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Research article

The case for life expectancy at age 60 as a prominent health indicator. A comparative analysis

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Abstract: The aim of this paper is to argue the case of using life expectancy at age 60 (LE60) as a significant health indicator closely related to sustainable economic development. To this purpose, we investigate the impact of GDP on LE60 in parallel with the impact of GDP on Infant Mortality Rate (IMR). The rationale for selecting IMR as a comparison indicator is twofold. First, the relationship between IMR and GDP has been widely studied. Second, the two indicators display opposite trajectories, making the comparison more striking. For our comparison, we conduct several statistical analyses on LE60, IMR and GDP using global country data grouped by income level and region. Our results endorse the effect of GDP on LE60 and IMR and suggest a differentiation of the effect based on region and ultimately on income. We observe that as countries develop, their IMR values lower and their LE60 values increase. We conclude that, once countries reach the upper stages of development, LE60 becomes a better health indicator than IMR.

Keywords: population; population aging; life expectancy at age 60; infant mortality rate; economic development; health indicator; income; region; inequality; corruption

JEL Codes: I10, I14, I15, I19, J10, J11, J14, J18, J19

Abbreviations: Infant Mortality Rate (IMR), Life expectancy at age 60 (LE60), Under 5 Mortality (U5M), Gross Domestic Product (GDP), Gross National Income (GNI), World Health Organisation (WHO), World Bank (WB), Organisation of Economic Cooperation and Development (OECD), Centers for Disease Control and Prevention (CDC), High Income (HI), Low Income (LI), Upper Middle Income (UMI), Lower Middle Income (LMI), Corruption Perception Index (CPI), Fragile States Index (FSI), Economic Inequality Index (EEI), Health Expenditure as percentage of GDP (HE%), Eastern Mediterranean (E Med), South East Asia (SE Asia), Western Pacific (W Pacific).

1. Introduction

In little over 20 years, aging populations are projected to be the norm for Europe, North America, Latin America and Asia, where those over 60 will significantly outnumber those under 15 (Harper, 2014). A number of factors are believed to be behind this aging population phenomenon: falling fertility, falling mortality and increasing longevity (Harper, 2014). While low fertility rates were widely encouraged to counteract the falling mortality trend that had emerged in the late 1970s, the generalized increase in longevity is a relatively new and unexpected trend (Harper, 2014; Cairns et al., 2006). Longevity, understood as the increase in life expectancy at a given age, is particularly problematic when occurring at older ages, incurring costs that are difficult to sustain by both governments and individuals. Indeed, in advanced economies, over 40% of the state budget is allocated towards pensions and the healthcare needs of the elderly (Harper, 2014). Life expectancy at age 60 (LE60) is one of the many indicators on the World Health Organization's (WHO) comprehensive indicator list. LE60 represents the average number of years of life left at the age of 60. LE60 is a health indicator that directly reflects the phenomenon of increasing longevity, and like other health indicators, it is likely to be dependent on economic development. In Europe, where the ratio of those aged 60 to those aged 15 has already surpassed unity, reductions in mortality at older ages were experienced as early as the 1950s by some Western European populations, while Eastern and Central countries have only recently showed small and consistent mortality improvements (Rau et al., 2018). However, there is evidence that at least in the developed countries, LE60 has been fluctuating for some time, with recent signs of stagnation and even decline (Li and Liu, 2021). This trend has been partially attributed to the offset of favorable longevity factors, such as the cardiovascular revolution of the 1970s, by an increasing number of dementia cases. Other factors that are believed to have contributed to this trend are obesity and insufficient healthcare expenditure (Hiam et al., 2018, Olshansky et al., 2005). More recently, Andrasfay and Goldman (2020) reported a 0.87-year reduction in estimated life expectancy at age 65 (LE65) for the US population in 2020 and attributed this decline to the large and unexpected number of COVID-19 deaths (Andrasfay and Goldman, 2020). While contractions in old age life expectancy, including LE60, due to COVID-19 are to be experienced, at least by the countries that have been severely affected by the pandemic, it is not yet clear if this is going to be a long-term situation or rather a short-term fluctuation, such as the one triggered by the 1918 influenza. It is worth pointing out that while Andrasfay and Goldman (2020) attributed a loss in life expectancy of 1.13 years to COVID-19, the 1918 influenza pandemic contributed a 12-year decline to the US average life expectancy (Andrasfay and Goldman, 2020; CDC, 2018). COVID-19 aside, whether stagnation and decline are short-term or long-term trends in LE60, at least for the developed countries, is a matter of debate. Regarding life expectancy in general, there are two prevailing views among researchers and practitioners as to its near-future trend: 1) Life expectancy will continue to rise, yet more slowly than before, with a chance for decline, and 2) life expectancy will continue to rise at the same pace (Vaupel, 2010). We believe that these trends are equally applicable to LE60. We also believe that as economies continue to develop and grow, societies that are now less developed will experience the same longevity trajectory as that of currently developed countries.

Population aging and longevity at older ages remain trends that are likely to continue their trajectory throughout the century, resulting in a concentration of the world population at ages over 60. To paraphrase Coughlin (2017), once you turn grey, you stay that way (Coughlin, 2017). This monumental shift entails not only an increased budgeting for the over 60s but also a potential restructuring of the society, with significant implications for the economic models that are currently implemented. As society ages, individuals may choose to reconsider the traditional frameworks of study, work, retirement, etc. and also the products and services that they consume and desire (Vaupel, 2010; Coughlin, 2017). As the older population grows more numerous, the longevity economy, i.e., the total economic contributions of the 60+ age group, will grow in importance and prominence.

It is within this context that we propose the introduction of LE60 as a prominent health indicator that is related to economic development. LE60 features among the WHO comprehensive list of indicators, but it is not widely used. We believe that the use of LE60 as a prominent health indicator matches the current and future demographic and economic societal circumstances, i.e., population aging and old age longevity as demographic phenomena and the longevity economy as the natural recalibration of economic mechanisms in response to these phenomena. We propose to investigate the feasibility of LE60 as a prominent health indicator by examining its relationship to economic development. The relationship between health indicators and economic development is well established, and we believe that, similar to the one between mortality and economic development, it can be traced back at least to biblical times (Preston, 2015). It is generally assumed that the healthier a population is, the longer it lives and that a healthy population contributes to and is stimulated by economic development. Although the two- way causality between economic development and health status is unequivocal (Bloom and Canning, 2009), the existing literature unilaterally concentrated on the effect of health indicators upon GDP proxied economic growth. Economic development and economic growth are used interchangeably in the scientific literature. For example, Bloom et al. (2004) found a positive effect of life expectancy on GDP (Bloom et al., 2004). However, a more restricted number of studies focused on the effect of economic growth on health status. Preston (1975) concentrated on the relationship between economic growth and life expectancy (Preston, 1975). He concluded that income growth accounted for 10 to 25 percent of the growth in global life expectancy between the 1930s and 1960s. More recently, Erdogan et al. (2013) found a significant negative relationship between IMR and real per capita GDP in a sample of selected OECD (Organisation for Economic Cooperation and Development) countries (Erdogan et al., 2013). Isolating the effect of income on health status from reverse causation and accidental association, Pritchett and Summers (1996) obtained a significant effect of income on IMR and child mortality but not on life expectancy (Pritchett and Summers, 1996). The authors acknowledged the universal impact of income on health (Pritchett and Summers, 1996). Both studies concluded that IMR decreases as countries become richer.

The literature on health indicators and economic development, of which the above studies are only a few examples, predominantly uses GDP as a proxy for economic development. Preston (1975) considered GDP not only as the best indicator for the national standard of living but also as the most appropriate indicator to use in tandem with health status variables (Preston, 1975). In its standard format, GDP includes both private consumption and health expenditure and government expenditure. Health expenditure has been found to have a positive effect on life expectancy and a negative effect on mortality indicators, such as IMR, in both advanced and developing economies. Using a cross-country sample of 175 countries and a time span of 16 years, Jaba et al. (2014) found significant positive effects of health expenditure on life expectancy (Jaba et al., 2014). Restricting the area of interest to Sub-Saharan Africa, but working with an identical time frame, Novignon et al. (2012) observed significant effects of health expenditure in the desired direction for both life expectancy and

IMR (Novignon et al., 2012). While health expenditure, both public and private, has a more direct and obvious effect on health, private consumption that excludes health expenditure influences population health indirectly, through the product and service choices that consumers make in their domestic markets. It is this particular concentration within one economic indicator of various factors that affect health, that underlies the choice of GDP as proxy variable in studies on economic development and health status. In line with previous research on health indicators, we will test the relationship between LE60 and GDP, using a global sample of countries and a time span of 17 years. We will use the IMR data to illustrate the already established relationship between IMR and GDP. We will evaluate the performance of the relationship between LE60 and GDP based on comparisons with the relationship between IMR and GDP.

The global LE60 data indicates that LE60 is higher in developed than in less developed countries and the reverse is valid for IMR. We believe that these imbalances indicate health inequality between countries and we will attempt to investigate such inequalities as part of our analysis. From an ethical point of view, IMR and LE60 are not only statistical measures of population but opportunities for individuals to live beyond a certain age (IMR) and for a number of years once a certain age is reached (LE60). Identifying and mitigating health interstate inequalities not only in infancy, but also in late adulthood, contributes to the creation of a fair and stable global environment, an aim both governmental and extra-governmental organizations should strive for.

2. Data and methods

We have used LE60 and IMR data from the World Health Organisation (WHO) database and GDP data from the World Bank (WB) database. The WHO database lists LE60 country data starting with the year 2000 and ending with the year 2016. The WHO IMR data spans the time period 1950–2019. The WB database lists GDP per capita current and constant, with a wider coverage for the former. Regarding GDP, we opted for GDP per capita current and referred to it simply as GDP. After matching the two databases, we obtained a set that consisted of 172 countries and covered all the WHO geographic regions and all the WB income levels. We opted for the timespan 2000–2016, a time period that witnessed larger improvements in LE60 and less extreme values in IMR. Our research aims to investigate the relationship between LE60 and GDP and not to find a complete explanation of LE60 by socio-economic factors. We intend our study as a preliminary study and wish that, if our hypothesis is validated, this particular set of data is used for more thorough investigation into the nature of the relationship between LE60 and economic development. As we have not found any previous studies on LE60 and GDP, we decided to evaluate the relationship between LE60 and GDP through comparisons and parallels with the relationship between IMR and GDP. We believed that selecting identical time periods would help us in this endeavor.

We conducted several regression analyses, with LE60 as the response variable and GDP as the explanatory variable. Our aim was to identify the most suitable univariate regression model for our proposed prominent health indicator, LE60. Although the literature on IMR and income uses the log-transform of either GDP alone or of both GDP and IMR, there is indication that log-transforming both variables is the more suitable option. Indeed, Schell et al. (2007) conducted partially and fully logged univariate and multivariate regressions between IMR and GDP and found that fully log-transformed regressions provided the best model fit (Schell et al., 2007). Commenting on the relationship between mortality and income, Filmer and Pritchett (1999) recommended the log-transform of both health indicator and income variables, as it allowed for comparisons with other studies via elasticities (Filmer and Pritchett, 1999). We could not find studies to help us infer model suitability for LE60. Our country data were grouped by region (WHO classification) and country income level (WB classification). The six regional groups were Europe, Western Pacific, Americas, Eastern Mediterranean, South-East Asia and Africa. The four country income levels were High Income ($12536 or higher), Upper Middle Income ($4046 to $12535), Lower Middle Income ($1036 to $4045) and Lower Income ($1035 or less). For each category (region and income level), we first run a number of individual regressions as follows:

- Linear Model with logged GDP to control for non-linearity;
- Linear Model with logged GDP and demeaned data to control for non-linearity and fixed effects;
- Linear Model with quadratic logged GDP to allow for non-linearity of the regression line;
- Linear Model with cubed logged GDP to allow for non-linearity of the regression line;
- Variants of the above on logged GDP and logged health indicator.

We obtained the best performing univariate regression based on AIC, BIC and deviance. Finally, for each region and income cluster, we performed pooled, fixed and random effects (country and year, country only, year only) panel data regressions and assessed whether an effects model or a simple model was more appropriate. In an attempt to further understand and explain our results, we also compiled the following measures: a Corruption Perceptions Index (CPI), a Fragile States Index (FSI), an Economic Inequality Index (EII) and a Health Expenditure as percentage of GDP measure (HE%) (Transparency 2021, Fragile States Index 2021, World Bank 2021).

3. Results

3.1. Descriptive statistics

3.1.1. Income groups

As a first step in our analysis, we obtained descriptive statistics for our two dependent variables, IMR and LE60. As seen in Table 1 and Table 2, both variables show a progressive improvement when moving through the four income levels, as evidenced by the mean, median, minimum and maximum values, suggesting a potential relationship between income and the two health measures. It is well known that IMR rates decrease with a country's level of economic development. We can only speculate that the reverse is valid for LE60.

Interestingly, based on skewness and kurtosis, IMR appears to be a more suitable indicator for Low Income Countries (LI) and Lower Middle Income Countries (LMI), while LE60 seems a better match for High Income Countries (HI) and Upper Middle Income Countries (UMI). Having plotted the densities of the two health variables by income group, we observe that there is a possibility that some of the distributions are at least bimodal (see Figure 1 and Figure 2).

Table 1. Descriptive statistics IMR by income.

Income	N	Mean	Standard deviation	Median	Min	Max	Skewness	Kurtosis	SE
High	918	6.54	4.32	4.9	1.7	24.9	1.58	2.44	0.14
Upper Middle	844	20.76	14.06	17.05	2.9	107.4	2.50	9.51	0.48
Lower Middle	798	43.28	21.67	40.85	7	121.2	0.57	−0.19	0.77
Low	434	68.72	22.43	66.35	16.4	139.5	0.36	−0.05	1.08

Table 2. Descriptive statistics LE60 by income.

Income	N	Mean	Standard deviation	Median	Min	Max	Skewness	Kurtosis	SE
High	918	21.82	2.18	22.2	17	26.4	−0.20	−1.07	0.07
Upper Middle	844	19.02	1.94	18.9	15.1	24.1	0.21	−0.68	0.07
Lower Middle	798	17.45	1.92	17.1	12.9	22.8	0.73	0.34	0.07
Low	434	15.86	1.39	15.8	10.7	19.9	−0.19	1.13	0.07

Interestingly, based on skewness and kurtosis, IMR appears to be a more suitable indicator for Low Income Countries (LI) and Lower Middle Income Countries (LMI), while LE60 seems a better match for High Income Countries (HI) and Upper Middle Income Countries (UMI). Having plotted the densities of the two health variables by income group, we observe that there is a possibility that some of the distributions are at least bimodal (see Figure 1 and Figure 2).

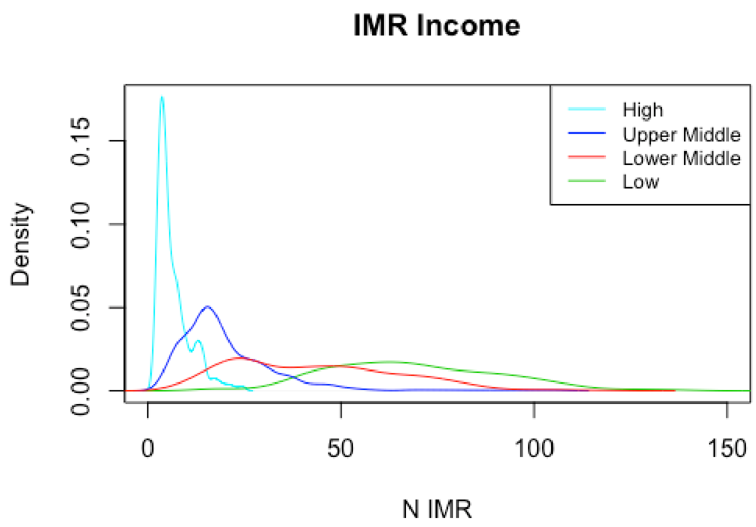

Figure 1. Density plot of IMR by income.

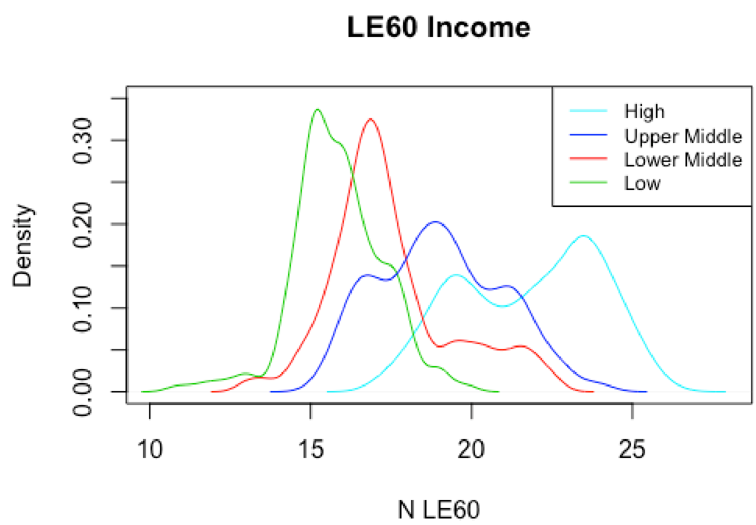

Figure 2. Density plot of LE60 by income.

This observation is confirmed by Hartington's Dip Test, for which we report the D statistics and associated p-values (see Table 3). Exploration of the local maxima gives further insight into the data (see Table 4). As some of our distributions feature up to four local maxima, for brevity, our tables reproduce only the lowest and the highest maxima points and include the total number of maxima per income level.

Table 3. Hartington's Dip Test Values for IMR and LE60.

Income	IMR D	p.value	LE60 D	p.value
High	0.01	0.33	0.03	< 0.001
Upper Middle	0.009	0.92	0.02	0.21
Lower Middle	0.01	0.77	0.02	0.05
Low	0.01	0.99	0.03	0.04

Table 4. Local maxima for IMR and LE60 by income.

Income	IMR (1)*	IMR (2)**	N***	LE60 (1)*	LE60 (2)**	N***
High	3.62	24.24	4	19.52	23.48	2
Upper Middle	15.47	103.15	3	16.77	21.08	3
Lower Middle	23.68	47.50	2	13.41	21.52	4
Low	20.21	54.30	2	12.98	15.20	2

Note: *lowest values, **highest values, ***total number of values.

We notice a wider spread of the maxima values within each income group for IMR than for LE60. This is particularly noticeable for IMR UMI, where the lowest and the highest local maxima can be explained by the values for IMR for Iran in 2012 (15.5) and for Equatorial Guinea in 2000 (107.4). The corresponding GDP values for the two countries are 7927.85 for Iran and 1725.55 for Equatorial Guinea. We suspect that the local maxima indicate clustering within each of the income groups; therefore, the lower the number of maxima is, the more homogenous the income group from the point of view of IMR and LE60. We suggest that income group reporting of the two heath indicators might benefit from further intragroup splitting. The local maxima values suggest a potential relationship between IMR, LE60 and GDP, with LE60 providing a neater differentiation by GDP level. We observe that, based on development status, the distributions of the two health indicators migrate towards the left side (IMR) and the right side (LE60) of the plot, respectively. We interpret this as an indication of the opposing responses that the two variables have to economic development. We can see that the higher the income level is, the higher the proximity to the desired side of the plot.

3.1.2. Region groups

The lowest mean value for IMR is the one for Europe (10.13), while the highest value is the one for Africa (61.23). The values for the other four regions are Americas (18.87), Western Pacific (19.95), Eastern Mediterranean (27.7) and South-East Asia (35.76).

Table 5. Descriptive statistics IMR by region.

Region	N	Mean	Standard deviation	Median	Min	Max	Skewness	Kurtosis	SE
Europe	850	10.13	11.23	5.2	1.7	67.6	2.27	5.05	0.38
W Pacific	340	19.95	15.45	17.9	2.0	79.2	0.94	0.42	0.84
E Med	325	27.70	22.11	18.6	6.3	84.9	1.05	−0.22	1.23
Americas	559	18.87	11.44	16.6	4.1	85.4	2.18	6.91	0.48
Africa	767	61.23	25.06	60.5	11.8	139.5	0.18	−0.28	0.90
SE Asia	170	35.76	18.54	36.3	7.0	84.8	0.16	−0.85	1.42

The gradual progress of the IMR means through the 6 regions invites speculation on the potential link between income levels and IMR within each region. For example, Europe and Africa have the lowest and the highest mean and are also diametrically opposed when it comes to income levels. Indeed, out of the 50 countries that we selected for Europe, 62% are HI countries, while 28% are UMI countries (see Table 6). In contradistinction, out of the 42 countries that qualified for Africa, 49% are LI countries, and 38% are LMI countries (see Table 6). The minimum and maximum for each region further support this potential link. For example, the minimum for Europe (1.7) is the IMR for Iceland, a HI country in 2016, while the maximum (67.6) is the IMR for Tajikistan, a LI country in 2000.

Table 6. Income levels by region.

Income (no. of countries)	Europe (50)	W Pacific (21)	E Med (21)	Americas (33)	Africa (45)	SE Asia (10)
High	0.62	0.29	0.28	0.3	0.04	0
Upper Middle	0.28	0.28	0.24	0.55	0.09	0.3
Lower Middle	0.08	0.43	0.24	0.12	0.38	0.7
Low	0.02	0	0.24	0.03	0.49	0

Table 7. Descriptive statistics LE60 by region.

Region	N	Mean	Standard deviation	Median	Min	Max	Skewness	Kurtosis	SE
Europe	850	20.74	2.60	20.5	15.3	25.9	−0.007	−1.22	0.09
W Pacific	340	19.4	3.14	18.15	14.4	26.4	0.71	−0.89	0.17
E Med	325	18.32	2	18.3	15.2	21.7	−0.01	−0.57	0.07
Americas	559	20.66	1.97	21	10.7	25.7	−0.55	0.68	0.08
Africa	768	16.15	1.56	16	10.9	21.9	0.53	1.54	0.06
SE Asia	170	18.15	1.76	17.7	15.4	22.1	0.46	−1.14	0.13

The highest mean value for LE60 is the one for Europe (20.74), while the lowest is the one for Africa (16.15). The values for the other four regions are Americas (20.66), Western Pacific (19.4), Eastern Mediterranean (18.32) and South-East Asia (18.15). Interestingly, the mean values for LE60 and IMR follow an identical progress through the regions, the ranking of the values for LE60 corresponding to that of the values for IMR. This suggests that the two health measures respond opposingly to variations in income. As an element of performance, we notice that, in comparison with IMR, LE60 displays lower levels of skewness and kurtosis for all regions apart from Africa, indicating that the LE60 data is more symmetric and with lighter tails. Studying the density graphs for the two variables, we observe that at least some of the distributions are bimodal (see Figure 3 and Figure 4).

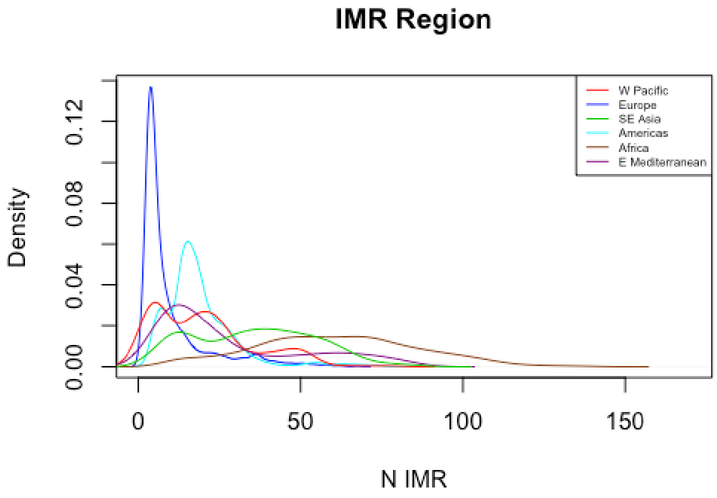

Figure 3. Density plot IMR by region.

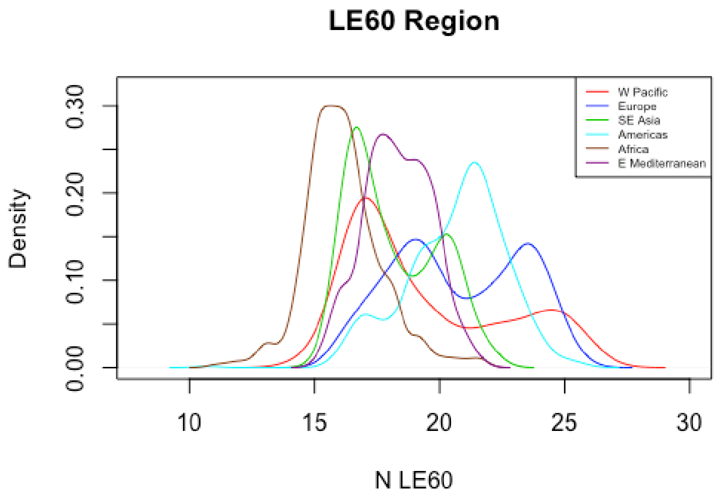

Figure 4. Density plot LE60 by region.

This observation is confirmed by Hartington's Dip Test (see Table 8). Exploration of the local maxima gives further insight into the data (see Table 9).

Table 8. Hartington's Dip Test Values for IMR and LE60.

Region	IMR D	p.value	LE60 D	p.value
Europe	0.01	0.29	0.04	0
W Pacific	0.05	0	0.02	0.11
E Med	0.02	0.82	0.02	0.35
Americas	0.02	0.25	0.02	0.33
Africa	0.02	0.32	0.03	0.02
SE Asia	0.05	0.01	0.04	0.05

Table 9. Local maxima and mean GDP for IMR and LE60 by income.

LE60 Income	IMR	IMR	N	LE60	LE60	N	Mean GDP
Europe	3.84	67.62	8	19.05	23.54	2	21606.68
W Pacific	5.28	73.53	4	17.07	24.48	2	12096.63
E Med	12.30	61.62	2	17.74	18.99	2	11688.35
Americas	7.03	85.36	5	10.71	21.39	3	9244.13
Africa	51.81	66.85	2	13.15	21.45	3	2054.28
SE Asia	12.65	39.11	2	16.68	20.28	2	1993.34

For all regions apart from Africa, LE60 has a lower number of local maxima than IMR. An interesting case is that of Europe, where IMR has 8 local maxima, while LE60 has only 2. The IMR local maxima reflect separate clusters for Central Asia, Central and Eastern Europe and Western Europe. A total of 6 maxima are based on the IMR levels of Central Asia and Azerbaijan, from 67.62 to 36.16. The two other maxima point towards the IMR values of Central and Eastern Europe (21.59) and Western Europe (3.83). The two local maxima for LE60 for Europe indicate separate values for Western Europe (23.54) and Central Asia and Central and Eastern Europe (19.05). Indeed, plotting the two subregions separately, we obtain unimodal distributions (Figure 5). As the case of Europe shows, regional group reporting of the two heath indicators might benefit from further intragroup splitting.

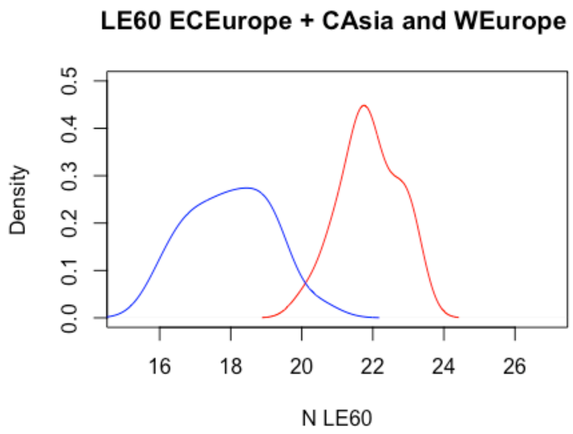

Figure 5. Density plot LE60 Eastern and Central Europe + Central Asia and Western Europe.

When grouped together, the regional mean GDP data, the IMR and the LE60 data reinforce the suggestion of a potential link between the two health variables and income (see Table 9). The density graphs confirm the "mirroring" behavior of the two health indicators, with IMR densities shifting towards the left of the graph and LE60 densities shifting towards the right of the graph. For both indicators, Western Pacific and Europe are the closest densities to the desired graph margins, while Africa is the furthest. Interestingly, Western Pacific and Europe have the highest GDP among the 6 regions, while Africa has the second lowest GDP.

3.2. Regression results

For each income and region subgroup, we have selected the most appropriate regression model, based on the AIC, BIC and deviance values. For brevity, the values of these criteria are not included in the article. All the subgroups benefitted from the univariate regression model that incorporated the log transform of both variables, suggesting an elastic relationship between the two health indicators and economic development, proxied by GDP. All qualifying models provided significant estimates, with higher estimates for IMR than for LE60. The deviance values were higher for IMR than for LE60, indicating a better model fit for the latter variable. We then proceeded to fitting panel regressions to our log-transformed variables.

3.2.1. Income group regressions

Prior to conducting our logged income group regressions, we plotted the variables of interest, color coded by income level (Figure 6). The data is clearly clustered by income level.

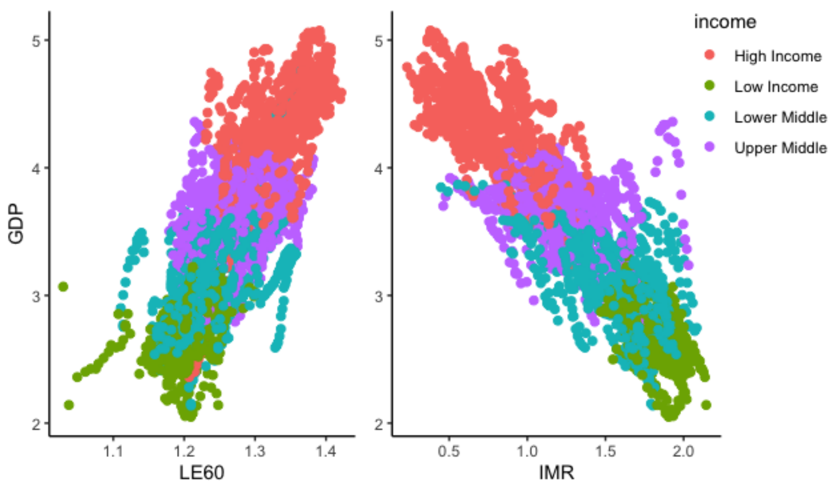

Figure 6. LE60, IMR and GDP by Income level.

3.2.1.1. Log transformed univariate regressions

Table 10. displays the regression coefficients for each of the income groups.

Health indicator	Income level	Intercept values	Estimate values	Intercrpt error	Estimate error	t test (1)	t test (2)	F statistic	p value	Adjusted r squared	RSE
LE60	HI	1.01	0.08	0.01	0.003	78.7	25.87	669.3	< 0.001	0.42	0.04
	UMI	1.12	0.04	0.02	0.005	57.5	8.13	66.09	< 0.001	0.07	0.04
	LMI	1.03	0.06	0.01	0.005	79.68	16.81	282.5	< 0.001	0.26	0.04
	LI	1.06	0.05	0.02	0.006	56.14	7.38	54.42	< 0.001	0.1	0.04
IMR	HI	2.84	−0.48	0.09	0.02	31.85	−23.64	559.03	< 0.001	0.38	0.2
	UMI	2.15	−0.25	0.11	0.03	31.85	−8.1	65.63	< 0.001	0.07	0.25
	LMI	2.98	−0.45	0.08	0.02	38.32	−18.4	338.6	< 0.001	0.29	0.22
	LI	2.68	−0.32	0.07	0.02	39.81	−13	169.1	< 0.001	0.28	0.13

The largest influence of GDP on both variables is displayed by the HI countries, while UMI countries show the smallest influence. T tests classified all coefficients as significant. RSE values indicate a similar level of fit for both variables. Least-squares means comparisons indicated that for

LE60 coefficients, HI > LMI, LI, LMI > UMI, while for IMR coefficients, HI > UMI, LMI, LMI > UMI, LI (see Table 11).

Table 11. Least-squares means comparisons, LE60, IMR and GDP by income.

Health indicator	Contrast	Estimate values	Estimate error	t ratio	p value
LE60	HI-LI	0.02	0.008	2.97	0.016
	HI-UMI	0.03	0.005	5.53	< 0.0001
	LMI-UMI	0.02	0.006	4.003	0.0004
IMR	HI-LI	−0.16	0.05	−3.42	0.003
	HI-UMI	−0.23	0.03	−6.78	< 0.0001
	LI-LMI	0.13	0.05	2.81	0.003
	LMI-UMI	−0.21	0.04	−5.81	< 0.0001

3.2.1.2. Panel effects regressions

We conducted panel pooled, fixed and random effects regressions on a total of 172 countries (countries with complete time data) for the following effects: country and year combined, country and year separate. Our panel random effects regressions indicated minimal or no impact of year and a considerably impaired model when the year effect was combined with the country effect. We therefore selected the country effect models. F tests and Hausman tests singled out the random effects model for all income groups, apart from IMR LI. All coefficients were significant, and the models are reliable. Coefficient values indicated similar changes in LE60/IMR to those suggested by our simple univariate regressions. However, there were noticeable improvements in the R^2 values for all the income groups in our data. Detailed results are presented in Tables 12a and 12b. Significant variances for the random effects, together with their error component share, suggested the presence of unobserved time-invariant heterogeneity for all income groups, apart IMR LI (see Table 13).

Table 12a. Random Effects Regression performance, LE60, IMR and GDP by income.

Health indicator	Income	Intercept values	Estimate values	Intercept error	Estimate error	z test (1)	z test (2)	Chi test	p value	Adjusted r squared
LE60	HI	0.98	0.08	0.011	0.002	87.04	34.16	1166.9	< 0.001	0.55
	UMI	1.11	0.05	0.008	0.001	127.59	26.96	726.72	< 0.001	0.47
	LMI	1.05	0.06	0.008	0.001	127.17	33.35	1111.9	< 0.001	0.58
	LI	1.03	0.06	0.014	0.004	70.07	12.99	168.75	< 0.001	0.3
IMR	HI	2.55	−0.42	0.06	0.01	43.63	−34.9	1218.5	< 0.001	0.57
	UMI	2.5	−0.35	0.05	0.01	49.15	−34.64	1200.06	< 0.001	0.6
	LMI	2.6	−0.35	0.04	0.008	63.03	−40.18	1614.5	< 0.001	0.67

Table 12b. Fixed Effects Regression performance IMR by income.

Health indicator	Income	Estimate values	Estimate error	t test (1)	F test	p value	Adjusted r squared
IMR	LI	−0.4	0.02	−27.17	738.36	< 0.001	0.65

Table 13. Share of country effects.

Health indicator	Income	Idio* var	Ind* var	Idio error	Ind error	Idio share	Ind share
LE60	HI	0.0001	0.001	0.01	0.03	0.09	0.91
	UMI	0.0001		0.01	0.04	0.06	0.94
	LMI	0.0001		0.01	0.05	0.05	0.95
	LI	0.0002		0.02	0.04	0.18	0.82
IMR	HI	0.04	0.05	0.05	0.2	0.07	0.93
	UMI	0.06	0.06	0.06	0.25	0.06	0.94
	LMI	0.05	0.05	0.05	0.22	0.05	0.95
	LI	0.01	0.01	0.05	0.1	0.18	0.82

Note: *Idiosyncratic error term and Individual specific effect.

3.2.2. Region group regressions

Prior to conducting our logged region group regressions, we plotted the variables of interest, color coded by region (Figure 7). Depending on the region, there is less or more cohesion among the data but mostly no clear demarcation, as in the case of the income groups.

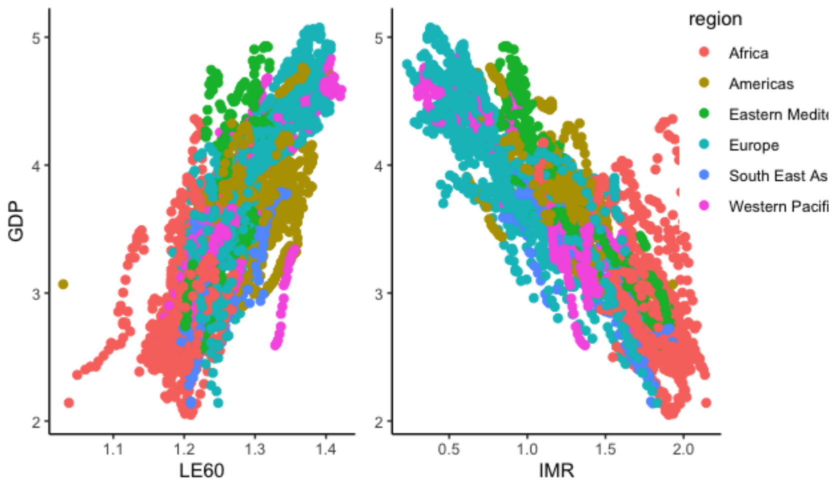

Figure 7. LE60, IMR and GDP by region.

3.2.2.1. Log transformed univariate regressions

Table 14 displays the regression coefficients corresponding to the region subgroups.

The largest influence of GDP on both variables is displayed by Western Pacific, Europe and South East Asia. The smallest influence of GDP is registered by Africa for IMR and by Eastern Mediterranean for LE60. T tests classified all coefficients as significant. RSE values indicate a similar level of fit for both variables. Pairwise comparisons identified a number of relationships among the LE60 coefficients: Africa < West Pacific, Europe, South East Asia, Americas < West Pacific, Europe, South East Asia, Eastern Mediterranean < West Pacific, Europe, South East Asia, South East Asia < Western Pacific. The following relationships were identified among the IMR coefficients: Africa <

Western Pacific, South East Asia, Europe, Eastern Mediterranean, Americas, Americas < Western Pacific, South East Asia, Europe, Eastern Mediterranean, Eastern Mediterranean < WP, Europe < Western Pacific. Detailed results are not included for brevity.

Table 14. Regression coefficients LE60, IMR and GDP by region.

Health indicator	Region	Intercept	Estimate	Intercept error	Estimate error	t test (1)	t test (2)	F test	p value	Adjusted r squared	RSE
LE60	Europe	0.99	0.08	0.006	0.002	157.86	52.69	2776	< 0.001	0.77	0.02
	W Pacific	0.96	0.09	0.01	0.003	76.15	26.32	692.9	< 0.001	0.67	0.04
	E Med	1.14	0.03	0.008	0.002	142.38	15.05	226.6	< 0.001	0.41	0.02
	Americas	1.16	0.04	0.02	0.004	75.12	10.03	100.6	< 0.001	0.15	0.04
	Africa	1.08	0.04	0.008	0.002	132.12	15.98	255.23	< 0.001	0.25	0.04
	SE Asia	1.05	0.07	0.02	0.005	60.05	12.16	147.82	< 0.001	0.47	0.03
IMR	Europe	2.96	−0.52	0.04	0.01	70.53	51.3	2631	< 0.001	0.76	0.18
	W Pacific	3.37	−0.6	0.05	0.01	61.65	−41.41	1715	< 0.001	0.84	0.17
	E Med	3.11	−0.49	0.05	0.01	67.75	−39.77	1581.3	< 0.001	0.83	0.14
	Americas	2.88	−0.42	0.06	0.02	43.54	24.87	618.6	< 0.001	0.52	0.17
	Africa	2.59	−0.28	0.01	0.01	67.22	−22.41	502.3	< 0.001	0.4	0.17
	SE Asia	3.17	−0.54	0.09	0.03	33.41	−17.98	323.11	< 0.001	0.66	0.16

3.2.2.2. Panel fixed and random effects regressions

Similar to our income panel regressions, the country effects were deemed the most appropriate effects for our regional data. All coefficients were significant, and the models were reliable. F tests and Hausman tests singled out the fixed effects model for LE60 Europe and Africa and for IMR Europe, Western Pacific and Eastern Mediterranean. Therefore, for these regions, the country specific effect is correlated with the GDP variable. For the remaining regions, the country effect is uncorrelated with the GDP variable and is included in the error term.

Significant variances for the random effects, together with their error component share, suggest the presence of unobserved time-invariant heterogeneity (see Table 17). Detailed results are presented in Tables 15 and 16

Table 15. Random Effects Regression performance LE60, IMR and GDP by region.

Health indicator	Region	Intercept	Estimate	Intercept error	Estimate error	z test (1)	z test (2)	Chi test	p value	Adjusted r squared
LE60	W Pacific	1.04	0.07	0.01	0.002	81.15	25.95	673.78	< 0.001	0.66
	E Med	1.1	0.04	0.01	0.003	73.71	11.85	140.44	< 0.001	0.60
	Americas	1.09	0.06	0.02	0.003	70.9	15.84	250.97	< 0.001	0.31
	SE Asia	1.1	0.05	0.01	0.005	74.31	14.56	212.19	< 0.001	0.55
IMR	Americas	2.4	−0.32	0.05	0.01	46.25	−28.09	789.35	< 0.001	0.59
	Africa	2.7	−0.32	0.04	0.009	70.19	−32.36	1047.7	< 0.001	0.58
	SE Asia	2.76	−0.41	0.08	0.02	35.54	−22.73	516.87	< 0.001	0.75

Table 16. Fixed Effects Regression performance LE60, IMR and GDP by region.

Health indicator	Region	Estimate	Estimate error	t test	F test	p value	Adjusted r squared
LE60	Europe	0.05	0.002	26.15	683.83	< 0.001	0.43
	Africa	0.07	0.002	32.3	1043.83	< 0.001	0.58
IMR	Europe	−0.43	0.01	−41.39	1712.76	< 0.001	0.66
	W Pacific	−0.3	0.01	−21.001	441.04	< 0.001	0.55
	E Med	−0.38	0.02	−18.02	324.6	< 0.001	0.52

Table 17. Share of country effects.

Health indicator	Income	Idio* var	Ind* var	Idio error	Ind error	Idio share	Ind share
LE60	W Pacific	0.0001	0.002	0.009	0.04	0.05	0.95
	E Med	0.0001	0.005	0.01	0.02	0.19	0.81
	Americas	0.0002	0.001	0.01	0.04	0.12	0.88
	SE Asia	0.0001	0.009	0.01	0.03	0.1	0.9
IMR	Americas	0.002	0.03	0.04	0.17	0.07	0.93
	Africa	0.002	0.02	0.05	0.17	0.09	0.91
	SE Asia	0.002	0.03	0.05	0.17	0.09	0.91

Note: *Idiosyncratic error term and Individual specific effect.

4. Discussion

The main objective of this paper was to investigate the influence of economic development on a significant and potentially overlooked health indicator, LE60. We advocated the use of LE60 as a prominent health indicator based on the current structure of the world population, i.e., an aging population and the recent increase in life expectancy at old age. We hypothesized that proven influence of economic development on LE60 would help classify LE60 as a prominent health indicator, as there is a well-researched relationship between health indicators and economic development. As we could not find any studies on the relationship between LE60 and economic development, we decided to investigate the relationship between LE60 and economic development side by side with the one between IMR and economic development, an already established relationship. We hoped that the comparison between the two would add more weight to our findings. In line with the previous literature on health indicators and economic development, we used GDP per capita as proxy for economic development. Our two response variables were LE60, the number of years left to live at age 60, and IMR, the number of deaths per 1000 newborns. Our data spanned a total of 172 countries and 17 years (2000 to 2016). As secondary objective, we attempted to investigate the potential inequality inherent in the way clusters of countries benefit from the positive impact of economic growth on the two health indicators. To this purpose, we have looked at the influence of GDP on IMR and LE60 within four income and six regional country groups. We believed that working within income and regional groups brought additional and desirable information about the behavior of the two health indicators in response to GDP. Indeed, at least as far as the impact of economic development on IMR is concerned, there seems to be a scarcity of studies that provide analysis at national, regional and income level. In a meta-analysis on the impact of economic development on IMR and U5M (under 5 mortality), O'Hare et al. (2013) identified only 24 studies that used comparisons at national, regional and income level, all covering the 1950–2000 interval and none covering IMR and GDP for Africa (O'Hare et al., 2013).

The third objective of our paper was to identify the most efficient univariate linear regression model for LE60 and to establish whether univariate linear regression or panel effects regressions were more suitable for the relationships under investigation. A fourth aim was to venture potential explanations for the difference in coefficients between incomes and regions. To address these objectives, we first run univariate linear, demeaned, quadratic, cubic and fixed effects regressions on partially (explanatory variable) log-transformed data and fully log-transformed data (both response and explanatory variables). All of the regression analyses that we conducted pointed towards a significant effect of GDP on both LE60 and IMR. However, based on AIC, BIC and deviance, log-transforming both variables within our simple equations provided the best results. 30% (7 studies) of the 24 studies identified by O'Hare et al. (2013) were conducted with partially log-transformed data, while the majority of the studies used log-transforms for both income and health variables (O'Hare et al., 2013). The authors chose to exclude the former group from their meta-analysis. Our results endorse their decision. We then conducted fixed and random effects panel regressions, that were proven by F and Hausman tests to be more suitable for our data than the initial standard regressions.

All our coefficients featured the expected signs, positive for LE60 and negative for IMR, and were statistically significant, with IMR coefficients indicating a higher impact of GDP on IMR than that of GDP on LE60. We believe that, biology aside, this result endorses the validity of LE60 as a health indicator that is linked to economic development. The policies and infrastructure that address IMR issues have been studied and are well known. Furthermore, the technology behind reductions in IMR is available and affordable: for example, ante and post-natal care or campaigns of awareness and education targeting the mothers to be. In contradistinction, LE60 is highly dependent on the advancement and implementation of geriatric care and of social environments that favor the well-being of the older population. These influencers are more costly and have only recently been singled out for funding and development, albeit mostly in developed countries. Taking into consideration the associated costs and the biological boundaries in which the two health indicators activate, it is plausible to assert that 1% increase in GDP will have a bigger impact on IMR than on LE60. It is well known, for example, that mortality improvements at older ages are not the result of radical genetic changes but rather a rescheduling of mortality as it is being pushed forward towards the upper end of our "survival frontier" (Vaupel et al., 2021). Where exactly is that frontier located on our lifespan continuum is a matter of debate among specialists, with some cautiously placing it at 85, while others venturing as high as 115 (Vaupel et al., 2021).

All our income group regressions provided significant coefficients and generally low R^2 values, pointing towards the suitability of a more complex model for a comprehensive socioeconomic explanation of IMR and LE60. Indeed, the studies included in the meta-analysis of O'Hare et al. (2013) featured up to 7 explanatory variables and displayed very high R^2 values (O'Hare et al., 2013). We restricted ourselves to a simple univariate regression, as our aim was not to find the best explanatory model for the selected health variables but to identify a potential effect of economic development on LE60 and verify our finding through the proven effect of economic development on IMR.

Surprisingly, our UMI regression coefficients were lower than those for LMI for both LE60 and IMR. We have not been able to identify a study run on IMR and UMI for comparison. For both LE60 and IMR, the HI coefficients were higher than all other income groups' coefficients. This is an expected finding that confirms our belief that the more developed a country is, the more suitable LE60 becomes as a health indicator.

To evaluate our IMR coefficients, we visually inspected the coefficient values for IMR HI, UMI and LMI featured in the meta-analysis conducted by O'Hare et al. (2013) (see Table 18), and, considering the exhaustive nature of the regressions included in the meta-analysis, we concluded that our coefficients were of plausible values. As novelty, we obtained a coefficient for IMR LI. We were not able to identify a study for comparison.

The LE60 coefficients for the income groups suggested that the influence of GDP on LE60 increased with income level. Similar to IMR, HI countries displayed the highest coefficient values and were followed by LMI countries. We were not able to find any studies on GDP and LE60 for comparison.

We obtained an unusual result, the lowest coefficient values for both LE60 and IMR were associated with UMI countries. We venture a potential explanation for our finding. We believe that this result can be partly explained by the level of corruption associated with UMI countries. To substantiate our claim, we computed the mean values for each of the four income levels, based on values retrieved from the Corruption Perception Index (CPI) for the year 2020 (Table 19).

Table 18. Estimates for the effect of GDP on IMR from O'Hare et al. (2013).

		Estimates
Income groups	HI, MI and LI	−1.05 [−1.64 to −0.46)]
	MI and LI	−0.85 [1.43 to −0.26)]
	LI only	No estimates
Regions	All regions	−0.92 [−1.34 to −0.50]
	Latin America and The Caribbean	−1.17 [−1.68 to −0.66]
	Sub-Saharan Africa	No estimates
All estimates		−0.95 [−1.34 to −0.57]

We calculated CPI values of 64.26 for HI, 38.82 for UMI and 34.11 for LMI, with the UMI value significantly yet not considerably higher than the LMI value, as evidenced by a two-sample t-test (1.66, p value = 0.02). The income level for UMI is considerably higher than that for LMI (GNI, Gross National Income per capita of $4,046 to $12,535 in comparison to $1,036 to $4,045). It follows that UMI countries have an income level significantly higher than that of LMI countries yet comparable levels of corruption. It is possible that corruption levels in the UMI countries do not allow for the benefits of income to trickle down fully. Our hypothesis is motivated by Sommer (2020), who obtained significant interactions between health expenditure, corruption and IMR in a sample of LI and MI countries and therefore highlighted the importance of lowering corruption in order to heighten the impact of health expenditure on IMR (Sommer, 2020). We also noticed that the HI countries had the highest CPI score. Based on our analysis, the same group of countries had the highest proportion of variance in the two health variables explained by variance in GDP alone and benefitted from the highest coefficients among all income groups. We can speculate that the low levels of corruption that are characteristic to HI countries facilitate a fairer distribution of the economic resources that result from economic development.

All our region-based regressions provided significant coefficients and reasonably high R^2 values, testifying for the suitability of our simple model. In order to potentially explain the coefficient values, including their hierarchy, particularly those for South-East Asia, Eastern Mediterranean and the Americas, we calculated the group measures CPI, FSI, EII, HE% and GDP for our six world regions for the year 2020 (Table 19). Economic inequality and health expenditure are two variables that have been proven to be associated with IMR. Working with panel data for 177 countries, Owusu et al. (2021) found a negative effect of health expenditure on IMR, advancing therefore the hypothesis of a universal effect of health expenditure on IMR (Owusu et al., 2021). The Gini Index was positively associated with increased infant mortality, after adjusting for GDP, in a substantial sample of LI and MI countries in a study conducted by Ward and Viner (2017) (Ward and Viner, 2017). We have not identified a study investigating the relationship between FSI, economic development and IMR. Our calculations show that FSI follows a similar pattern with CPI and EII, indicating a potential relationship between FSI, income and health indicators. Perhaps future research will be carried out in this area.

Table 19. Mean CPI, FSI, EII, HE% and GDP corresponding to the year 2020.

		CPI	FI	EI	HE%	Mean GDP
Income	HI	64.26	37.86	2.98	NA	NA
	UMI	38.32	65.42	5.03	NA	NA
	LMI	34.11	75.11	6.17	NA	NA
	LI	27.34	94.87	7.87	NA	NA
Region	Europe	54.9 (1)	45.99 (1)	3.02 (1)	7.42 (1)	21606.68(1)
	W Pacific	51.73 (2)	54.32 (2)	4.8 (2)	5.59 (3)	12096.63(2)
	E Med	33.95 (5)	80.47 (5)	5.75 (5)	4.73 (5)	11688.35(3)
	Americas	42.65 (3)	60.6 (3)	5.4 (3)	6.79 (2)	9244.13 (4)
	Africa	33.91 (6)	84.4 (6)	7.4 (6)	5.54 (4)	2054.27(5)
	SE Asia	38.9 (4)	77.64 (4)	5.48 (4)	4.05 (6)	1993.34(6)

Table 20. Interaction results between level of income and GDP within region.

IMR	Region	Reference factor	Interaction	Coefficient interaction	p value	GDP
	Europe	HI	LMI*GDP	−0.15	0.02	−0.38
	W Pacific	HI	NA	NA	NA	
	E Med	HI	LMI*GDP	−0.59	< 0.001	−0.2
	Americas	HI	LMI*GDP	−0.23	0.04	−0.36
	Africa	LI	NA	NA	NA	
	SE Asia	LMI	NA	NA	NA	
LE60	Europe	HI	LI*GDP	−0.09	< 0.001	0.09
	Europe	HI	LMI*GDP	−0.07	< 0.001	
	Europe	HI	UMI*GDP	−0.06	< 0.001	
	W Pacific	HI	LMI*GDP	−0.1	< 0.001	0.12
	W Pacific	HI	UMI*GDP	−0.07	0.001	
	E Med	HI	LMI*GDP	0.04	0.001	0.02
	Americas	HI	NA	NA	NA	
	Africa	LI	NA	NA	NA	
	SE Asia	LMI	UMI*GDP	0.04	0.02	0.08

We suggest that a complex interplay between corruption, fragility, inequality, health expenditure and total GDP mediates the relationship between the two health indicators and economic development. For example, Eastern Mediterranean coefficient values for LE60 are smaller than those for Western

Pacific, Europe and South East Asia and no different from those of Africa and the Americas, while those for IMR are higher than those of Africa and the Americas, smaller than that of Western Pacific and no different from those of Europe and South East Asia. Based on our measures, Eastern Mediterranean scores third in terms of GPD but second last, before South-East Asia, in terms of HE% and is second highest in corruption, fragility and inequality. However, none of these measures were useful in explaining the rankings of South-East Asia—larger than Africa and the Americas and no different from the other three regions for IMR and second only to Western Pacific for LE60. We decided to run an additional set of regressions, looking at the potential interaction between income level and GDP within each region. All regressions featured significant and of appropriate sign GDP coefficients. The significant interactions are reported in Table 20.

As far as the relationship between IMR and GDP is concerned, income level is a moderator variable only for Europe, Eastern Mediterranean and the Americas. For all three regions, the impact of GDP on IMR is higher for LMI than for HI levels. The relationship between LE60 and GDP is moderated by income level for Europe, Western Pacific, South-East Asia and Eastern Mediterranean. While for the first three regions the moderator effect of income level is significant for all income levels, Eastern Mediterranean displays significant moderator effects for all income levels apart UMI. While for the first three regions, the impact of GDP on LE60 increases with income level, the opposite is true for Eastern Mediterranean. Interestingly, Eastern Mediterranean scored second highest on all corruption measures and second lowest on HE%, with these scores potentially explaining the unusual results for this region. The highest scores on corruption were obtained by Africa, where no significant interactions and effects were obtained. Overall, the results of the regional regressions, supplemented by our additional measures, endorse the effect of income on both IMR and LE60 and testify for the intricacies of such relationship. Moreover, they point towards regional and even within- income group inequalities regarding the impact of income (GDP) on health indicators (IMR and LE60).

Our study did not benefit from the inclusion of lagged-GDP regressions in our analysis, this being a potential limitation. Performing a longitudinal analysis on 99 countries, Farahani et al. (2009) concluded that the impact of lagged GDP on IMR was insignificant (Farahani et al., 2009). Baird et al. (2007) found a large negative association between per capita GDP and infant mortality in developing countries; however, lagged-GDP was not significant (Baird et al., 2007). They concluded that economic conditions shortly before and shortly after were most likely to influence IMR and that IMR does not depend on lagged-GDP. We did not identify any studies on the impact of lagged-GDP on LE60. We suspect that, given the particularities of LE60, i.e., its dependence on long-term and costly investments, lagged-GDP might have an influence on LE60. We recognize the importance of another health indicator, Healthy Life Expectancy at 60 (HALE60) and we believe this to be an important counterpart of LE60. We therefore welcome any future studies that will study the relationship between HALE60 and economic development.

5. Conclusions

Our statistical analyses indicate that both LE60 and IMR are influenced by economic development (proxied by GDP). At regional level, the relationship between the two health indicators and economic development is moderated by level of income. Moreover, the higher the level of income is, the more beneficial the relationship becomes. Indeed, we may conclude in the words of Pritchett and Summers (1996) that wealthier is healthier but with a caveat: Wealthier is healthier only when the environment is conducive to fair investment and dissemination of wealth into the population.

Based on our analysis, we believe that LE60 is less sensitive to income than IMR, i.e. that higher levels of income are required for noticeable improvements in LE60 than in IMR, and that, as health indicator and even as social barometer, LE60 is more relevant than IMR for countries with a high level of economic development, HI countries. Indeed, as our data shows, the highest LE60 values are registered among HI countries, while the lowest LE60 values are registered among less economically developed countries, LI and even LMI countries. Similar to IMR, LE60 points towards health inequality both at group (income and region) and intra-group level.

IMR remains to this date a matter of concern for less developed countries and it is among these countries that the largest improvements in IMR have been registered since 2000, the start year for our data. In contradistinction, HI countries have a considerable aging population, are able to allocate the necessary funds to invest in research, technology and infrastructure addressing this particular demographic group and have already developed an economy subsector catering for the health and leisure needs of the elderly. The very recent historical approval of Biogen’s ground-breaking Alzheimer drug by FDA, the first FDA approved drug targeting the mental decline associated with the disease, gives hope not only for a healthier and happier old age, but potentially for a longer old age. It may not be possible to reduce mortality after age 100, but it may well be possible to get there quicker. With such possibility in sight, the world should keep an eye on LE60.

Availability of supporting data:

For LE60 and IMR: World Health Organisation data accessed in R via package whoapi (requires older versions of R): https://cran.r-project.org/web/packages/whoapi/index.html. LE60 was extracted with the following code: LE60<-get_data(“WHOSIS_000001”). IMR was extracted with the following code: IMR<-get_data(“MDG_0000000001”). For GDP: World Bank data accessed in R via package wbstats: https://cran.r-project.org/web/packages/wbstats/index.html. GDP was extracted with the following code: GDP <- wb_data(indicator = c(“NY.GDP.PCAP.KD”, “NY.GDP.PCAP.CD”)).

Conflict of interest

The author declares no conflicts of interest in this paper.

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