Time Dimension of the Link between Income Inequality and Health: The Immediate, Cumulative, and Comparative Effects

Abstract

Since Wilkinson proposed the income inequality hypothesis (IIH), the contextual effect of income inequality on individual health has been under extensive examination, whereas the results are at best mixed. We argue that the time dimension of the IIH is poorly understood and severely understudied. This study scrutinizes the link between income inequality and individual health by demarcating the immediate, cumulative, and comparative effects. Using data from the World Values Survey longitudinal database, we test different dimensions with a multilevel fixed-effect model that controls cross-national heterogeneity. Results show subtle distinctions among dimensions, and the comparative version of the IIH receives the most empirical support. Furthermore, in response to the mixed findings from the literature, we also run grouped regressions by national economic development where the effect of income inequality on individual health varies substantially across development stages. We conclude with a brief discussion on possible implications and future directions.

Keywords: Income inequality; Self-rated health; Time dimension; Cumulative exposure; Comparative effect

Introduction

The income inequality-health relationship has been one of the most heated debates in social epidemiology during the past several decades. This topic is especially pertinent with the global increase of inequality since the last quarter of the twentieth century (Piketty, 2014; 2020). Accompanied by accelerating globalization and technological innovation, many countries have witnessed elevated income disparity and polarization. The potential consequences of rising inequality, including its harmful impact on population health, have attracted growing attention throughout the social science and public health community.

However, despite the large stack of literature, little consensus has been reached on whether and how income inequality damages individual health. Theoretically, Richard Wilkinson and colleagues (Wilkinson, 1992; 1996; 2005; Wilkinson & Pickette, 2010) elaborate on the psychosocial mechanisms through which income inequality does harm to population health, also known as the income inequality hypothesis (IIH); however, this proposition has encountered fierce challenges from theories that stress the fundamental role of material forces in determining health (i.e., the absolute income hypothesis and the neo-materialism). Empirically, the results are quite diverging due to differences in study designs, sample coverages, data sources, and modeling strategies, thus making it almost impossible to draw a uniform conclusion. It is especially the case for studies that utilize multilevel data and adequately control the compounding effect of individual income. Therefore, much is left for a thorough understanding of the nature of the relationship.

To go beyond the current literature, this study explicitly demarcates three different time dimensions of the IIH, namely the immediate effect, the cumulative effect, and the comparative effect, to capture how the current level of income inequality, the historical accumulation, and its changing trend get under the skin of individual health. We test these dimensions with the 1981-2016 World Values Surveys (WVS) dataset, which enables rigorous control for between-country heterogeneity. Our results show that the comparative impact can better capture the harmful effect of income inequality on individual health than the immediate and cumulative effects. It signifies a dynamic and prospective framework in our perception of social inequality, as implied by the prospect theory in psychology. We also find that the relationship between income inequality and health varies along the stage of economic development.

LITERATURE REVIEW

Theoretical Debates on the Link between Income Inequality and Health

Through a series of influential publications, Richard Wilkinson (1992, 1996, 1997, 2004, 2005) first developed a systematic theory on how an unequal social fabric exerts a detrimental impact on individual health. He argues that the vast majority of the population in developed countries has achieved the minimum material standard for the fundamental health, thanks to improved economic conditions, widespread public health infrastructure, and accessible medical care. With the progress of epidemiologic transition, chronic and degenerative diseases become major threats to public health. As a result, he postulates that one's relative social status instead of absolute material resources becomes a decisive determinant for his/ her health. More importantly, the less privileged are likely to undergo a stronger sense of relative deprivation and more psychological distress if exposed to wider income inequality and more stagnant social mobility. Severe polarization in a society often leads to excessive competition, interpersonal friction, declining social trust, and eroding social capital. These subsequently result in interrupted social networks, low self-esteem, prolonged anxiety and depression, aggravated insecurity, and loss of a sense of control for low-status individuals. In addition, highly hierarchical societies are often indicative of undue oppression, pervasive hostility, frequent crimes, and a disruptive state. Adverse social milieu and extensive exposure to harmful psychosocial risks are known to cause chronic diseases and undermine life spans. Accordingly, Wilkinson asserts that income inequality has become an essential threat to population health, and it erodes individual health primarily through psychosocial pathways, i.e., the income inequality hypothesis (IIH).

Nevertheless, the income inequality hypothesis faces severe challenges from the so-called "absolute income hypothesis" (AIH), an alternative explanation for the income inequality-health association. According to Gravelle (1998), the assumed relationship in the IIH is nothing but a "statistical artefact". It is well established that the positive relationship between income and individual health is concave due to the law of diminishing marginal returns. Even if the average income for society remains the same, when personal income is partly transferred from the wealthy to the impoverished, the population will achieve better health on average as long as the health improvement of the impoverished is larger than the health deterioration of the rich. Thus, even if narrowing income inequality per se does not enhance individual health independently, we can still observe a negative association between income inequality and population health. In this regard, the AIH claims that the postulated inequality-health correlation is spurious and should be attributed to confounding variables such as absolute personal income.

In addition, the "neo-materialism pathway" places the IIH in another competition (Lynch, 2000). It claims that a progressive-liberal government tends to reduce social inequality, expand medical insurance coverage, and promote public health. Therefore, social regime and associated public policy could be a plausible confounder for the inequality-health link. This view is echoed by Piketty's (2020) historical-comparative investigation on the variations and trends of global inequality, which proclaims that income inequality is never a simple economic matter and is always political and ideological at its core.

In sum, despite the persuasive psychosocial mechanisms postulated by the IIH, the same phenomenon can also be explained by the AIH and the neo-materialism hypothesis. These theoretical debates have to be settled through empirical investigations.

Empirical Studies Examining the Income Inequality-Health Relationship

Early studies primarily rely on aggregate data, but the level of aggregation varies from country to community. Among the 155 between- or within-country studies reviewed by Wilkinson & Pickett (2006), 70 percent report supportive results (i.e., significantly negative coefficients of measures of income inequality on population health indicators). Overall, cross-national studies are more supportive than those conducted at lower levels, namely communities, counties, cities, or states. Even for those unsupportive studies, Wilkinson and Pickett claim that supportive results would have been reached if they had adopted higher analysis units, avoided mistaken controls on average income and educational attainment, or excluded countries with abnormal inequality fluctuations. Wilkinson and Pickett (2009b) further point out the invalidity of lower-level analyses, arguing that social stratification works at larger geographic units such as countries/states rather than communities or towns, which may be too homogeneous to reveal the impact of inequality.

Nevertheless, the evidence supporting a negative income inequality-health link is not unanimous even at the aggregate level. For instance, among the 26 international studies reviewed by Lynch et al. (2004), only 15 of them report supportive results, five report mixed results, and the other six show no link between inequality and health. As studies yielding mixed or unsupportive results are implemented after 1995 when data quality is presumably better, Lynch et al. assert that the mixed or unsupportive results are more plausible. However, these aggregate analyses, failing to control for individual income, remain incompetent for testing the IIH and AIH.

To overcome the inherent flaws featured by aggregate research, multilevel analyses incorporating individual socioeconomic status have become a norm in recent work. Yet, results so far are, at best inconclusive. Some studies identify significantly negative coefficients of income inequality on individual health, thus providing supports to the IIH (Etienne et al., 2007; Gugushvili et al., 2020; Hildebrand et al.,2005; Karlsson et al., 2010), whereas others find the opposite and even report significant positive coefficients (Jen, Johnston, and Jones, 2009b; Mansyur et al., 2008; Qi, 2012), especially for developing countries. Nonetheless, the examinations on the mediating roles of social integration, social trust, and social network receive more consistent supports (Ichida et al. 2009; Jen, Sund, Johnston, Jones, 2010; Kim, 2018; Mansyur et al. 2008). They cast light on the social integration mechanism (Wilkinson, 1996, 2005) in which social integration withers as income inequality grows (Rözer & Volker, 2016), and there is also evidence that trustful people are more vulnerable to health losses caused by income inequality (Rözer, Kraaykamp & Huijts, 2016).

The damage that income inequality does to health cannot happen overnight. Indeed, nobody would argue that the psychosocial process advocated by the IIH, including relative deprivation and chronic stress, can take effect instantaneously (Blakely et al., 2000; Kondo et al., 2011). Even if one encounters those psychosocial risks, it usually takes years before coronary heart disease, cancer, asthma, and diabetes magnify themselves (Yusuf et al., 2001). Thus, psychological mechanisms follow a "latency period" (Lynch & Davey Smith, 2005), which justifies the time lagging consideration (Zheng, 2012). In addition, the level of inequality in a society changes itself, and the implied assumption about a static inequality in early studies does not hold true, given the sharp increase of income inequality in many countries around the world.

Therefore, for a thorough inspection of the IIH, scholars shift their attention to the time lagging effect of income inequality. Early research tests the time lagging effect with aggregate data but fails to reach consensus on the exact number of lagged years (Blakely et al. 2000; Macinko et al. 2004; Mellor, Milyo, 2003; Shi et al. 2003). Follow-up multilevel studies are again inconsistent. Some reveal the affinities between the current Gini index and individual health even net of the time lagging effect (Subramanian et al., 2006); others suggest that the harmful effect of income inequality wanes, disappears, or even reverses over time (Rözer and Volker, 2016; Zheng, 2012). In general, the time dimension of the IIH has not been understood sufficiently, and further examinations are needed.

For a complete understanding of the IIH, it is critical to examine perceived inequality, as illuminated by recent psychological progress. First, a high level of inequality can trigger adverse psychosocial reactions only if people perceive so. In other words, it is the perceived unequalness rather than real inequality that threatens health directly (Gugushvili et al., 2020; Oshio et al., 2010). Although most available literature assumes that people's perception of inequality is accurate, it is far from reality, especially when high fairness perception mismatches with the fact of low fairness (Bjönskov et al., 2013). Second, psychological research confirms that a steeper social gradient endangers happiness or well-being (Oshio et al., 2010; Oishi et al., 2011; Okulicz-Kozaryn et al., 2017; Rözer et al., 2012; Wang et al., 2015) as suggested by the relative deprivation mechanism and social integration mechanism, thus counteracts the well-being uptick initiated by income improvement (Bartolini, 2013). Thus, how people perceive inequality may be the missing piece that underlies the link between objective income inequality and individual health. At the same time, perception bias may also explain why the empirical evidence in support of the IIH is so mixed.

A New Scrutiny on the Causation

The great inconsistency of previous studies mentioned above is clearly unsatisfying, which indicates there exist knowledge gaps in our understanding of the phenomenon. We identify the following caveats from the existing literature and propose new insights on the causal nature of the link between income inequality and health.

First, both negative and positive signs of the income-inequality and health link call for inspecting potential mediating factors that come into play. Since the perplexing positive relationship is more apparent for subsamples of developing countries, it is worth checking whether the impact of income inequality on health may vary across different stages of economic development. In other words, in this study, we seek to explore the moderating role of the level of economic growth for a complete examination.

Second, the inconsistent findings may also result from inadequate controls for cross-national heterogeneity. Most prior multilevel studies rely on random effect models, which may ignore important country-level confounders such as history, culture, and institutional arrangement, thereby subject to substantial bias. A few exceptions include investigations on population health by cross-national panel data and multilevel fixed-effect models (e.g., Curran & Mahutga, 2018) or multilevel within-nation studies (e.g., Mellor & Milyo, 2002; Etienne et al., 2007). Other than these exceptions, researchers neither effectively control for cross-country heterogeneity nor check the exogenous assumption for random-effect models (i.e., independent variables do not correlate with unobserved contextual effects). Consequently, the neo-materialism pathway, such as cultural norms regarding inequality, public health policies, or economic developments, cannot be ruled out as potential confounders. This urges us to opt for a fixed-effect modeling strategy to minimize biases caused by unobserved/uncontrolled heterogeneity (details are given in the next section).

Last but not least, the current literature hasn't paid enough attention on the time dimension of the IIH. Distinctions are hardly made between the time-lagging effect and cumulative exposure to inequality in previous studies. Even when the time-lagged Gini index is included, many still concentrate on interpreting the current impact (for aggregate studies, see Macinko et al. 2004; Mellor and Milyo, 2003; Shi et al. 2003; multilevel analyses, see Subramanian et al., 2006). Multilevel studies that test the time lagging effect rarely devote to a cumulative perspective either (for exceptions, see Elgar et al., 2017; Rozer & Volker, 2016; Zheng, 2012). Given that the psychosocial pathways will take a certain amount of time to unfold and cause chronic conditions, it is reasonable to assume that the impact of inequality on health is accumulated over time. To fill this gap, we explicitly test the cumulative effect of income inequality in this study, which allows us to take a closer observation on the longitudinal feature of the inequality-health link.

Likewise, to our knowledge, no relevant research has taken a comparative and dynamic framework on the relationship between income inequality and individual health. Despite a few scholars point out the superiority of perceived unfairness over factual inequality in predicting individual health (Gugushvili et al., 2020; Oshio et al., 2010), relatively little has been explored on how people perceive and react to inequality in a society. According to recent progress in psychology, especially the prospect theory (Kahneman, 2011), individual perception and judgment are subject to substantial bias. Given a fixed level of income inequality, the psychosocial burden felt by individuals can vary greatly. First, people judge the current stimulation upon whether the stimulus exceeds or falls short of the level of stimulus to which they have accommodated, i.e., a reference point (Helson, 1964; Brickman & Campbell, 1971; Brickman & Bulman, 1977). Thus, the psychological impact of income inequality is inherently comparative rather than fixed. In this sense, the value (be it utility or happiness) attached to a possible state is determined by gains or losses relative to the status quo (Kahneman & Tversk, 2019; Tversky & Kahneman,1974). Second, human psychology is adaptive to the external environment. For instance, when discussing why the high inequality in China has not caused significant social unrest, Whyte (2010; 2014) asserts that China has historically always been an unequal society. Therefore, people are more accustomed to and have a higher tolerance for inequality. Third, given the same amount of change, people are susceptible to worsening conditions (i.e., loss aversion). Accordingly, we expect that the worsening trend of income inequality may do more damage to individual health instead of the level of inequality per se. Inspired by the prospect theory, we explore that comparative and dynamic aspect of the IIH by using the changing trend of income inequality as one of our key independent variables in the subsequent analysis.

In short, we aim to extend the literature in the following: First, we test the IIH with a modeling framework that better controls for between-country heterogeneity.

Second, we scrutinize how subgroup differences vary across development stages. Third, we conduct a systematic examination on the timing dimensions of the IIH, and we distinguish the current situation (the immediate effect), historical accumulation (the cumulative effect), and dynamic trend (the comparative effect) of inequality.

DATA AND METHODS

Data

This study uses data from the 1981-2016 World Values Survey (WVS) longitudinal dataset, comprising 316,251 individuals from 89 countries/regions. Geographically, the sample covers all major areas globally, including eight low-income countries, 18 lower-middle-income countries, 28 higher-middle-income countries, and 35 high-income countries[1].

Country-level statistics, such as Gross Domestic Product (GDP) per capita, national income group membership, are taken from the World Income Inequality Database (WIID) released by the World Institute for Development. Following the common practice, income inequality is measured by the Gini index. Though the Gini in-

[1] The WVS is essentially a repeated, crossnational survey, and it is only "longitudinal" in the sense that many countries participated in multi-waves of the survey. Altough the participating countries are not randomly sampled, they are highly representative with repsect to stages of economic development. In the sample, high-income countries account for 39.3%, higher-middle-income countries 31.5%, lower-middle-income countries 20.2%, and low-income countries 8.9%. In comparison, among the 218 countries/regions recorded by the World Bank, the proportions of high, higher-middle, lower-middle, and low-income countries are 38.1%, 25.7%, 22.9%, and 13.3%, respectively.

dex is also available in WIID, it is raw and not directly comparable. Thus, we replace them with more comparable estimates from the Standardized World Income Inequality Database (SWIID) (Solt, 2020). Among the various estimates SWIID provides, we utilize the Gini index of equivalized (square root scale) household disposable (post-tax, post-transfer) income (i.e., variable *gini_disp* in SWIID).

Variables

Our key country-level variables are listed in Table 1. Specifically, we construct three versions of the Gini index to represent the immediate, cumulative, and comparative effects, respectively. In addition to the current Gini index (variable *gini*, the Gini index for a given country/region in the survey year), variable *cum_gini*, indicating the cumulative exposure to the income inequality context in a given country/region, is operationalized as the average Gini index in the past ten years. Variable *dif_gini*, suggestive of the changing inequality trend, is measured as the current Gini index minus its value ten years before.

Table 1 Descriptive statistics for country-level variables

Variables	Definition	Obs	Mean	Std.dev.	Min	Max
gini	The Gini index in the survey year	220	36.967	8.720	17.492	59.467
cum_gini	Average Gini index in the past 10 years	220	36.694	9.025	17.703	59.414
dif_gini	The current Gini index minus that 10 years before	184	0.443	2.377	-8.981	7.494

gdp_ppp	GDP per capita measured by comparable US dollars in 2011	215	117485.84	15690.66	732	118832

All individual-level variables are drawn from the abovementioned WVS, including sex, age, educational attainment, and individual income. We measure individual health with respondents' subjective evaluation, which ranges from very poor to very good. The operationalization and descriptive statistics for these variables are shown in Table 2.

Table 2 Descriptive statistics for individual-level variables

Variables	**Definition**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
health	State of subjective health, from 1 (very poor) to 5 (very good)	316,251	3.798	0.889	1	5
sex	Sex (0 = female; 1 = male)	311,624	0.481	0.499	0	1
age	Age	312,121	40.982	16.209	13	99
income	Scale of individual income, from 1 (least) to 10 (highest)	285,103	4.602	2.325	1	10
edu	Number of years of schooling	316,251	8.804	5.135	0	16

Methods

Taking advantage of the longitudinal nature of the dataset at the country level, we build the following three-level model[2]:

Level 1 (individual) Model:

$$\text{health}_{itc} = \pi_{tc} + \sum_{1}^{p} \alpha_{ptc} SES_{pitc} + e_{itc} \quad \text{Equation 1}$$

Level 2 (country* year) Model:

$$\pi_{tc} = \eta_c + \tau \log GDP_{tc} + \sigma ineq_{tc} + v_{tc} \quad \text{Equation 2}$$

where $ineq_{tc}$ denotes the current Gini index, cumulative exposure to income inequality (variable *cum_gini*), and the differences of Gini index (variable *dif_gini*) for the *c*th country at the *t*th period in the corresponding models.

Level 3 (country) Fixed-effect Model:

$\eta_c = \eta + \alpha_c$, where α_c denotes the *c*th country's fixed effect Equation 3

In this model specification, we fit the country fixed-effects at level 3 to purge away potential confounding biases from all the time-constant country characteristics. It also helps to enhance cross-population comparability of self-rated health, thus improving the interpretability of the estimated results.

EMPIRICAL RESULTS

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[2] Before settlting with this model, we also fit a two-level random-effect null model with individual as level 1 and country as level 2. The level 2 component of variance is 0. 29 and rho is 0.11, indicative of the necessity for multilevel models. In the three-level random-effect null model, level 2 (country *year) variance component is 0.02, and that of level 3 is 0.06. Likelihood ratio test reports that both are significantly different from zero with $p <$ 0.001. Therefore, the three-level model fits the data.

The Immediate Effect of Income Inequality on Individual Health

We start from a baseline model with the Gini index as the only predictor. As shown in Model 1 of Table 3, the regression coefficient of the Gini index is significantly positive, which is clearly not in line with the IIH or any other theories proposed by the existing literature. When respondent's age and sex are added into Model 2, the coefficient for Gini is reduced in magnitude and no longer statistically significant. After adding country fixed effects and GDP per capita (on the logarithmic scale) into Model 3, the Gini index's coefficient becomes much more considerable and returns to significantly positive, indicating a positive link between income inequality and individual self-rated health for the full sample. Still, the association between the Gini index and individual health can result from individual-level confounders, especially individual income. Hence we further incorporate individual SES (income and education) into Model 4, and yet the positive effect of income inequality on individual health remains largely unchanged. To cross-validate the result, we also fit a corresponding three-level random-effects model (Model 5), but the coefficient of Gini is still positive, despite to a lesser extent. Although this result contradicts the IIH, it is nevertheless in accordance with what is reported in some early studies (e.g., Mansyur et al., 2008; Jen, Johnston & Jones, 2009b).

Table 3 The immediate effect of income inequality on individual health (all countries/regions)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
gini	.008***	.003	.015***	.011***	.007*
	(.002)	(.002)	(.004)	(.004)	(.003)
age		-.016***	-.016***	-.014***	-.014***
		(0)	(0)	(0)	(0)
sex		.112***	.113***	.093***	.093***
		(.003)	(.003)	(.003)	(.003)
income				.052***	.052***
				(.001)	(.001)
education				.017***	.017***
				(0)	(0)
GDP per capita (log)			.227***	.147***	.097***
			(.038)	(.036)	(.020)
Consider national fixed effects?	No	No	Yes	Yes	No
Observations	316251	308652	303414	275760	275760
Numbers of coun-tries	89	89	82	82	82

*Standard errors are in parentheses; *** p<.01, ** p<.05, * p<.1.*

To decipher this confusing finding and test whether the income inequality- health relationship varies systematically by stage of economic development, we divide the total sample into four subsets according to the national income category and refit the models. The results are shown in Table 4. First of all, the Gini index's coefficients vary substantially across different subsets. In particular, only lower-middle-income countries (Model 8) display a positive estimate analogous to the entire sample reported above. In contrast, the coefficient of Gini is significantly negative among higher-middle-income (Model 7) and low-income countries/regions (Model 9), thus supporting the IIH. In contrast, it is not statistically significant for high-income countries (Model 6).

Therefore, the immediate effect of the IIH only gains partial support from higher-middle-income and low-income countries. And the perplexing positive sign between income inequality and individual health observed in the entire sample is driven mainly by lower-middle-income countries.

Table 4 The immediate impact of income inequality on individual health by national income groups

Variables	Model 6 High income	Model 7 Higher-middle income	Model 8 Lower-middle income	Model 9 Low income
gini	-.002	-.011**	.017***	-.76***
	(.006)	(.005)	(.005)	(.032)
sex	.050***	.126***	.116***	.040***
	(.005)	(.005)	(.006)	(.015)
age	-.013***	-.015***	-.016***	-.011***
	(0)	(0)	(0)	(.001)
income	.050***	.051***	.053***	.078***
	(.001)	(.001)	(.002)	(.004)

education	.018***	.019***	.013***	.009***
	(.001)	(.001)	(.001)	(.002)
GDP per capita (log)	.256***	.042	.118	1.193***
	(.057)	(.035)	(.075)	(.074)
Intercept	1.817***	4.285***	2.009***	22.084**
	(.518)	(.383)	(.712)	(1.139)
Consider national fixed effects?	Yes	Yes	Yes	Yes
Observations	94040	108176	61926	11618
Number of countries	32	27	15	7

*Standard errors are in parentheses; *** p<.01, ** p<.05, * p<.1.*

Cumulative Exposure to Income Inequality and Individual Health

In this section, we use the average Gini index in the past ten years before the survey to denote respondents' cumulative exposure to income inequality in their countries/regions. By so doing, we explicitly test the accumulated effect of income inequality on individual health and relax the assumption that national income inequality remains constant mainly over time that underlies the immediate effect specification.

We start from the baseline model, where only individual age and sex, and country fixed-effects are controlled (Model 10 in Table 5). Consistent with the immediate effect result (Model 3 in Table 3), the coefficient of the average Gini index is significantly positive. After further controlling for individual SES in Model 11, the coefficient shrunk somewhat yet still indicates a highly significant link between greater inequality and better health. Therefore, we proceed to subgroup analyses by stage of economic development. Despite this new measure for income inequality, high-income countries (Model 12 in Table 5) appear to be unaffected by cumulative inequality, whereas GDP per capita displays a significant positive effect on individual health. It is somewhat surprising given that the early evidence supportive of the IIH is predominantly from developed countries. The estimate for higher-middle-income countries is negative yet does not reach statistical significance, so the relationship is weak at best. Again, lower-middle-income countries present a mystery, for they hint at better health under more unequal circumstances. The low-income countries offer the most robust evidence for the IIH, parallel to the results for the immediate effect above.

Overall, the results for the cumulative exposure (with the exception for higher-middle-income countries) are pretty similar to those that arrived for immediate effect using the current Gini index. Therefore, previous studies that only utilize the current Gini index are unlikely off the mark by much.

Table 5 Cumulative exposure to income inequality and individual health

	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15
Variables	**All**	**All**	**High income**	**Higher-middle income**	**Lower-middle income**	**Low income**

cum_gini	.027***	.016***	.003	-.006	.019***	-3.668***
	(.004)	(.004)	(.008)	(.006)	(.005)	(.157)
age	-.016***	-.014***	-.013***	-.015***	-.016***	-.011***
	(0)	(0)	(0)	(0)	(0)	(.001)
sex	.112***	.093***	.05***	.126***	.116***	.04***
	(.003)	(.003)	(.005)	(.005)	(.006)	(.015)
income		.052***	.05***	.051***	.053***	.078***
		(.001)	(.001)	(.001)	(.002)	(.004)
education		.017***	.018***	.019***	.013***	.009***
		(0)	(.001)	(.001)	(.001)	(.002)
GDP per capita (log)		.118***	.233***	.053	.099	7.192***
		(.037)	(.064)	(.041)	(.073)	(.291)
Consider national fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	308652	275760	94040	108176	61926	11618
Number of countries	85	82	32	27	15	7

*Standard errors are in parentheses; *** p<.01, ** p<.05, * p<.1*

Comparative Trend of Income Inequality and Individual Health

As implied by the prospect theory in psychology, the historical Gini index may serve as a reference point for people's perception of income polarization. If psychosocial pathways are indeed in play, we suspect that individual health is more likely to be worsened by exacerbating income inequality (i.e., loss aversion) rather than the level of inequality per se. To test this, we fit Model 16-20 in Table 6.

Results in Table 6 are relatively consistent in that all the estimates for changes in the Gini index are negative. Although the coefficient for the full sample does not reach statistical significance, it is highly significant for high-income, higher-middle-income, and low-income countries. Moreover, the perplexing positive coefficient of income inequality on individual health discovered above does not hold true any longer, even for lower-middle-income countries. Thus, the comparative and dynamic perspective of the impact of income inequality provides the strongest support to the IIH.

Table 6 Trend of Gini index and individual health

Variables	Model 16 All	Model 17 High income	Model 18 Higher-middle income	Model 19 Lower-middle income	Model 20 Low income
dif_gini	-.009	-.01**	-.023**	-.018	-.336***
	(.006)	(.005)	(.009)	(.015)	(.017)
GDP per capita (log)	.17***	.205***	-.086	.081	.475***
	(.043)	(.063)	(.055)	(.076)	(.005)
sex	.082***	.043***	.117***	.105***	.046***
	(.003)	(.005)	(.005)	(.007)	(.016)
age	-.013***	-.013***	-.014***	-.016***	-.011***
	(0)	(0)	(0)	(0)	(.001)
income	.053***	.051***	.055***	.053***	.08***
	(.001)	(.001)	(.001)	(.002)	(.004)
education	.017***	.018***	.02***	.013***	.009***
	(0)	(.001)	(.001)	(.001)	(.002)

Consider national fixed effects?	Yes	Yes	Yes	Yes	Yes
Observations	235628	86406	82334	56106	10782
Number of countries	72	29	21	14	7

*Standard errors are in parentheses; *** p<.01, ** p<.05, * p<.1.*

Sensitivity Analyses

Before jumping to conclusions, we conduct the following robustness checks on our main findings.

First, we examine different model forms for the dependent variable. In contrast to the interval scale applied to self-rated health in the models above, we replicate our analyses with models for ordinal dependent variables. The results show that income inequality's immediate and cumulative impacts are congruently positive and significant, accompanied by somewhat larger estimates. By contrast, the comparative effect of the Gini index remains negative and becomes statistically significant even for the full sample. Therefore, our main findings are robust and not contingent on specific model assumptions.

Second, we also entertain with random-effect models rather than fixed-effect models. In three-level random-effects models, the primary findings are qualitatively the same and the only difference occurs in the comparative effect estimate for low-income countries, where the coefficient for income inequality loses its statistical significance. Therefore, the choice of model forms doesn't threaten our basic conclusion.

Third, we further check on the specific nature of the time dimension of the income inequality-health link. In line with the existing literature, we use the time-lagging Gini index instead of other measures of income inequality in our models. Time-lagging effects are more consistently positive than the cumulative effects (Model 10-15 in Table 5), irrespective of the time lag we used[3]. Noticeably, the insignificant coefficient for high-income countries becomes statistically significant for more than nine years lagging. Meanwhile, the negative coefficient for low-income countries also converts into significantly positive, a sign more contradictory to the IIH.

Finally, to complete our inspection on the effect of timing, we also slightly alter the duration in the indicator constructed. Cumulative exposure to income inequality exhibits stable coefficients for varying durations, with low-income countries as the only anomaly. As time intervals become wider for these countries, the absolute values of negative coefficients first increase, reaching a peak at year 11 and then turning positive[4]. For comparative trends of the Gini index, the coefficients are mainly insignificant for regions other than low-income countries in smaller time intervals (one or three years, for instance). However, when measured for more extended periods (typically greater than eight years), the results resemble what Table 6 exhibits. All in all,

[3] We try 1, 3, 5, 8, 10, 15, and 20 years.

[4] Specifically, these coefficients are -1.132** (t=3), -2.315*** (t=9), -7.223** (t=11), 8.228*** (t=13), and 1.372** (t=20), respectively.

the distinctions among the immediate, cumulative, and comparative effects of income inequality are largely immune from varying data treatments.

CONCLUSION AND DISCUSSION

In this study, we extend the income inequality-health debate in two crucial ways. First, we demarcate the nuanced yet vital distinctions among the impacts of the current income distribution, historical accumulation, and comparative trend of income polarization. Our results highlight that income inequality's comparative and dynamic aspects have a much stronger effect on health than a static or cumulative feature of inequality. It is consistent with the updated knowledge on human psychology highlighted by the prospect theory. It suggests that worsening inequality is more harmful to individual health than the absolute level of inequality per se. In view that income inequality has been steadily rising across the globe, its implication on health is alarming and worth more academic and public policy endeavors.

Second, the difference in stages of economic development may moderate the impact of income inequality on individual health. Our results show that the income inequality-health link varies significantly among countries with different levels of economic growth. A strong positive association between income inequality and individual health is observed in our analyses among lower-middle-income countries, especially for the immediate and cumulative effects. One possible explanation is that these lower-middle-income countries are likely the ones that are undergoing the most rapid social transformation in the studied period. Thus, our fixed-effect modeling strategy may not hold well for them by assuming that cross-national heterogeneity is largely time-constant. Further investigation is necessary to determine whether this is the case. In contrast, the IIH receives much more supportive evidence from the higher-middle income and low-income countries. For high-income countries, the impact of income inequality on individual health is mostly statistically insignificant. It may have something to do with the fact that the fixed-effect estimator is a within-estimator, which may underestimate the actual harmful effect of income inequality by throwing away between-country variations in inequality, whereas high-income countries are relatively less likely to encounter dramatic social changes and thus provide tiny within-country variations to capture a significant effect.

Overall, our study provides only partial support to Wilkinson's IIH. Together with the mixed results from the large stack of existing literature, we wonder that this may have something to do with the multidimensional nature of social inequality. In addition to income, a society is hierarchical in gender, race, education, power, and wealth. Traditionally, different inequalities may fuse, and income is arguably a good measure of micro-social positions. However, in modern societies that advocate diversity, this may not hold. In fact, there is evidence that income inequality deviates substantially from wealth inequality among countries (Pfeffer and Waitkus, 2020). Therefore, an exclusive focus on income inequality may be responsible for the inconsistency of findings, and future research in this field should pay more attention to inequality's comprehensive and dynamic nature. After all, the argument for IIH is more pertinent to a society's overall inequality than simple income distribution.

Finally, several limitations are acknowledged for the current study. Like most cross-national studies of this kind, we rely on self-rated health, which may suffer from severe comparability issues (Sen, 2002) [5]. Although our fixed-effect modeling strategy can alleviate the problem to a certain degree, further analysis that relies on more objective health measures is undoubtedly welcomed. Second, despite the expanded time and geographic spans of the WVS, its global representativeness is not guaranteed[6], and samples from high-income and higher-middle-income countries are somewhat overrepresented. It may affect the generalizability of our findings to all societies in the world. Last but not least, theories that inspire our understanding of the time dimension are still under-developed. Therefore, our distinctions and measures of the three time dimensions are subject to further refinement. For instance, because the dataset is not longitudinal at the individual level, our cumulative exposure to inequality

[5] The correlation coefficient between national average self-rated health (WVS) and population life expectancy (WIID) is only 0.015, and that of the Gini index and national average self-rated health is 0.313, while that of Gini index and population life expectancy is -0.453.

[6] There are 95 country * year records (2.7 records on average for each country). In comparison, there are 72, 43, and 10 records for 28 higher-middle-income, 18 lower-middle-income, and 8 low-income countries and regions. In addition, among the 316,251 individual samples, those from high-income, higher-middle-income, lower-middle-income, and low-income countries and regions accounts for 36.5%, 37.7%, 21.6% and 4.2%, respectively.

cannot account for the age-differentiated trajectory for each unique individual, as emphasized by the institutionalization of life courses (Kohli, 1985). Similarly, while our comparative and dynamic dimension of inequality highlights the central role of human perception, a further examination of subjective inequality and its formation and dynamics should be pursued to verify these propositions.

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Appendix A list of countries/regions included in the anlysis

Country/ region	Geographic area	National income group	Year	Gini index	Average health	Sample Size
Albania	Europe	higher-middle	1998	38.04	3.99	995
			2002	38.65	3.96	999
Algeria	Middle East and North Africa	higher-middle	2002	35.75	3.48	1273
Andorra	Europe	high	2005	30.82	4.17	1003
Argentina	Latin America	high	1984	39.83	3.53	974
			1991	42.48	3.67	994
			1995	43.87	3.72	1070
			1999	45.54	3.83	1274
			2006	43.17	4.09	1001
			2013	38.20	3.95	1024
Armenia	Europe	higher-middle	1997	38.81	3.47	1996
			2011	36.24	3.28	1098
Australia	East and Central Asia	high	1981	28.00	4.03	1227
			1995	30.23	4.10	2047
			2005	31.81	4.00	1412
			2012	32.39	4.04	1465
Azerbaijan	Europe	higher-middle	1997	31.65	3.66	1999
Bangladesh	South Asia	lower-middle	1996	33.73	3.46	1525
			2002	34.91	3.65	1497
Belarus	Europe	higher-middle	1990	23.02	3.15	1003
			1996	23.78	3.03	2084
			2011	23.90	3.27	1514
Bosnia Her-	Europe	higher-middle	2001	38.79	3.83	1196

zegovina						
Brazil	Latin America	higher-middle	1991	53.17	3.91	1779
			1997	52.86	3.93	1143
			2006	48.78	3.99	1499
			2014	45.07	3.91	1485
Bulgaria	Europe	higher-middle	1997	31.82	3.56	1071
			2006	33.50	3.54	998
Burkina Faso	Sahara Africa	low	2007	43.98	3.96	1519
Canada	North America	high	2000	31.01	4.18	1929
			2006	30.98	4.16	2159
Chile	Latin America	high	1990	48.06	3.62	1495
			1996	48.28	3.70	999
			2000	48.69	3.84	1199
			2006	46.13	3.82	1000
			2012	44.60	3.88	999
China	East and Central	higher-middle	1990	32.05	3.82	996
	Asia		1995	35.63	3.97	1500
			2001	39.64	3.79	998
			2007	42.65	3.77	1989
			2013	40.71	3.84	2285
Colombia	Latin America	higher-middle	1998	51.79	3.99	2994
			2005	51.11	3.92	3023
			2012	48.65	4.01	1511
Croatia	Europe	high	1996	28.62	3.53	1188
Cyprus	Europe	high	2006	29.87	4.09	1049
			2011	30.42	3.96	999
Czech Rep.	Europe	high	1991	20.52	3.46	924
			1998	24.43	3.54	1145

Dominican	Latin America	higher-middle	1996	45.89	3.91	414
Ecuador	Latin America	higher-middle	2013	42.56	3.96	1202
Egypt	Middle East and	lower-middle	2001	41.62	3.79	3000
	North Africa		2008	41.58	3.75	3051
			2012	43.75	3.57	1523
El Salvador	Latin America	lower-middle	1999	46.52	3.83	1254
Estonia	Europe	high	1996	33.91	3.30	1019
			2011	32.57	3.47	1530
Ethiopia	Sahara Africa	low	2007	32.80	3.81	1497
Finland	Europe	high	1981	20.63	4.06	1003
			1996	22.86	3.94	981
			2005	25.31	3.83	1014
France	Europe	high	2006	28.20	3.96	1001
Georgia	Europe	lower-middle	1996	36.50	3.47	2007
			2009	40.34	3.35	1498
			2014	39.44	3.36	1202
Germany	Europe	high	1997	25.60	3.66	2025
			2006	28.40	3.82	2052
			2013	28.75	3.87	2044
Ghana	Sahara Africa	lower-middle	2007	43.30	4.12	1533
			2012	43.68	4.39	1552
Guatemala	Latin America	higher-middle	2004	48.12	3.83	1000
Hong Kong	East and Central	high	2005	40.51	3.65	1246
	Asia		2014	40.83	3.67	997
Hungary	Europe	high	1982	21.69	3.27	1461
			1998	27.43	3.41	650
			2009	27.01	3.71	1006
India	South Asia	lower-middle	1990	39.99	3.73	2455
			1995	41.13	3.67	2027

			2001	43.73	3.73	1986
			2006	46.36	3.84	1997
			2012	47.32	3.91	4068
Indonesia	East and Central	lower-middle	2001	41.92	3.81	999
	Asia		2006	43.63	3.93	2001
Iran	Middle East and	higher-middle	2000	41.52	3.99	2490
	North Africa		2007	39.71	3.81	2629
Iraq	Middle East and	higher-middle	2006	31.43	3.72	2670
	North Africa		2013	31.00	3.75	1195
Israel	Middle East and	high	2001	34.71		1199
	North Africa					
Italy	Europe	high	2005	32.68	3.89	1012
Japan	East and Central	high	1981	25.09	3.45	1193
	Asia		1990	28.44	3.44	997
			1995	29.89	3.60	1050
			2000	30.98	3.62	1341
			2005	30.37	3.59	1088
			2010	31.81	3.56	2402
Jordan	Middle East and	higher-middle	2001	37.84	4.05	1223
	North Africa		2007	37.04	4.28	1199
			2014	36.90	4.14	1200
Kazakhstan	Europe	higher-middle	2011	26.90	3.69	1500
			2003	35.09	3.67	1043
			2011	33.92	3.91	1498
Latvia	Europe	high	1996	30.56	3.25	1196
Lithuania	Europe	high	1997	31.06	3.35	1007
Macedonia	Europe	higher-middle	1998	31.67	3.86	985
			2001	32.78	3.86	1053
Malaysia	East and Central	higher-middle	2006	42.38	4.16	1201

Malaysia	Asia		2012	41.26	4.24	1300
Mali	Sahara Africa	low	2007	39.99	3.86	1507
Mexico	Latin America	higher-middle	1981	47.30	3.42	1810
			1990	46.69	3.85	1508
			1996	47.61	3.67	1498
			2000	47.33	3.82	1530
			2005	45.49	3.83	1555
			2012	44.03	3.97	1999
Moldova	Europe	lower-middle	1996	37.59	3.03	983
			2002	38.51	3.02	1002
			2006	37.53	3.53	1021
Morocco	Middle East and North Africa	lower-middle	2001	41.01	3.95	1251
			2007	41.51	4.09	1200
			2011	41.10	4.04	1199
Netherlands	Europe	high	2006	26.45	3.91	1048
			2012	25.92	3.88	1889
New Zealand	East and Central Asia	high	1998	32.94	4.10	1197
			2004	32.60	4.16	949
			2011	32.00	4.15	828
Nigeria	Sahara Africa	lower-middle	1990	43.03	4.08	992
			1995	43.48	4.05	1989
			2000	43.48	4.47	2021
Norway	Europe	high	1996	24.09	4.13	1127
			2007	24.43	4.16	1025
Pakistan	South Asia	lower-middle	1997	33.85	3.78	733
			2001	33.84	3.77	2000
			2012	33.92	4.09	1194
Palestine	Middle East and North Africa	lower-middle	2013	36.35	3.97	1000

Peru	Latin America	higher-middle	1996	52.49	3.58	1207
			2001	51.61	3.58	1500
			2006	50.69	3.51	1500
			2012	45.35	3.64	1207
Philippines	East and Central Asia	lower-middle	1996	42.57	3.62	1200
			2001	42.42	3.68	1200
			2012	41.46	3.70	1200
Poland	Europe	high	1989	24.22	3.25	930
			1997	28.70	3.24	1151
			2005	32.01	3.59	998
			2012	30.63	3.72	966
Puerto Rico	Latin America	high	1995	49.72	3.88	1159
			2001	50.45	4.02	719
Qatar	Middle East and North Africa	high	2010	40.09	4.38	1060
Romania	Europe	higher-middle	1998	28.06	3.55	1237
			2005	31.93	3.49	1774
			2012	32.74	3.66	1502
Russia	Europe	higher-middle	1990	25.40	3.10	1914
Russia	Europe	higher-middle	1995	36.32	3.00	2036
			2006	36.85	3.36	2022
			2011	35.51	3.37	2482
Rwanda	Sahara Africa	low	2007	51.09	3.19	1501
			2012	50.52	4.13	1527
Serbia	Europe	higher-middle	2001	33.42	3.55	1194
			2006	34.53	3.61	1210
			2002	39.03		1512
Singapore	East and Central Asia	high	2012	39.00	4.10	1971

Slovakia	Europe	high	1990	17.49	3.35	465
			1998	24.23	3.49	1094
Slovenia	Europe	high	1995	23.77	3.36	1007
			2005	24.03	3.64	1035
			2011	24.93	3.75	1069
South Africa	Sahara Africa	higher-middle	1982	58.25	3.92	1587
			1990	58.80	4.02	2711
			1996	58.77	3.99	2933
			2001	58.92	4.24	2997
			2006	59.55	4.14	2984
			2013	59.47	4.25	3529
South Korea	East and Central Asia	high	1982	30.96	3.15	955
			1990	29.47		1251
			1996	29.33	3.93	1248
			2001	30.63	3.90	1200
			2005	30.92	3.96	1200
			2010	31.20	3.95	1190
Spain	Europe	high	1990	29.76	3.61	1491
			1995	32.58	3.81	1209
			2000	30.88	3.88	1206
			2007	31.32	3.95	1196
			2011	33.58	3.89	1187
Sweden	Europe	high	1981	20.30	4.02	944
			1996	23.56	4.11	1002
			2006	24.50	4.10	1003
			2011	25.65	4.07	1203
Switzerland	Europe	high	1989	30.30	4.11	1398
			1996	29.06	4.17	1211
			2007	29.19	4.13	1241

Taiwan	East and Central Asia	high	1994	28.65	3.57	780
			2006	30.44	4.04	1227
			2012	30.25	4.11	1235
Tanzania	Sahara Africa	low	2001	42.90	3.81	1150
Thailand	East and Central Asia	higher-middle	2007	42.28	3.94	1526
			2013	40.39	4.06	1200
Tunisia	Middle East and North Africa	lower-middle	2013	38.68	3.91	1204
Turkey	Europe	higher-middle	1990	42.55	3.70	1030
			1996	43.11	3.73	1905
			2001	42.64	3.70	3393
			2007	41.21	3.75	1341
			2012	40.30	3.85	1570
Uganda	Sahara Africa	low	2001	44.21	3.93	1002
Ukraine	Europe	lower-middle	1996	29.98	3.02	2791
			2006	28.82	3.43	998
			2011	27.25	3.25	1488
United Kingdom	Europe	high	1998	33.70		1093
			2005	33.42	3.98	1040
United States	North America	high	1981	31.98	4.07	2315
			1995	35.30	4.11	1538
			1999	35.91	4.23	1199
			2006	36.92	4.04	1248
			2011	37.46	4.06	2216
Uruguay	Latin America	high	1996	38.49	3.97	997
			2006	41.68	3.94	998
			2011	37.89	4.03	999
Venezuela	Latin America	higher-middle	1996	42.31	4.05	1195

			2000	42.28		1200
Vietnam	East and Central Asia	lower-middle	2001	34.34	3.65	999
			2006	35.03	3.61	1495
Yemen	Middle East and North Africa	low	2014	36.78	3.89	1000
Zambia	Sahara Africa	lower-middle	2007	54.97	3.91	1443
Zimbabwe	Sahara Africa	low	2001	47.55	3.88	1000
			2012	46.55	4.31	1500