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Income is more protective against pain in more equal countries☆

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ABSTRACT

It is empirically well-established that the rich suffer less pain on average than the poor. However, much less is known about the factors that moderate the size of the income gradient of pain. Using data from over 1 million adults from 127 countries worldwide, this article conducts a systematic test on whether income inequality moderates the pain gap between the rich and the poor. While pain is negatively associated with income in all but one country, there is strong evidence to suggest that an increase in income is much more protective against pain in countries where the income distribution is relatively more equal. The results are robust to using different measures of income inequality, removing outliers, and accounting for country and year fixed effects. We explain our results through the lens of income rank effects on health outcomes. Overall, our findings suggest that pain-reducing policies through income redistribution may need to take income inequality into consideration when evaluating their effectiveness.

1. Introduction

Pain is a highly debilitating and increasingly common human experience. With more than 100 million Americans reporting to be suffering from chronic pain (Pizzo et al., 2011), it is estimated to cost the U.S. economy and the healthcare sector millions of dollars annually (Gaskin and Richard, 2012). Pain is also one of the leading explanations for the ongoing opioids epidemic in the United States (McGreal, 2018), and the rising "deaths of despair" from suicides, drug and alcohol misuse (Case and Deaton, 2015). However, pain is not only an American problem. A study in 2011 estimated that 20% of the world's population, or 1.5 billion people, suffer from pain (Goldberg and McGee, 2011), with a more recent estimate standing at around 32% (Macchia, 2022).

One of the major predictors of pain is low income (Schurer et al., 2014; Stone et al., 2010). Yet very little is known about the conditions under which the influence of income on pain is reduced or amplified. In this paper, we propose that income inequality plays an important part in moderating the income gradient of pain across the world. Specifically, we hypothesise that income is more protective against pain in countries where income inequality is low. We based our prediction on the finding that the marginal effect of income increase on overall life satisfaction is higher in more equal countries because a fixed increment in income confers a greater increment in social position – which has been shown to be conducive to better health outcomes (Daly et al., 2015), life satisfaction (Boyce et al., 2010), and, more recently, associated negatively and strongly with pain (Macchia, 2022) – in a more equal society (Quispe-Torreblanca et al., 2021).

The association between income and pain has already been established. For instance, using representative data of US adults, Zajacova et al. (2021b) found that the percentage of people who reported pain was greater in the low income group (19%) than in the high income group (6%; see also Sturm and Gresenz, 2002; Zajacova et al., 2021a). Similarly, a cross-sectional study with 146 countries worldwide, showed that the percentage of people in pain was greater in the bottom quintile of the income distribution than in the top quintile (Macchia, 2022). The influence of income on pain seems to start early in life. Using data from the British Cohort Study, Macfarlane et al. (2009) showed that childhood income (and social class more broadly) was strongly linked to different types of bodily pain in adulthood.

Prior research has also documented the link between income inequality and different aspects of mental and physical wellbeing, including pain. The current evidence is mixed. For instance, a review article suggested that living in an unequal context might have negative psychological consequences, like stress about social status, that may

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affect people's mental wellbeing, such as happiness (Buttrick and Oishi, 2017). Other studies have found a negative relationship between income inequality and mental wellbeing for specific groups of the population: those who face scarcity (Sommet et al., 2018) and those in the lowest part of the income distribution (Oishi et al., 2011). With regard to physical outcomes, another comprehensive review showed that income inequality has detrimental consequences for people's physical health (Pickett and Wilkinson, 2015). Yet, Sturm and Gresenz (2002) have found no link between income inequality and physical health disorders in a representative sample of US citizens. More specifically on bodily pain, Bor et al. (2017) suggested that rising income inequality in the United States was accompanied by rising trends in physical health problems, including chronic pain.

Despite this body of work that examined the link between income and pain and the role of income inequality in overall wellbeing, no study has explored whether income inequality moderates the pain gap between the rich and the poor. Understanding how income inequality moderates the income gradient of pain is relevant to policymakers who have tools to directly address income inequality through tax and welfare policies.

2. Methods

2.1. Data

We used data from the Gallup World Poll (GWP). GWP is a cross-sectional survey that is conducted annually for 1000 randomly selected nationally representative individuals across more than 150 countries worldwide. The survey is mostly administered by telephone except for some developing regions, such as some Latin American countries, the former Soviet Union countries, and nearly all of Asia, the Middle East, and Africa, in which the survey is administered face-to-face. After excluding respondents with missing information on the key outcome and control variables, we end up with a representative sample of 1,116,991 individuals from 127 countries between 2009 and 2020.

2.2. Dependent variable

We measure pain from the question, "Did you experience the following during a lot of the day yesterday? How about physical pain? Yes (1) or No (0)", from Gallup World Poll (GWP). Case et al. (2020) and Macchia (2022) used the same variable to study the rising levels of pain in America and other parts of the world.

2.3. Independent variable

Respondents were asked to estimate their monthly household income in local currency before taxes. This measure was converted into an annual variable in International Dollars using the World Bank's individual consumption PPP conversion factor which makes all income estimates comparable across countries. To compute household income per capita, we divide the income measure by the household headcount.

2.4. Moderator

We used several measures of income inequality as the moderator. This includes the Gini index, the shares of taxable income (excluding capital gains) held by the top 1%, the top 10%, and the bottom 1% of income earners. The Gini index, which we retrieved from the World Bank Database (https://data.worldbank.org), ranges between 0 and 1 representing perfect equality with 0 and perfect inequality with 1. The shares of income held by the top and bottom income earners, which we retrieved from the World Inequality Database (www.wid.world), range between 0% and 100%. Our decision to use more than one measure of income inequality as the moderator of income and pain was inspired by Blesch et al. (2022), which demonstrates how the Gini index only narrowly captures inequality and that researchers should always check their results against other measures that capture inequality at the top and bottom income percentiles.

2.5. Covariates

Comprehensive information about the respondents' age, gender, education levels, marital and employment status, and number of children under 15 in the household, are also collected during the survey and were included in our regressions. Annual country-level characteristics such as inflation rates, Gini index, unemployment rates were also retrieved from the World Bank Database. We further augmented additional country level data from various sources, including worldwide governance indicators from the World Bank Database, incidences of disasters from the Emergency Events Database (https://www.emdat.be), grid-level climatic conditions from Climatic Research Unit (https://www.uea.ac.uk/groups-and-centres/climatic-research-unit), healthcare expenses from Global Health Expenditure Database provided by World Health Organization (https://www.who.int), and conflict deaths from Uppsala Conflict Data Program (https://ucdp.uu.se). See Table S.1 in the Supplementary Online Materials (SOM) for the descriptive and summary statistics.

2.6. Empirical framework

There are four main objectives to our empirical strategy. First, to conduct a raw data analysis on the relationship between pain and income in countries with low- and high-income inequality. Second, to establish whether there is a significant degree of heterogeneity in the income-pain gradient by country in the GWP. Third, to test the extent to which countries with higher levels of long-run income inequality exhibit smaller income-pain gradients, i.e., income is associated with less pain reduction in countries where income inequality is high. Fourth, to examine whether the income-pain gradient is moderated not only by between-country but also within-country variations in income inequality.

To make a first pass on the possible moderating property of income inequality on the income-pain gradient, a kernel density plot of average probability of being in pain at each income level is carried out for (i) all countries, (ii) countries that lie below the median income inequality, i.e., the relatively equal countries, and iii) countries that lie above the median income inequality, i.e., the relatively unequal countries. If there is preliminary evidence that income is less protective against pain in more unequal countries, then we should see in the raw data that the probability of being in pain is higher at each income level for individuals living in countries where income inequality is higher.

To systematically test whether the income-pain gradient varies significantly across countries, we first estimate the following regression equation:

$$P_{ijt} = \alpha + \sum_{j=1}^{J=127} \beta^{j}\left(Y_{ijt} \times \theta_{j}\right) + X_{ijt}^{'}\delta + C_{jt}^{'}\varphi + \theta_{j} + \tau_{t} + \varepsilon_{ijt}, \quad (1)$$

where our dependent variable, P_{ijt}, is a binary variable that takes the value of 1 if individual i living in country j at year t is in physical pain, 0 otherwise. Y_{it} represents the natural logarithm of annualized personal income. This variable is interacted with θ_j, which represents country fixed effects. The coefficient β represents the income-pain gradient, and if earning higher income allows individuals to alleviate pain, we expect $\beta < 0$. By interacting income with country fixed effects, Eq. (1) allows us to test whether β varies across each country j.

To avoid omitted variable bias that correlates with both income and pain, we further control for observable characteristics surrounding each individual and their country of residence. Specifically, matrix $X_i^{'}$ represents individual characteristics associated with individual i including

education levels, employment status, marital status (single, separated, divorced, married), gender, age, and number of kids under 15 years old. Matrix $C_{jt}^{'}$ denotes country-level time variant characteristics including unemployment rates, income equality, inflation rates, average out-of-pocket health care expenditures, government effectiveness, number of deaths from conflicts, and incidences of natural disasters (e.g., earthquakes, droughts, floods, heat waves). All these variables are controlled for as they could potentially affect the probability of being in pain. For more information on the definitions of these variables and their data source, one can refer to Table 1 in Supplementary Information in the OSF link provided at the end of this article.

The terms θ_j and τ_t denote country-fixed effects and year-fixed effects respectively. Country-fixed effects are included to absorb time-invariant unobserved factors within country that could explain pain probability. Year-fixed effects are augmented to control for changes in pain trends across time but are invariant across regions. For instance, the COVID pandemic has adversely affected everyone since the end of 2019. Robust standard errors (ε_{ijt}) are clustered at country level.

Provided that there is a significant degree of heterogeneity in β across countries, our next empirical analysis involves plotting each country's β against its long-run average of each income inequality measure, $\bar{I}_j$. Our decision to use the long-run average measure of income inequality comes from the fact that income inequality is a slow-moving variable that hardly changes over time; see Fig. S.1 in the SOM for the long-run percentage point changes in the Gini index across countries in the GWP. If there is evidence that income is less protective against pain in more unequal countries, then we would expect the gradient between long-run income inequality and the income-pain gradient across countries to be positive (or negative if the income inequality measure captures the income concentration of individuals at the bottom income percentiles, i.e., the bottom 1% income share).

Finally, to test the extent to which income inequality moderates the relationship between income and pain within-country over time, we estimate the following regression equation:

$$P_{ijt} = \alpha + \beta Y_{ijt} + \gamma I_{jt} + \lambda\left(Y_{ijt} \times I_{jt}\right) + X_i^{'}\delta + C_{jt}^{'}\varphi + \theta_j + \tau_t + \varepsilon_{ijt}, \quad (2)$$

where I_{jt} represents country j's income inequality at year t. Given that income inequality hardly changes within-country over time, Eq. (2), which includes income inequality alongside country and time fixed effects as regressors, provides a much more stringent test of the moderating property of income inequality than the earlier between-country analysis. By including both country and time fixed effects, we expect $\lambda >$ 0 (or < 0 for the bottom 1% income share) to suggest that the income-pain gradient becomes weaker as the country grows more unequal over time.

3. Results

3.1. Main findings

Fig. 1 presents a kernel density plot of the average probability of being in pain at each income level for i) all countries, ii) countries that lie below the median income inequality, i.e., the relatively equal countries, and iii) countries that lie above the median income inequality, i.e., the relatively unequal countries. Looking at the raw data, we can see that the probability of being in pain is noticeably higher for those with lower income; around 3 in 10 people with annual income below US $20,000 per capita report to be in pain. For these low-income individuals, the size of the income gradient of pain does not seem to depend on income inequality. In other words, having low incomes are painful irrespective of how unequally distributed incomes are in the country. However, an increase in income beyond US$20,000 per capita is, on average, significantly more protective against pain for those living in relatively more equal than unequal countries. Hence, Fig. 1 produces one of the first raw data evidence that income inequality may have a moderating property on the income-pain gradient.

To explore the hypothesis more carefully and systematically, Fig. 2 plots the income-pain gradient for each of the 127 countries that we obtained from Eq. (1) estimation, i.e., β_j. The figure divides these countries into the top and bottom halves according to the income gradient. Here, we can see that income is statistically significantly associated with less pain – i.e., the income gradient for each country is negative and statistically significantly different from zero at the 1% level – in all but one country (Angola). However, we can also see evidence of substantial heterogeneity in the income-pain gradient across countries in the GWP, which suggests that income may be less effective at reducing pain in some countries more than others. For instance, there is evidence that income is most protective against pain in Lebanon, Slovakia, Belgium, Israel, and Mauritius and least protective against pain in Nicaragua, Costa Rica, Madagascar, and Malaysia. Specifically, a one percentage point increase in income corresponds to a 0.073 decrease in pain probability in Lebanon, and the corresponding estimated effect is more than 40 times smaller for Nicaragua at 0.0017.

Could cross-country variations in the long-run income inequality explain why income may be less effective at reducing pain in some

Table 1
Pain, income, and income inequality in 127 countries, 2009–2020. Ordinary Least Squares.

	Dependent variable: Pain (0–1)				
	(1)	(2)	(3)	(4)	(5)
Log Income	−0.0328***	−0.0283***	−0.0230***	−0.0324***	−0.0114***
	(0.0086)	(0.0039)	(0.0036)	(0.0051)	(0.0022)
Log Income × Gini index	0.0004*	0.0003**			
	(0.0002)	(0.0001)			
Log Income × Income Share (Top 1%)			0.0331		
			(0.0207)		
Log Income × Income Share (Top 10%)				0.0321***	
				(0.0108)	
Log Income × Income Share (Bottom 1%)					−3.0366***
					(0.7727)
Observations	1,116,991	1,116,991	1,046,522	1,046,522	1,046,522
R^2	0.06	0.08	0.08	0.08	0.08
Country Fixed Effects	N	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y

Note: *$p < .1$; **$p < .05$; ***$p < .001$. Table shows standardized regression coefficients from Ordinary Least Squares (OLS). Dependent variable is a binary variable denoting whether respondent experienced physical pain the day before. Log income coefficient can be interpreted as the average marginal effect of income on the probability of being in pain. The coefficients from the interaction of Log Income and various income inequality variables (Gini/Income Share) measures how income inequality affects the relationship between income and pain. For all regressions, we control for individual (endogenous) and country (exogenous) level characteristics. For column 1, we only control for year fixed effects but from columns 2–5, we control for both year and country fixed effects.

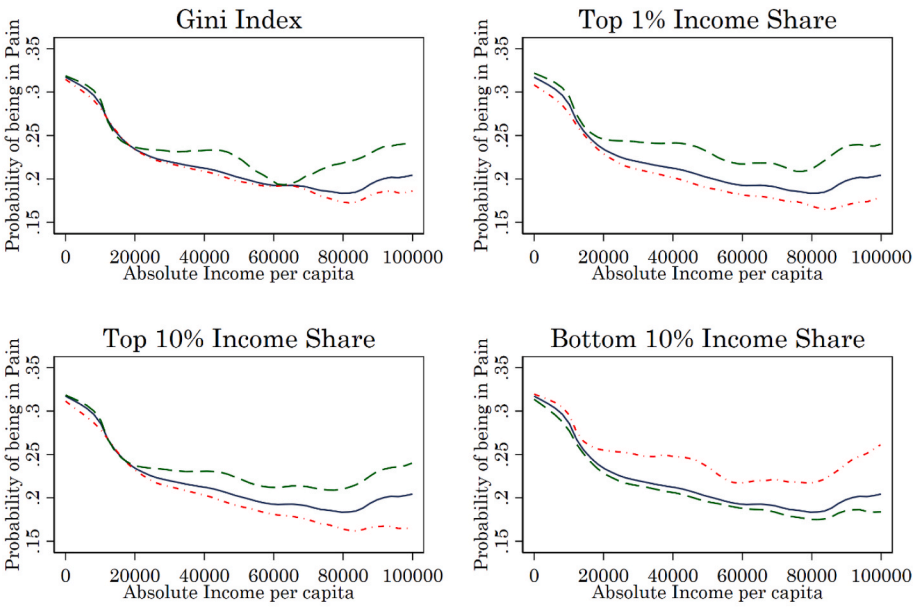

Fig. 1. Average probability of pain across absolute annual average self-report income for all countries, and for countries below and above median various income inequality measures including Gini index, Top 1%- and 10%-income share, and Bottom 10% income share. Solid lines denote all countries, red and green dashed lines denote below and above median values of income equality measures. The figure is constructed with local polynomial smoothing of pain probability across income levels. (Bandwidth: $5000, Kernel: Epanechnikov).

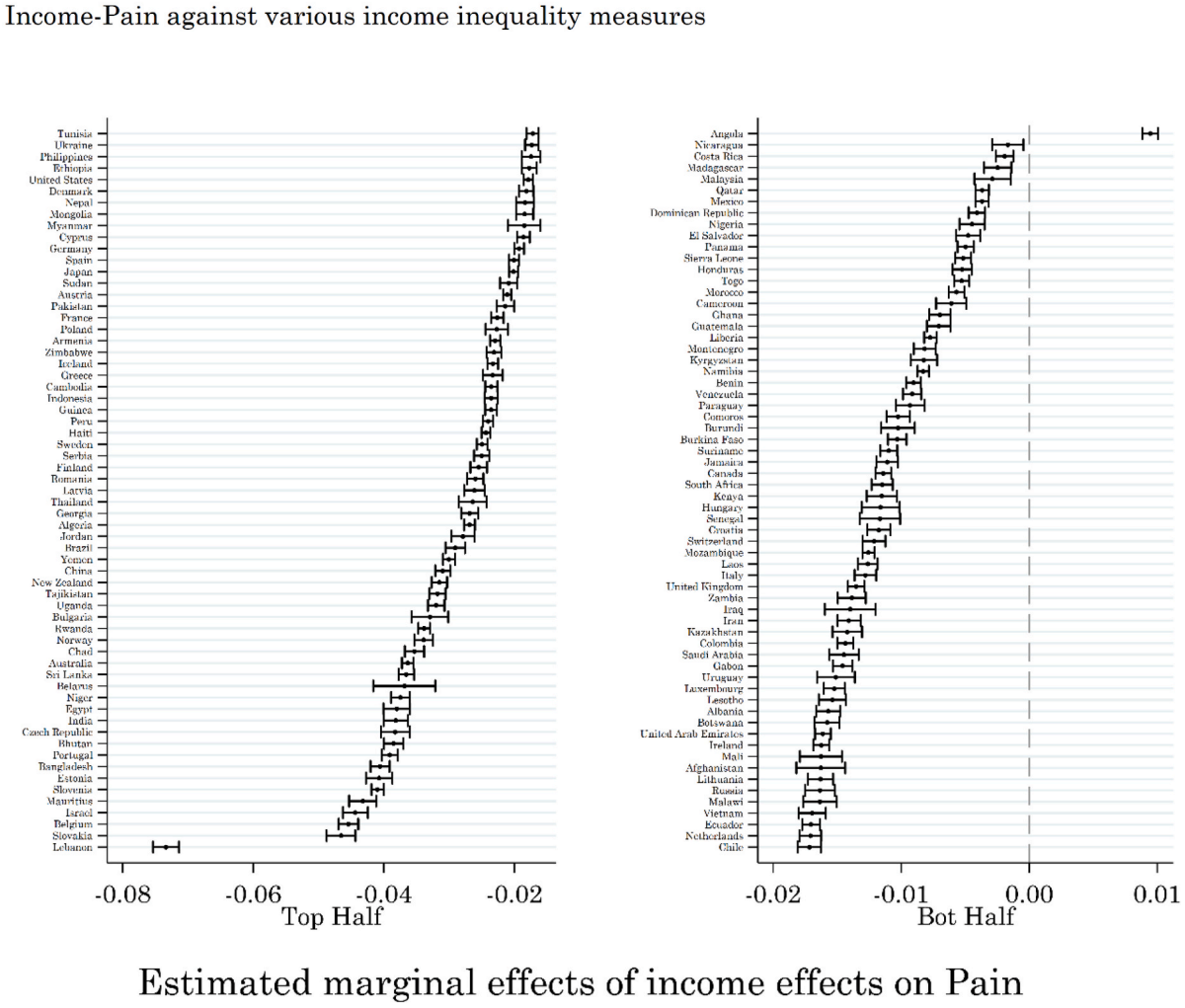

Fig. 2. Estimated marginal effects of income on probability of pain across countries. Reported estimates are estimated coefficients (β_j) of country-specific income effects on pain ($Y_{ijt} \times \theta_j$) from a specification that control for individual (endogenous) and country (exogenous) level characteristics. The estimates can be interpreted as the marginal effect of income from affecting the probability of being in pain for each country holding all other factors constant. Refer to equation (1) for the empirical specification. Tails denote 95% confidence intervals constructed from the standard errors clustered at country level.

countries than others? To test this, Fig. 2 plots the income-pain gradient for each country, β_j, obtained from Eq. (1) against each country's long-run average of different measures of income inequality, i.e., the Gini index, the shares of taxable income held by the top 1%, the top 10%, and the bottom 1% of income earners.

We can see from Fig. 3 that the relationship between the income-pain gradient and income inequality is moderately positive for the Gini index (the Pearson r coefficient = 0.31), the top 1% income shares ($r = 0.16$), and the top 10% income shares ($r = 0.28$), and negative for the bottom 1% income shares ($r = -0.34$). In terms of the size of the correlation, 0.3 is considered by Cohen's rules-of-thumb as a medium-sized association (Cohen, 1988). Three out of four of the r coefficients (except for income share from top 1%, which is statistically significant at the 10% level) are statistically significantly different from zero at the 1% level. Hence, we have strong, cross-country evidence to suggest that income is associated with less pain reduction in countries where income is heavily concentrated at the top rather than at the bottom of the income percentiles.

One objection to Fig. 3's findings might be that the results are driven primarily by a few countries of outliers. Fig. S.2 in the SOM accounts for the possibility of outliers driving our estimates by dropping countries that have very unequal or equal distribution of income (i.e., the top and the bottom 1% and 5%), as well as removing countries that are most and least painful (the top and the bottom 1% and 5%). Given that highly unequal countries also have poor institutions, we also further account for country-level measures of voice and accountability, political stability, regulatory quality, corruption levels, and the rule of law. As can be seen in Fig. S.2 in the SOM, the results from all these specifications are virtually the same as those obtained using the Gini index in Fig. 3, which suggests that our initial results are not driven by outliers and omitted institutional variables.

Table 1 reports Eq. (2)'s estimates in which income is interacted with different measures of income inequality. While we control for individual and country level characteristics in all columns, only Column 1 controls for year fixed effects and not for country fixed effects. In other words, we only include country fixed effects in Columns 2–5, which allows us to conduct a within-country instead of a between-country analysis.

Consistent with Fig. 1's results, log income enters the pain equation in a negative and statistically significant manner in all five columns. The positive albeit marginally significant interaction term between log income and the Gini index in Column 1 ($\beta = 0.004$; $p = .06$) suggests that the income-pain gradient is less negative in countries where income inequality is high, which is consistent with Fig. 2's findings.

As can be seen from Column 2, the positive interaction term continues to be positive and statistically robust even after controlling for both country and year fixed effects ($\beta = 0.003$; $p = .017$). The coefficient on the interaction term between log income and the Gini index is 0.0003, with a robust standard error of 0.0001. Though statistically significant at the 5% level, the moderating effect of the Gini index on the income-pain gradient is not large. For example, the difference in the income-pain gradient from a move from everyone having the same income (Gini index = 0) to perfect income inequality (Gini index = 1) is only 0.03 percentage point (or 1% of the income-pain gradient).

However, the estimated moderating effects of the top and the bottom income shares appear to be more sizeable than those obtained using the Gini index. For instance, Column 4's estimates suggest that the income-pain gradient is essentially equal to zero, i.e., income has no meaningful association with pain, if the top 10% earners hold all the country's income: the sum of the coefficients $-0.0324 + 0.0321$ is virtually equal to zero ($p = .960$). While the estimated moderating effect of the top 1% income share in Column 3 is also positive and sizeable, it is nevertheless imprecisely estimated ($\beta = 0.0331$; $p = .112$).

On the other hand, the protective effect of income against pain is estimated to be substantially larger, i.e., more negative, as the income shares of the bottom 1% earners go up. In column 5, the size of the interaction term between log income and the bottom 1% income share is negative, sizeable, statistically well-determined; the coefficient is -3.037, with a robust standard error of 0.773 ($p < .001$). Such finding makes perfect sense as (i) pain is much more prevalent among the very poor, and (ii) an increase in income rank is easier for the very poor individuals to achieve when higher shares of the nation's incomes are concentrated at the bottom of the income percentiles.

More generally, our findings seem to suggest, as Belsch et al. (2022) have indicated in their study, that the use of the Gini index, which only narrowly captures inequality, may have led to an underestimation of the

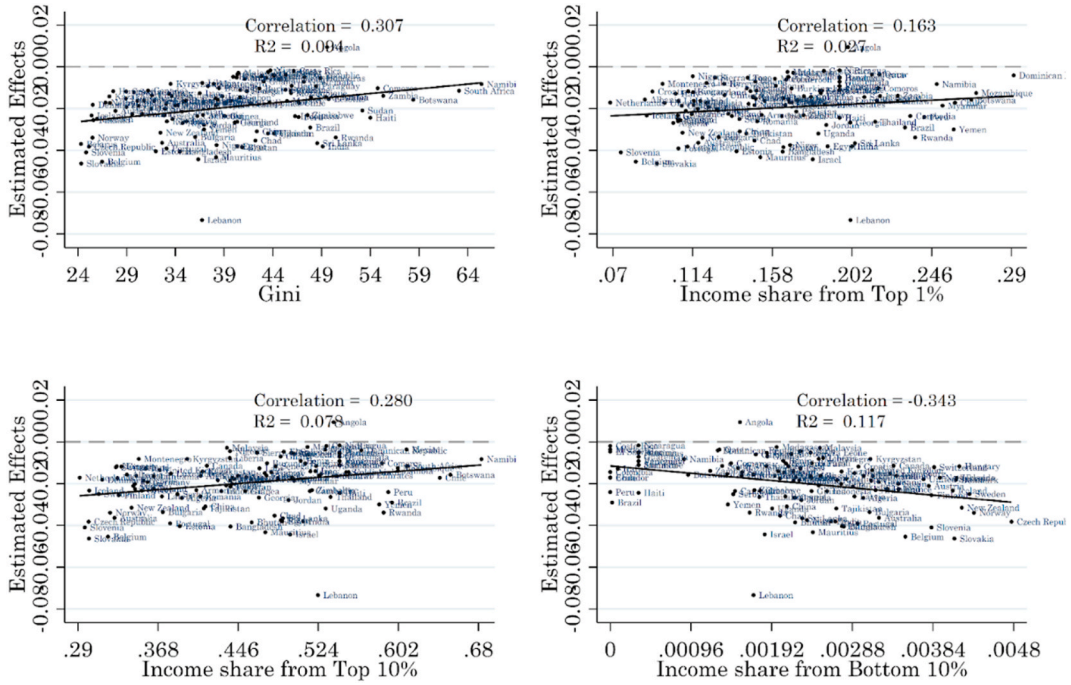

Fig. 3. Each country's income-pain gradient (β_j) against each measure of income inequality averaged across all years in the GWP. Income inequality on the x-axis are averaged income inequality within country over time.

true moderating effect of income inequality on the income-pain gradient.

3.2. Potential mechanisms

Could we explain our findings based on the assumption that income buys less rank in more unequal countries? To test this hypothesis, Table 2 re-estimates Eq. (2)'s with individual's income rank as the dependent variable. We find the interaction term between income and income inequality to be negative and statistically significant in three out of four specifications (and positive in the expected direction for the bottom 1% income shares in the last column), which suggests that greater income buys less income rank when income inequality is high. More specifically, this can be seen in Column 1 in the model without country fixed effects ($\beta = -0.0014$; $p < .001$) and in Column 2 in the model with country fixed effects ($\beta = -0.0016$; $p < .001$) using the Gini Index to capture income inequality.

Once again, estimated moderating effects of the top and the bottom income shares seem to be more sizeable than those obtained using the Gini index. Column 4 shows that having greater income in a highly unequal setting, as shown by the interaction between income and the top 10% income share, is rather small 0.2119–0.1247 = 0.0872. However, column 5 shows that income could buy income rank in contexts with lower income inequality which is represented by the positive interaction between income and the bottom 1% income share on income rank ($\beta = 13.7950$; $p < .001$). These findings suggest that income can buy more income rank in more equal vs unequal contexts. This situation can explain why income is more protective against pain in more equal settings.

Table 3 tests whether income rank rather than absolute income that is protective against pain. We can see from Column 1 that there is a negative association between income rank and pain ($\beta = -0.1173$; $p < .001$), whilst the association between income and pain is now attenuated to zero. However, Column 2 shows that the estimated protective effect of income rank on pain is smaller in a highly unequal context. This can be seen in the positive interaction between income rank and the Gini Index on pain ($\beta = 0.0021$; $p < .001$). The same pattern of result can be found when using the income share to capture income inequality. A positive coefficient can be seen in the interaction between income rank and the top 1% income share ($\beta = 0.1876$; $p = .089$, column 3) and the interaction between income rank and the top 10% income share ($\beta = 0.1180$; $p = .036$, column 4). Column 5 shows an insignificant interaction between income rank and the bottom 1% income share.

4. Discussions and conclusions

In this article, we present between- and within-country evidence on the protective effect of income on pain across levels of income inequality. Using nationally representative data from over one million individuals from 127 countries worldwide, we find strong evidence of a significant pain gap between the rich and the poor in all but one country. The regression results, which are robust to including country and year fixed effects, suggest that income is likely to have an important protective property against pain in most regions worldwide.

However, we also find evidence of substantial heterogeneity in the estimated income-pain gradient between and within countries, which can be explained, in part, by the corresponding variations in income inequality. We have strong evidence to suggest that income may be significantly less protective against pain in more unequally distributed countries and within countries as inequality widens over time. This result represents our main finding, which is robust to using different measures of income inequality and accounting for outliers in the data.

Further analysis of the potential mechanisms yields results that suggest that (i) the relationship between pain and income is not absolute but guided by how much social position each dollar buys for the individual in society, and (ii) the same increase in income produces less gain in income rank in more unequal than equal countries. These results are consistent not only with the income rank literature (see, e.g., Daly et al., 2015; Macchia, 2023) but also with the findings that the marginal effect of income increase on overall life satisfaction is higher in more equal societies (Quispe-Torreblanca et al., 2021).

Despite this, we have also uncovered new evidence suggesting a diminishing protective effect of income rank as income inequality increases. This result suggests that not only is a gain in income rank harder to achieve in more unequal countries, but its marginal effect on pain may also become smaller as income inequality widens. We are not sure why this is, but it might be that it is generally more painful for individuals to gain income rank in highly unequal countries. Individuals living in countries with higher income inequality generally must work much harder to achieve the same income rank gain than those living in countries with lower income inequality, which may dampen the protective property of income rank on pain. Similarly, as climbing up the income hierarchy might be harder in an unequal than in an equal context, feelings of lack of hope in upward social mobility might be

Table 2
Income rank, income, and income inequality in 127 countries, 2009–2020. Ordinary Least Squares.

	Dependent variable: Income rank (0–1)				
	(1)	(2)	(3)	(4)	(5)
Log Income	0.1884***	0.2159***	0.1718***	0.2119***	0.1261***
	(0.0190)	(0.0175)	(0.0114)	(0.0174)	(0.0061)
Log Income × Gini index	−0.0014***	−0.0016***			
	(0.0005)	(0.0005)			
Log Income × Income Share (Top 1%)			−0.1064		
			(0.0737)		
Log Income × Income Share (Top 10%)				−0.1247***	
				(0.0393)	
Log Income × Income Share (Bottom 1%)					13.7950***
					(2.8573)
Observations	1,166,888	1,166,888	1,095,986	1,095,986	1,095,986
R^2	0.54	0.64	0.64	0.64	0.64
Country Fixed Effects	N	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y

Note: *$p < .1$; **$p < .05$; ***$p < .001$. Table shows standardized regression coefficients from Ordinary Least Squares (OLS). Dependent variable is the income rank for respondent.
Log income coefficient can be interpreted as the average marginal effect of income on the income rank.
The coefficients from the interaction of Log Income and various income inequality variables (Gini/Income Share) measure how income inequality affects the relationship between income and income rank. For all regressions we control for individual (endogenous) and country (exogenous) level characteristics.

Table 3
Pain, income, income rank, and income inequality in 127 countries, 2009–2020. Ordinary Least Squares.

	Dependent variable: Pain (0–1)				
	(1)	(2)	(3)	(4)	(5)
Income Rank	−0.1173***	−0.1917***	−0.1437***	−0.1652***	−0.0981***
	(0.0060)	(0.0258)	(0.0176)	(0.0241)	(0.0124)
Log Income	0.0003	0.0100*	0.0015	0.0008	0.0005
	(0.0019)	(0.0052)	(0.0046)	(0.0062)	(0.0028)
Log Income × Gini		−0.0003*			
		(0.0002)			
Income Rank × Gini		0.0021***			
		(0.0007)			
Log Income × Income Share (Top 1%)			−0.0094		
			(0.0244)		
Income Rank × Income Share (Top 1%)			0.1876*		
			(0.1094)		
Log Income × Income Share (Top 10%)				−0.0025	
				(0.0124)	
Income Rank × Income Share (Top 10%)				0.1180**	
				(0.0557)	
Log Income × Income Share (Bottom 1%)					−0.3631
					(0.8787)
Income Rank × Income Share (Bottom 1%)					−6.5346
					(4.3980)
Observations	1,116,991	1,116,991	1,046,522	1,046,522	1,046,522
R^2	0.08	0.08	0.08	0.08	0.08
Country Fixed Effects	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y

Note: *$p < .1$; **$p < .05$; ***$p < .001$. Table shows standardized regression coefficients from Ordinary Least Squares (OLS). Dependent variable is a binary variable denoting whether respondent experienced physical pain the day before. Log income coefficient can be interpreted as the average marginal effect of income on the probability of being in pain, while Income Rank coefficient can be interpreted as the average marginal effect of income rank on the probability of being in pain. The coefficients from the interaction of Log Income and Income Rank with various income inequality variables (Gini/Income Share) measure how income inequality affects the relationship between income/income rank and pain. For all regressions, we control for individual (endogenous) and country (exogenous) level characteristics.

experienced. These negative feelings have been found to be linked to greater pain (see Cherlin, 2016; Graham and Pinto, 2019).

We may be able to explain our findings using the evidence that the healthcare disparities between the rich and the poor are generally more considerable in more unequal regions (Bor et al., 2017). What this implies is that an increase in income in an equal society may translate into better access to healthcare, possibly through a rise in social status, than in an unequal society, which in turn reduces feelings of pain.

An important implication of our study is that poverty reduction policies that increase the income shares at the bottom percentiles are likely to effectively reduce pain for those at the bottom of the income distribution. On the other hand, rank-preserving income redistribution will likely have little to no effect on reducing aggregate pain experienced by the population in the country. Moreover, pursuing rank to reduce pain in highly unequal countries may even be counterproductive for the individuals as we have evidence that the marginal benefit of a gain in income rank on pain gets increasingly smaller as income inequality widens.

Like all studies in social sciences, our studies have limitations. First, since we cannot find an appropriate instrument for income and income inequality in the GWP data, it is difficult to infer causality from our study. Second, our binary measure of pain did not allow us to know the intensity of the pain. However, we were able to offset these limitations by the robustness of our findings across different model specifications, including estimation results from the within-country analysis, which lends credence to our main findings. In addition to this, we were able to show that the main findings are robust to using different measures of income inequality, which is something previous studies on the effects of income inequality on health outcomes had not been able to do.

More generally, this study is relevant to researchers and policymakers that aim to understand the new social phenomenon of pain. These findings demand further work to continue uncovering the protective factors of pain and the settings in which these factors may be more effective.

Credit author statement

All authors conceptualised the paper, designed the research, analysed the data, and wrote the paper.

Declaration of competing interest

Authors have no conflict of interests.

Data availability

The Gallup World Poll data belong to Gallup, Inc. For more information, see: https://www.gallup.com/analytics/318875/global-research.aspx. Scripts for analyses are available through the Open Science Framework (OSF) https://osf.io/yeub5/?view_only=39efefb7e00e41eaa6f162bd5bcc079b

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2023.116181.

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