixed-effects regression controlling for country- and year-effects; R^2 for within-countries estimator reported; Robust standard errors clustered by country and in parenthesis; Constant term calculated but not reported.

Table A2
Effect of income on health outcomes during periods of change in poverty and decreasing inequality.

		Life expectancy	Log TB mortality	Log infant mortality
GDP with increasing poverty and decreasing inequality	β	3.63 (6.18)	−1.23** (0.28)	−1.08** (0.46)
	Number of country-years	29	37	51
	Number of countries	14	12	14
	R^2	0.07	0.64	0.30
	95% C.I.	(−9.72, 16.97)	(−1.85, −0.62)	(−2.09, −0.08)
GDP with decreasing poverty and decreasing inequality	β	12.39* (4.13)	−2.57** (0.33)	−1.62** (0.44)
	Number of country-years	36	52	50
	Number of countries	13	15	13
	R^2	0.34	0.73	0.48
	95% C.I.	(3.39, 21.39)	(−3.29, −1.85)	(−2.58, −0.67)
GDP with decreasing/constant poverty and decreasing inequality	β	10.59** (3.53)	−2.56** (0.30)	−1.54** (0.31)
	Number of country-years	41	61	60
	Number of countries	15	18	16
	R^2	0.32	0.73	0.53
	95% C.I.	(3.02, 18.15)	(−3.19, −1.92)	(−2.18, −0.87)
Overall	β	6.04* (2.50)	-0.93 (0.56)	−1.17** (0.26)
	Number of country-years	286	378	506
	Number of countries	22	22	22
	R^2	0.27	0.21	0.45
	95% C.I.	(0.84, 11.25)	(−2.08, 0.22)	(−1.71, −0.62)

Notes: *Coefficient is significant at $p < 0.05$; ** Coefficient is significant at $p < 0.01$; Fixed-effects regression controlling for country- and year-effects; R^2 for within-countries estimator reported; Robust standard errors clustered by country and in parenthesis; Constant term calculated but not reported.

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