Economics Bulletin

Volume 41, Issue 2

Global inequality in life expectancies: what role does income inequality play?

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Abstract

This paper examines trends in global inequalities in Life Expectancy at birth between countries from 1960 to 2017, and studies how income inequality affects inequality in life expectancy. The study uses data from the World Development indicators data set. Inequality is measured using the Gini coefficient. The causal relationship between inequality in Life Expectancy and per capita GDP is examined using reduced form regression models. Life expectancy at birth shows a steadily rising trend. There is a decline in the global inequality in life expectancy over time. Moreover, the decomposition analysis for the Gini coefficient shows that in any year, the between groups inequality is more important than the within groups inequality. This is corroborated by the decomposition of Gini over time. We infer from the devised regression models that there is a positive association between per capita income inequality and inequality in life expectancy. The regressions point out evidence that inequality in lifespan and inequality in per capita income can be explained in terms of inequality in health expenditure.

We would like to thank Prof. Zakir Husain, for his guidance and suggestions. He has taught us so much along the way, and – without his support – this paper would not have been possible. We are also grateful to Dr Diganta Mukherjee, Sampling & Official Statistics Unit, Indian Statistical Institute, Kolkata for his suggestions regarding the data analysis, and Prof. Mousumi Dutta, Economics Department, Presidency University, Kolkata, for her comments on the manuscript. The responsibility for any remaining errors lies with the authors.
Citation: Nirajana Banerjee and Ritojeet Basu and Ananya De and Monalisa Poali, (2021) "Global inequality in life expectancies: what role does income inequality play?", *Economics Bulletin*, Vol. 41 No. 2 pp. 553-563.
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Submitted: November 13, 2020. **Published:** April 09, 2021.

1. Introduction

Life expectancy at birth (referred to as life expectancy, hereafter) is by far the best measure of health. Among all the major human development indicators, life expectancy plays a crucial role in analysing the constantly changing trends in the average life-span of a person during the period under study. As per the United Nations Development Programme (UNDP), Sustainable Development Goals (SDG) (UNDP, 2015) for 2030, life expectancy is one of the indicators of the objective to "Ensure healthy lives and promote well-being for all at all ages" (SDG3). However, life expectancy is seen to exhibit disparities between different groups of individuals, and between different countries. The objective of this study is to analyse global inequalities in life expectancy between countries from 1960 to 2017, and examine its relationship with income inequality.

Historically, there have been two approaches to studying inequality. One focuses on inequality *within* countries, while the other analyses inequality *between* countries. While there has been a considerable body of work on inequality in life expectancy, the literature in this field has largely concentrated on within-country inequality, focussing on identifying vulnerable groups. In contrast, there has been few studies on global trends in inequality in life expectancy between countries (Permanyer and Scholl, 2019). However, a study of variations in life expectancy *between* countries is important because of many reasons:

1. A situation where the lifespan of an individual depends upon where he/she is born is not acceptable because of ethical reasons;
2. We can examine the impact of fundamental changes in technology, economy and society upon between-country variations in lifespans; and,
3. We can explore how life span changes over time between countries, enabling us to understand human mortality and improve the quality of public health policies.

Studies of life span at the global level indicate increasing life expectancy over time. This is often attributed to economic growth. With rising national income, life expectancy of a country is seen to increase (Preston, 1975). However, exogenous factors accounted for around 75-90 percent of the increase in life expectancy, for both developed and developing nations (Preston, 1975). The increasing trend in life span, however, hides considerable variations in life span between countries. Smits and Monden (2009) reported that there was substantial variation in the length of adult life across nations and time periods. They found most of the life inequality could be attributed to inequality within countries. They tested two hypotheses: the *forerunner hypothesis* and the *diffusion hypothesis*. The former hypothesized that those nations that reached a certain level of life expectancy ahead of others faced a higher level of life inequality; it was found to be true in their analysis. The diffusion hypothesis tested whether countries that lagged behind in life expectancy had a lower level of life inequality, given that they could adopt the better health practices in the forerunner countries. White (2002) concluded that the rate at which life expectancy increased for the developing nations was faster than the rate at which life expectancy increased for the developed nations of the world. In a study of the Human Mortality Database, Edwards (2011) found that the inequality in the expectation of life at birth had declined after 1970 for the world as a whole and for advanced countries. In addition, Edwards also found that the share of within-country inequality, out of total inequality, declined over the years and the proportion of between-country inequality rose over the years. The work done by Anand and Ravallion (1993) in this field show that the commonly observed positive relationship between life expectancy and affluence across countries ceases to hold once provisions are made to account for incidence of poverty and the public expenditure on health. Finally, Moser, Shkolnikov and Leon (2005) incorporated factors such as infant mortality, fertility, the global outbreak of contagious diseases such as HIV/AIDS in Sub-Saharan Africa and human development into their scope of analysis to report a convergence in mortality up to 1980, and a divergence thereafter.

This study examines long run trends in inequalities in life expectancy, and examines its relationship with inequalities in per capita income. Unlike other studies we focus on the decomposition of inequality measures for life expectancy across income groups, and over time. We also incorporate health expenditure into our analysis, as a possible explanation of the relationship between inequality in life expectancy and inequality in per capita income.

2. Research objective and hypotheses

The study seeks to examine trends in inequality in life expectancy over time at the global level, and decompose this inequality at specific years, and its change over time, into sub-groups of countries classified in terms of per capita income levels. We will also analyse the role of income inequality underlying inequalities in life spans. The analysis will be undertaken using the Gini coefficient, and its two components—a *within-group* of countries measure of inequality, and a *between* country measure of inequality. We will also decompose the change in inequality over the period of study.

The study rests on the following research hypotheses:

> **H_1:** *Inequality in life expectancy is decreasing over time.*
> **H_2:** *The inequality in life expectancy may be attributed to (i) differences in mean income of countries classified by income levels (between), and (ii) income differences between countries in each sub-group (within-group). The weight of the former (between) will be greater.*
> **H_3:** *The change in global inequality in life spans over the period of study may similarly be attributed to these two causes, with between group changes playing a major role.*
> **H_4:** *The inequality in life expectancy may be attributed to inequality in per capita income.*

3. Data and Methodology

3.1 Variables

The main variable of the study is Life expectancy at birth, measured in years. It indicates the number of years a new born infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. Data on life expectancy at birth is obtained for 218 countries for the period 1960 to 2017 from The World Bank *World Development Indicators* site, and is based on estimates provided by the United Nations Population Division, in *World Population Prospects: 2019 Revision*. In addition, we have used data on Gross Domestic Product (GDP) per capita at purchasing power parity (PPP), Health expenditure per capita, and Government expenditure on health per capita. These data have also been downloaded from the WDI website (https://databank.worldbank.org/reports.aspx?source=world-development-indicators).

In Table I, we sum up the statistical characteristics of the study variable, life expectancy at birth. Statistics are given for all countries as well as for countries divided into groups on the basis of per capita income.

Table I: Descriptive statistics of Life expectancy at birth—World, and Countries divided into Income groups

Group	N	Maximum	Minimum	Mean	Median	Variance
Low Income	3696	85.41708	42.672	73.39772	73.71464	31.49335
Low Middle Income	1798	74.43	26.172	49.79139	49.0225	85.01185
High Middle Income	2696	76.31	18.907	57.7985	58.154	85.07006
High Income	3139	79.914	36.535	66.40062	68.17	56.34059
World	**11329**	**85.41708**	**18.907**	**64.00028**	**67.134**	**131.2127**

3.2 Measures of Inequality

For measuring global inequalities in life expectancy within-group of countries, we have used the Gini Coefficient: It is a widely used measure in economic researches on inequality. It varies from 0 to 1, with higher numbers indicating greater inequality. It is the mean of the absolute value of the inter-country differences in age at death, divided by the life expectancy:

$$I_{LE} = \frac{2}{n^2 \bar{y}} \sum_{i=1}^{n} i(LE_i - LE) \qquad (1)$$

The temporal trends in life expectancy and inequality in life expectancy are analysed using graphs. We have also examined similar trends for groups of countries. We have divided the countries into four groups based on the World Bank classification of countries by per capita income: High Income Countries (HIC), High Middle Income Countries (HMIC), Low Middle Income Countries (LMIC), and Low Income Countries (LIC). [1]

3.3 Decomposition of inequality measures

A question often encountered in studies of inequality relates to the extent to which inequality in the total population is a consequence of income differences between population subgroups (Deutsch and Silber, 1999). In comparison to other inequality measures, the Gini coefficient is not perfectly decomposable into between groups and within groups contributions. Lambert and Aronson (1993) have shown that the Gini coefficient may also be decomposed into between groups and within groups components, and a residual component.

The Lambert-Aaronson decomposition analysis studies the inequality at a single point of time. But, in studies over time, changes in economic, and socio-demographic variables occur; such changes will affect the change in inequality over time. Mookherjee and Shorrocks (1982) propose a method for decomposition over time based on:

> "use of additively decomposable inequality measures, and involves disaggregating total inequality in each year into various components and examining the time paths of these individual contributions. The conventional type of cross section decomposition in a single year associates two main contributions (the 'within group' and 'between group' terms) with each disaggregation characteristic. These contributions are in turn completely specified by information about the subgroup mean incomes, population shares and inequality values. *In the decomposition of the trend in inequality, we identify three main components corresponding to the influence of changes in subgroup*

[1] Given in The World Bank Development Indicators data set, https://bit.ly/2YXM3sr, accessed on 13 May 2020.

inequality values, shifts in the subgroup population shares and relative variations in the subgroup mean incomes" (Mookherjee and Shorrocks, 1982: 887; italics, our).

Two decomposition results are obtained: one an exact decomposition, and the other, a slight approximation of the exact decomposition offering a more practical interpretation. The approximate decomposition yields four components—labelled A, B, C, and D:

A: Effect due to changes in within subgroup inequality,
B: Effect due to changes in population shares of within component,
C: Effect due to changes in population shares of between component, and
D: Effect due to relative changes in subgroup means.

The exact decomposition does not provide the same neatly-identified conceptual components; however, they can be presented in four distinct terms, of which the first two corresponds to A and B of the approximate decomposition, while the remaining two cannot be interpreted.

3.4 Econometric methodology

The causal relation between inequality in life expectancy and per capita GDP is examined using a reduced form regression of inequality in life expectancy on inequality in per capita income:

$$LE_G = \alpha_1 + \beta_1 GDP_G. \quad (2)$$

Similar regressions are also estimated for within and between measures:

$$LE_B = \alpha_2 + \beta_2 GDP_B. \quad (2a)$$

$$LE_W = \alpha_3 + \beta_3 GDP_W. \quad (2b)$$

Our hypothesis is that the regression coefficients (β_1, β_2, and β_3) should all be positive. The reduced form enables us to focus on the relationship between two variables; however, particularly in the case of time series data, the presence of confounding variables may lead to the observation of spurious or misleading relationships.

In particular, given that we are using time series data, time may be a confounding variable. To eliminate the role of time, we regress LE_G and GDP_G upon time, estimate the residuals and then regress residual of LE_G (LE_{RG}) upon residual of GDP_G (GDP_{RG}):

$$LE_{RG} = \delta_1 + \gamma_1 GDP_{RG}. \quad (3)$$

This is repeated for LE_B and LE_W:

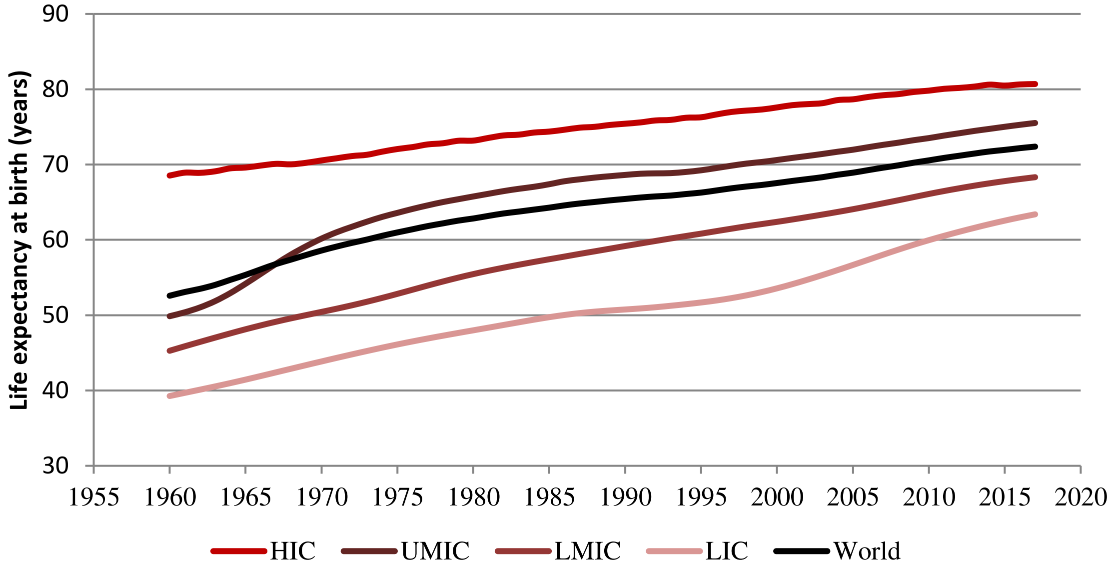
$$LE_{RW} = \delta_2 + \gamma_2 GDP_{RW}. \quad (3a)$$

$$LE_{RB} = \delta_3 + \gamma_3 GDP_{RB}. \quad (3b)$$

4. Findings

An analysis of global life expectancy over time indicates a steadily increasing trend (Fig. 1). In the period 1960 to 2017, it has increased by about 25 years from 50 years to 75 years. This is also observed for the four groups of countries, HIC, HMIC, LMIC and LIC. Further, life expectancy at birth has been uniformly higher for richer countries, indicating a positive association between per capita income and life expectancy.

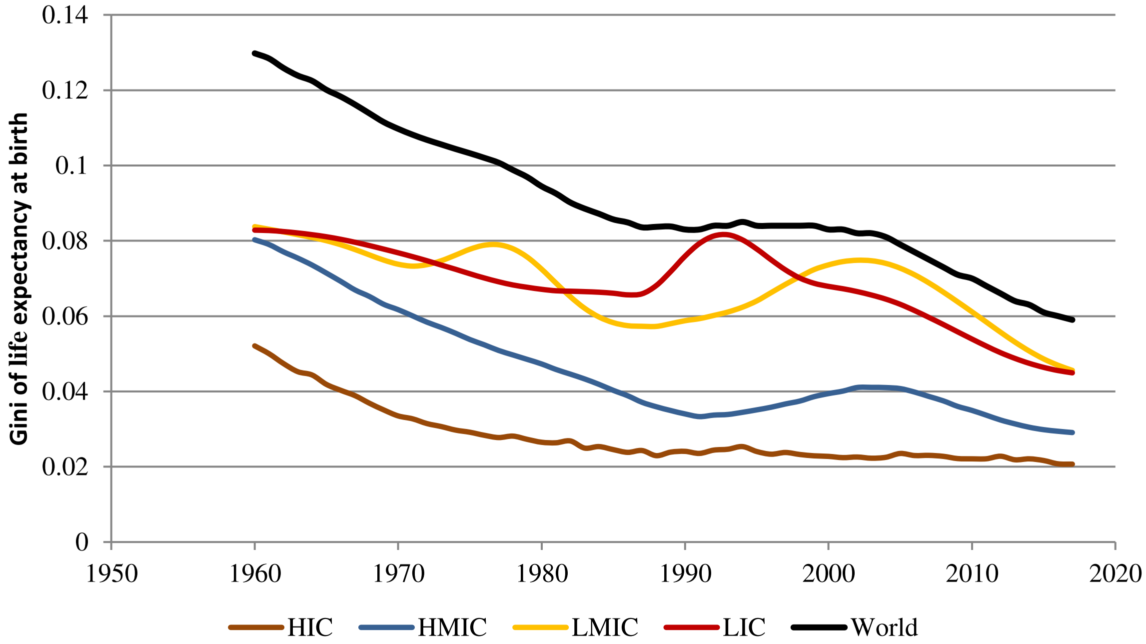
Figure 1: Life expectancy at birth—World, Countries classified by Income



Source: *Own estimate*

In Fig. 2 we have plotted the Gini coefficient of life expectancy. Global inequality in life spans has decreased steadily, except for the first decade in this millennium. Per capita income appears to be associated with, not only life spans, but inequality in life expectancy. While all country groups display a decreasing trend in inequality in life spans in general, the level of inequality is lower in HICs and HMICs.

Figure 2: Gini of life expectancy at birth—World, and countries by income groups



Source: *Own estimate*

4.1 Results of decomposition

It may be seen (Table II) that inequality in life expectancy has halved over the study period from 0.13 to 0.06. Further, the decompositions indicate, generally, that in any year the between groups inequality is more important than the within groups inequality. In case of the Gini coefficient, the weight of the between groups inequality is about 80 percent, while the within groups inequality counts only for about 12-14 percent of total inequality. Although, the relative weights of these two components, as well as that of the overlapping element, vary from one decomposition to the other, the correlation between each total, within group and between group inequality is, however, close to unity (about 0.99). Since the country groups have been formed based on levels of per capita income, it implies that the difference in mean life spans *between* HI, HMI, LMI and LI countries is greater than the inequality in life inequality *within* each of these groups.

Table II: Results of decomposition analysis for Gini coefficient

YEAR	WITHIN (%)	BETWEEN (%)	OVERLAP (%)	GINI
1960	14.64	78.59	6.93	0.1298
1970	12.76	81.11	5.47	0.1097
1980	12.70	81.52	5.29	0.0945
1990	12.01	84.06	3.6	0.0833
2000	13.24	80.63	6.02	0.0831
2010	14.34	80.31	5.74	0.0697
2017	13.53	81.19	5.07	0.0591

Source*: Own estimate*

The above decomposition is for specific years. But what happens to the change in distribution of life expectancies over the entire period of study? The answer to this question is provided by the Mookherjee-Shorrocks decomposition results (Table III). It may be seen that inequality decreases marginally by 0.02 between 1960 and 2017. Again, the between effects component has greater weight. Approximately, about two-thirds of this decline may be attributed to relative changes in means of each group. In case of the exact decomposition, only about 35 percent may be attributed to relative changes in within subgroup distribution and changes in population shares within each group. This underlines the lower weight of the within effect components in the decomposition analysis.

Table III: Results of Shorrocks-Mukherjee decomposition analysis over 1960-2017

Components of Inequality change	Value	Percentage
Approximation decomposition components:		
A. Effect due to changes in within subgroup inequality	-0.007516	35.01
B. Effect due to changes in population shares of within component	-0.000075	0.35
C. Effect due to changes in population shares of between component	-0.000056	0.26
D. Effect due to relative changes in subgroup means	-0.013824	64.39
Sum of components	**-0.021470**	
Exact decomposition components:		
A. Effect due to changes in within subgroup inequality	-0.007516	34.95
B. Effect due to changes in population shares of within component	-0.000075	0.35
C.	-0.005539	25.76
D.	-0.008376	38.95
Sum of components	-0.021507	
Exact difference in I(0)	**-0.021507**	

Source*: Own estimate*

4.2 Explaining Inequality in life expectancy

The decomposition analysis indicates that change in inequality between the country groups formed on the basis of per capita income levels is crucial in understanding the decline in inequality in life expectancy at the global level. This hints that income inequality may be an underlying factor associated with the global change in life span inequality. To check this, we estimated reduced form regression models of Gini, within and between of life expectancy upon Gini, within and between of per capita income, respectively (Table IV). These equations correspond to (Equations 2, 2a, 2b).

Table IV: Results for regression of Inequality in LE upon Inequality in GDP

Life expectancy	Gini	Between	Within
$\beta_{\text{GDP per capita}}$	-1.83	0.14	-0.03
t-value	-4.96***	45.47***	-0.74
Intercept	1.61	0.01	0.02
t-value	5.22***	16.30***	1.84*
N	28	28	28
F	24.61***	2067.53***	0.55
R^2	0.47	0.99	0.01

Note: ****, ** and * indicates probability < .01, < .05 and < .10, respectively.*
Source*: Own estimate*

From Table IV, we see that inequality in Life expectancy is significantly related with inequality in GDP per capita—for the overall and between components. However, although we would expect a positive sign for the coefficient of GDP per capita, in the "Gini" and "within" models, they are negative.

A possible reason is that time plays a confounding role.[2] To eliminate the role of time, we have regressed each variable upon time, and estimated residuals (Equations 3, 3a, 3b). The coefficients are statistically significant and positive in each model—indicating that higher income inequalities are reflected in higher inequalities in life expectancies (Table V).

Table V: Results for regression of Residuals of LE upon Residuals of GDP per capita—eliminating time effect

R(Life expectancy)	**Gini**	**Between**	**Within**
$\beta_{R(\text{GDP per capita})}$	1.08	0.20	0.17
t-value	4.60***	6.34***	9.51***
Intercept	0.00	0.00	0.00
t-value	0.00***	0.00***	0.00***
N	28	28	28
F	21.19***	40.19***	90.38***
R^2	0.29	0.48	0.79

Note: ****, ** and * indicates probability < .01, < .05 and < .10, respectively.*
Source*: Own estimate*

What is the explanation for this positive association between inequality in per capita income and life expectancy? A possible explanation runs in terms of health expenditure per capita. Expenditure on health is a form of investment in human capital; it will increase productivity, and hence increase GDP per capita. On the other hand, increased expenditure on health is expected to improve health and life expectancy. So, the role of inequality in health expenditure in our research context needs to be examined. We take two indicators for health spending: Government expenditure on health per capita, and Expenditure on health per capita (which includes private out of pocket expenditure as well as Government expenditure).

Table VI: Results for regression of Residuals of LE upon Residuals of GDP per capita—eliminating time and health expenditure effects

R(LE)	**Government exp. on health**			**Expenditure on health**		
	Gini	**Between**	**Within**	**Gini**	**Between**	**Within**
$\beta_{R(\text{GDP per capita})}$	-0.25	0.03	-0.23	-0.32	0.04	-0.20
t-value	-2.14**	1.31	-3.76***	-2.14*	1.54	-2.63**

[2] In case of regressions of Gini, Between and Within estimates for per capita income on Time, we find that coefficient of Time is always positive and statistically significant at 1% level. Results of multiple regression models, controlling for Time, will be affected by multi-collinearity.

Intercept	0.00	0.00	0.00	0.00	0.00	0.00
t-value	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
N	17	17	17	17	17	17
F	4.56	1.72	14.12	4.56	2.37	6.90
Prob	0.05	0.21	0.00	0.05	0.14	0.02
R^2	0.16	0.09	0.47	0.19	0.13	0.43

Note: ****, ** and * indicates probability < .01, < .05 and < .10, respectively.*
Source*: Own estimate*

In the last step of our analysis, we regress Inequality in Life expectancy and Inequality in GDP per capita on time and health expenditure; residuals are estimated and regressed upon each other.[3]

$I_{LE} = \alpha + \beta_1\text{Time} + \beta_1\text{HealthExp}$ (for Gini, Within and Between) => R_{LE} (4)

$I_{GDP\ per\ capita} = \alpha + \beta_1\text{Time} + \beta_1\text{HealthExp}$ (for Gini, Within and Between) => $R_{GDP\ per\ capita}$ (5)

$R_{LE} = \alpha + \beta\ R_{GDP\ per\ capita}$ (for Gini, Within and Between) (6)

when

I: Inequality (Gini, Within and Between)

R: Residual

Results are similar for (6) whether we take Government expenditure per capita, or Total expenditure on health per capita (Table VI). The coefficient of residual of GDP per capita is significant at 5% level only in the Within model. The sign, too, is negative—which is not expected. However, as we have seen earlier, the Within effect component comprises a relatively small proportion of the decomposed Gini coefficient. In contrast, the coefficient of residual of GDP per capita in the models for Gini and the Between component is insignificant at 5% level. This result may be interpreted as evidence that the positive relation between inequality in life span and inequality in per capita income may be explained in terms of their association with inequality in health expenditure.

5. Conclusion

The study had examined four hypotheses:

> **H_1:** *Inequality in life expectancy is decreasing over time.*
>
> **H_2:** *The inequality in life expectancy may be attributed to (i) differences in mean income of countries classified by income levels (between), and (ii) income differences between countries in each sub-group (within-group). The weight of the former (between) will be greater.*
>
> **H_3:** *The change in global inequality in life spans over the period of study may similarly be attributed to these two causes, with between group changes playing a major role.*
>
> **H_4:** *The inequality in life expectancy may be attributed to inequality in per capita income.*

Our analysis provides evidence in support of all our hypotheses. Inequality in life expectancy is decreasing over time (H_1). The decomposition of inequality measures reveals that both between and within components decline over time; however, the between effects dominate over the within effects (H_2). It implies that differences in the mean life expectancy in the four country groups (HIC, HMIC, LMIC, and LIC) are the dominant force reducing inequality in

[3] Again, multiple regression models are not estimated as multicollinearity will distort regression results.

life span (H_3). Finally, we find evidence of an association between inequality in life span and inequality in per capita income; it is observed for the overall, between, and within components (H_4). This result is explained in terms of the association between inequality in per capita income and inequality in health expenditure. Although further analysis is required to establish a causal relationship, our results underline the importance of increased spending on health expenditure. It is likely to lead to human capital formation, and is also accompanied by reductions in within-group of countries inequalities.

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