Comparative Analysis of Mortality Sources in Latin America

The health status of a country or region can be assessed using mortality and morbidity indicators. Of the two, mortality is the most widely used in demographic and epidemiological research, due to its greater availability and standardization in official statistics. One of the most relevant indicators in this area is life expectancy at birth (VLE), widely recognized as a synthetic summary of the population's level of health and, at the same time, as a reflection of economic and social development, since it is part of the Human Development Index (HDI).

The evolution of mortality over time has been addressed by different demographic and epidemiological theories. From a historical perspective, the theory of the first demographic transition (Notestein, 1945) describes a structural change from high mortality rates to lower levels, associated with socioeconomic transformations. In turn, epidemiological transition theory complements this view by focusing on changes in the structure of causes of death: from a predominance of communicable diseases in the early stages to an increase in noncommunicable diseases in more developed contexts. In the case of Latin America, Frenk et al. (1991a) reformulate this theory to account for specific patterns in the region, characterized by high heterogeneity between countries and by the coexistence of multiple groups of causes of death.

To study these transition processes and assess the health situation at regional level, various international sources of mortality data are used. These include the World Health Organization (WHO), the Latin American Mortality Database (LAMBdA) project, the World Population Prospects (WPP) database and the Global Burden of Disease (GBD). These sources vary in terms of the way the data are processed: while the WHO limits itself to compiling the national registries without adjusting, the other projects apply their own methodologies to correct problems of under-reporting, coding or quality in the original data, seeking to offer more comparable estimates between countries and over time.

This diversity of sources and adjustment methods can lead to inconsistencies in mortality analysis, especially if differences between outcomes introduce biases into theories, research conclusions, or public policymaking.

This study focuses on evaluating changes in mortality in different Latin American countries based on the analysis of life expectancy at birth, in the context of the multiplicity of data sources. On the one hand, it seeks to determine whether the theories of demographic and epidemiological transitions are still applicable in the new millennium. On the other hand, to evaluate the robustness of the conclusions about changes in mortality and their determinants by analyzing the consistency between different data sources. It is assumed that, in recent decades, lower-income countries have experienced greater relative improvements in VNE than higher-income countries, although significant inequalities in survival persist (Castro, M. C. et al, 2025). It is also hypothesized that in lower-income countries the completeness of vital records is more limited, which could introduce relevant biases in the results, depending on the data source considered.

Background

The study of mortality in Latin America has been the subject of numerous studies that, from different perspectives, have addressed its evolution, determinants and inequalities. Overall, the region has experienced a sustained reduction in mortality, although with significant differences between countries, age groups, and territories.

One of the most significant advances is observed in infant mortality, which has decreased considerably since the 1990s. However, substantial gaps persist between countries, as shown by Orbea López (2019), who points out that while Haiti and Bolivia have rates above 30 per thousand, countries such as Cuba, Chile, and Uruguay have managed to reduce them to less than 10 per thousand. This disparity is mainly associated with structural factors such as maternal educational level, ethnicity and territorial inequality, especially between urban and rural areas.

At older ages, the panorama is more heterogeneous. Adult mortality remains high in many countries, due to the persistence of chronic diseases and external causes such as violence. Calazans et al. (2020) identify an intermediate stage of the epidemiological transition in the region, where although signs of convergence between countries in adult mortality levels are observed, these advances are limited and fragile.

From a more structural approach, several studies have explored the relationship between mortality and inequality. Solís and García-Guerrero (2019) examined the distribution of years of life in Latin America and found that inequality in the age of death decreases as life expectancy increases, although not homogeneously. Social inclusion and institutional quality appear as key factors to explain these differences between countries in the region.

The relationship between life expectancy and income has also been widely documented. Temporelli and Viego (2011) showed that income has a positive effect on longevity, and that educational level, particularly literacy, is a central determinant. Their results underscore how inequality in these variables directly contributes to inequality in life expectancy levels.

In a broader and long-term perspective, Castro et al. (2025) analyzed the evolution of mortality in low- and middle-income countries between 1950 and 2019. Their findings reinforce the idea of a global convergence in life expectancy, albeit with faster progress in lower-income countries. The observed pattern indicates that the reduction in mortality occurs first in young and adult ages and then advances to older ages. Despite this trend, significant differences persist between countries and regions, determined by structural conditions and unequal access to health services.

Objectives

To analyze the changes in mortality in the different Latin American countries for the period 1950-2019, to contrast the observed changes with the prevailing transition theories and to evaluate the influence of the data source on the interpretation of results.

Specific objectives:

1 - To analyze the evolution of life expectancy at birth in Latin America, in terms of value and exchange rate, at the regional and country levels.

2 - To analyze whether there are groups of countries with similar behaviors in the evolution of the LEB, and to verify the behavior over time of these groups of countries, in contrast to theories of changes in mortality.

3 - To assess whether analyses of changes in mortality may be biased using one source or another.

Background

When a historical analysis of mortality has been carried out, a quantitative and qualitative transformation has been observed. These changes are presented as a downward trend in death and a change in the weight of the different causes of death, from communicable to non-communicable diseases. The demographic theories that explain changes in mortality begin with the first demographic transition (PTD) (Thompson, 1929), which explains the evolution of populations from high mortality and fertility rates to a status of low mortality and fertility.

In line with this fall in mortality and in an attempt to explain this decline, observations made in European societies, in particular, the change in the weight of communicable and non-communicable diseases in mortality led Omran (1971) to propose the existence of "the epidemiological transition". This transition focuses on the change in mortality patterns and their determinants, as well as the demographic and social consequences that this generates. Omran explains the decline in mortality by three factors. Ecobiological factors are associated with an interaction between pathogens, environmental hostility and host resistance. Socioeconomic, political, and social determinants include people's behavior and habits in terms of health care, hygiene, and nutrition. Finally, there are the technological and medical determinants that include all the scientific advances in combatting diseases.

The author proposes that:

> During the transition, there is a long-term shift in mortality and disease patterns, whereby infection pandemics are gradually displaced by degenerative and human-caused diseases, as the main form of morbidity and the leading cause of death. (Omran, 1971)

In this way, the author proposes the following three stages of epidemiological transition:

- "The age of pestilence and famine": at this stage mortality is high, with a higher prevalence of communicable diseases and famines. This prevents a sustained growth of the population, which at this stage has a life expectancy that is between 20 and 40 years.
- "The era of receding pandemics": It is an intermediate stage, in which mortality begins to gradually decrease as pandemics become less frequent. Life expectancy at this stage reaches up to 50 years.
- "The age of degenerative and human-caused diseases": It is a stage where mortality continues to decrease to finish stabilizing at low levels, with a higher prevalence of mortality from non-communicable diseases.

The formulation of this theory was made based on the observations on mortality made in Europe, which Omran called classical transition, as opposed to the accelerated transition, observed in countries such as Japan, or late transitions, such as those that occurred in Latin America.

In the years following the publication of Omran's original theory, two types of criticisms were formulated: those that propose extensions to the model and those that imply a reformulation of the model.

Within the extensions to the model, Olshansky (1986) proposes the need to add a fourth stage of "late degenerative diseases", to account for the changes observed in high-income countries from the 1970s, and which were not contemplated in Omran's original version. These changes are based on an even greater postponement of adult mortality at advanced ages, because of health improvements, and the reduction of cardiovascular mortality. Subsequently, the author proposes a fifth stage where a re-emergence of infectious diseases occurs (Olshansky, 1998).

On the other hand, thirty years after proposing the original theory, Omran (1998) makes a review in which he proposes two potential new stages: a fourth stage that involves the cardiovascular revolution, and a fifth theoretical stage called "Age of expected quality of life, with paradoxical longevity and persistence of inequalities". In this fifth stage, the author speculates on a quality-of-life expectancy, where a life expectancy of 90 or more years is reached. In turn, Omran suggests that this level of health may not be reached by all subpopulations, due to inequalities in access to health.

In this new model, Omran classifies the different countries of Latin America according to the following table:

Table 1: Classification of countries, according to the Omran (1998) models

Classification	Countries
Semi west	Argentina and Uruguay
Non-Westerners:	
- Fast	Chile, Costa Rica, Cuba, Puerto Rico
- Intermediate	Brazil, Colombia, Mexico, Panama, Venezuela
- Low Intermediate	Ecuador, Dominican Republic, Paraguay, Peru
- Slow	Bolivia, El Salvador, Guatemala, Haiti, Honduras, Nicaragua

However, a critique by Mackenbach (1994) points out that it is impossible to determine whether individual countries have completed the transition due to the absence of a definition of the end of the transition. In turn, it is pointed out that the beginning of the transition should be linked to the retreat of pandemics, since the stage of "The age of pestilence and hunger" will refer to the appearance of the human species.

In a broader paradigm of transition, the theory of "health transition" (HCT) is proposed, which seeks to explain not only the change in the pattern of morbidity and mortality and mortality, as in the case of the epidemiological transition, but also the social and behavioral transformations of the population that allow these changes (Cadwell, 1990) (Frenk et al., 1991a). In this theory, it is proposed that ET is only one dimension, together with the "transition of health care" and "transition in risks". The second refers to the social, economic, and technological transformations that condition health care, and the third to the shift towards risks generated by these changes.

The transition in health care is then associated with social, economic and technological changes that transform the way health care is provided and that enable changes in the response to different types of diseases. The transition in risks poses how the "old risks", typical of the pre-industrial era, are displaced by new risks. These new risks (e.g., pollution, traffic accidents, those derived from tobacco and alcohol consumption, or unhealthy eating habits) favor an increase in mortality (Smith, K. 1990) and (Kuri-Morales, P.A., 2011). In this context, Vallin and Meslé (2004) propose incorporating the epidemiological transition as a first stage of the health transition.

Finally, Vallin and Meslé (2004) state that changes in mortality are not uniform but are carried out through a sequence of divergences and convergences in mortality. In this sequence, technological improvements that generate an improvement in mortality are not accessible simultaneously by all countries. When the advance occurs, the global north benefits first, generating a divergence with the global south. When this progress is also accessible in the global south, a convergence in mortality occurs

As mentioned above, the original model of the epidemiological transition is based on what has been observed in European societies, so it is doubtful whether this experience can be fully transferred to the rest of the world. Considering the changes in mortality observed in Latin America, Frenk, J. et al. (1991b) suggest that the reality in the region is considerably different from what is observed in Eurocentric models. The authors state that in Latin America there are great differences in the epidemiological profile between different countries, classifying them into three large groups. The first of these represents countries with a profile similar to those in Europe, which present changes in mortality consistent with the so-called "late" development proposed by Omran. A second group is made up of countries that are just beginning the transition, where infant mortality is still high and mortality is largely dominated by infectious diseases and malnutrition. On the other hand, and as a major discrepancy with Omran (1971), the authors propose the existence of a third group of countries that follow a different path, called the "polarized-prolonged model", which has four characteristics:

- Overlapping stages: The theory of epidemiological transition assumes a sequence of stages, well defined and mutually exclusive. However, this does not occur in many Latin American countries, where the stages of prevalence of communicable and non-communicable diseases overlap.
- Counter transition: The resurgence and emergence of infectious diseases calls into question the strict unidirectionality of Omran's original theory. Therefore, the possibility of a return to a non-marginal prevalence of communicable diseases is proposed.
- Prolonged transition: The two previous characteristics lead to the conclusion that there is no end to the epidemiological transition process and admits the possibility of stagnation in its development, where the prevalence of communicable causes is not marginal compared to non-communicable causes for an extended period.
- Epidemiological polarization: This characteristic explains why the previous three do not affect the different social groups and regions within the same country equally, but rather exacerbate the differences already present in terms of health. Frenk et al. suggest that inequalities in morbidity and mortality are mainly articulated by the urban-rural opposition. Thus, it is proposed that rural populations have a morbidity and mortality regime characterized by a high prevalence of communicable diseases.

It is possible, then, that this polarization is partly responsible for the occurrence of a superposition of stages. This could imply that subpopulations of the same country go through different stages of the epidemiological transition.

Table 2: Classification of Latin American countries according to Frenk (1991)

Model	Countries
Late model (classic Omran model)	Cuba, Costa Rica, Chile
Polarized-Extended	Rest of Latin America
Initial stage (classic Omran model)	Bolivia, Haiti, Peru

Complementing what Frenk proposed regarding the polarization of mortality, García J, (2020), points out that the urbanization process coincides with periods of decrease in general mortality and in particular, mortality from infectious causes. The author cites as an example that Uruguay and Argentina, pioneers in reducing mortality, were the countries with the greatest urbanization at that historical moment. This decrease is observed in capital cities. In addition, it is concluded in this study that the least urbanized countries maintain the highest infant mortality rates.

This regional polarization is also supported by Curto S (1993) when he classifies the countries of the region according to variables such as infant mortality, infant mortality, mortality in older adults, VND, and mortality by causes. The author concludes that higher-income regions are associated with higher VNE and mortality from noncommunicable causes, while lower-income regions are correlated with lower VND.

Palloni A, and Pinto-Aguirre G (2013) also analyzed the decrease in mortality in Latin America. According to the authors, adult mortality has decreased rapidly in the region since 1950, approaching the epidemiological profile observed in the global north in some countries at the end of the twentieth century. However, the authors point out that this rapid decline was accompanied, as Vallin and Meslé (2004) point out, by a set of divergences and convergences in the growth of life expectancy. This divergence begins with an increase in life expectancy in Uruguay, Argentina and Cuba in 1950, compared to the rest of the countries in the region. When the phase of greatest weight of infectious diseases in the rest of Latin America is overcome, a process of convergence of life expectancy occurs. A next stage of divergence in the growth of life expectancy is related to the success in reducing deaths from circulatory diseases in Chile and Costa Rica (García J, 2020). In the rest of the region, except for Mexico, a stage of convergence began due to a decrease in circulatory diseases in the period 2000-2016 (Calazans JA, Queiroz BL, 2020). On the other hand, Palloni and Souza

(2013) point out that an important aspect of the limitations to the reduction of mortality in the region is due, in the first place, to problems in maternal health, nutritional difficulties in childhood, and exposure to infections.

It should be noted that in Omran's (1998) revision of his theory, he proposes models for other regions, called "non-Western models". In this new paradigm, the author proposes an intermediate stage, between the prevalence of transmissible and non-communicable diseases, called "the age of the triple burden of the disease". This stage has been going on since the 70s and involves at least three fundamental health problems, overlapping with each other: old unresolved health problems; new health problems on the rise, and inadequate health systems. This new model can be compared to the polarized-prolonged model of Frenk et al. (1991), highlighting that there is a group of countries in the region that are in a model of prolonged or even stagnant transition.

Available data

For the study of mortality in Latin America, different data sources are available where data from multiple countries are aggregated. This study analyzes data compiled by the World Health Organization (WHO) (WHO, 2023) from the official data reported by each country. The LAMBdA project was developed by Palloni et al., (2014). The World Population Prospects (United Nations, Department of Economic and Social Affairs, Population Division, 2024), published by the Department of Economics and Social Affairs, United Nations Population Division. The Global Burden Disease (GBD) (GBD, 2021) is a project to study morbidity and mortality at regional and global levels, published by the Institute for Health Metrics and Evaluation (IHME) at the University of Washington.

Below is a comparative table with the main characteristics of these sources:

Table 3: Main characteristics of the sources of mortality for Latin America.

Item / Fuente	WHO	Lambda	WPP	GBD
Countries included	All	Latin America (excluding Bolivia)[1]	All	All
Time Frame	1950-2021	Mixed start (1905 Uruguay, 1980 Brazil), until 2016	1950-2021	1980-2021 for mortality 1950-2021 for life tables
Available data	Deaths	Deaths, Life Table	Deaths, Life Table	Deaths, Life Table
Age distribution	Simple ages up to 4, the rest five-year	0, 1-4, Rest: Five-Year Simple Ages in Life Tables	Simple Ages	<1, 2-4, <5, Quinquennials and Other Groups
Include sub-regions	No	No	No	Brazil and Mexico in Latin America
Adjusting the data	No	Yes	Yes	Yes
Types of settings	Not applicable	Redistribution of population and deaths by age and sex. Corrections for misdeclaration of age.	Empirical adjustments in countries with good data quality Models are applied for countries with poor mortality data (less than 60%	Under-5 mortality adjustment Adjustment of adult mortality (15 to 59 years) Adjustment of mortality by cause, age and sex

[1] Lambda includes Bolivia in mortality table data

			completeness) Adjustments for mortality crises	
They have data by cause of death	Yes	Yes	No	Yes

It should be noted that the Human Mortality Database (HMD) has not been included in this study since at the time of writing this work, only Chile has been included in that source.

Methodology

To solve the objectives proposed, it is proposed to analyze the LEB in the countries that make up Latin America. Based on this, life expectancy is obtained directly from the sources analyzed, or the mortality table is constructed in cases where necessary.

(1) The evolution of the LEB in the region is compared, analyzing the evolution of the measures of central tendency and dispersion considering all the countries of the region.

(2) To study the behavior of the evolution of the LEB, a cluster analysis is carried out with the k-means method, in the different countries of Latin America. The number of groups is decided based on minimizing the sum of squares of the intra-cluster distances, so that adding a new group reduces this distance by a non-marginal amount.

(3) The rate of change of the LEB is studied by the first and second derivatives of the LEB. Prior to this, an interpolation and smoothing of the annual values is carried out by means of cubic splines.

(4) On the other hand, in order to study the variability of this indicator between the different sources, the range of the NVD values, provided by each source, for each year, sex and country of the region, is calculated, understood as:

$$\text{Range}(\text{LEB}_{isp}) = \text{Max}(\text{LEB}_{isp}) - \text{Min}(\text{LEB}_{isp})$$

Where LEB_{isp} is the values provided by WPP, Lambda and GBD for the i-th year, for sex *s*, in country *p*.

(5) It is analyzed whether any age group explains the difference between the GBD and WPP estimates by decomposing Arriaga (1984). In this part of the study, as it is an indicator that is calculated for 2-to-2 comparisons, Lambda is not included because it presents information from fewer countries, during a shorter time interval.

(6) The indicator e+ (e dagger) is calculated to study the inequality in life span according to WPP and GBD.

(7) The variation of the LEB, at the subregional level, in Brazil is also studied, to verify whether the conclusions obtained at the country level regarding the estimates of the sources are reproduced at the subnational level. The data of the LEB estimated by GBD are compared with the official data, adjusted for completeness, by the Brazilian Institute of Geography and Statistics (IBGE)

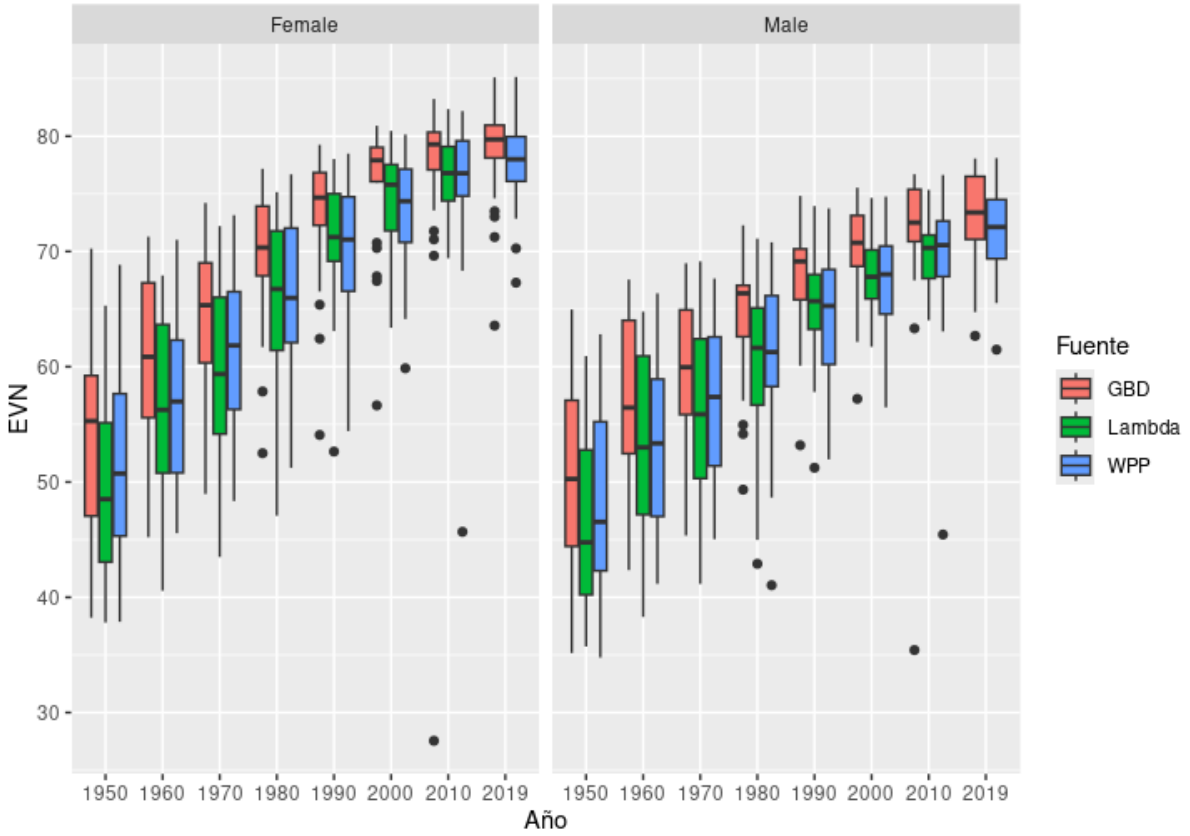
(8) Finally, the methodologies published by GBD, WPP and Lambda are analyzed to determine whether it is possible to identify differences in the estimates offered, in those countries where the results may be affected by the selection of the source.

Results

The results of the analysis of the LEB are presented below, first a study is carried out at the regional level, and then the variation of the LEB by country is studied.

At the regional level, we can see in Figure 1 that the LEB has grown consistently regardless of the source used, with a greater dispersion between countries between 1950 and 1970 compared to the following decades. The latter may suggest a convergence in the value of the LEB of the different Latin American countries. However, the presence of outlier countries indicates the lag of some countries in this growth of the LEB. If we perform an analysis by source, this upward trend and reduction of dispersion is similar in the three sources, however, the estimate presented by GBD is consistently higher than that of the other sources, except for Haiti. These differences between the different sources have been reducing throughout the study period (from 6.78 years in 1950 to 1.2 years in 2016), which suggests better quality of the data, which results in better adjustments by the sources.

Figure 1: Box plots for the LEB of Latin America, for the period 1950-2019, according to GBD, WPP and LAMBDA, disaggregated by sex.

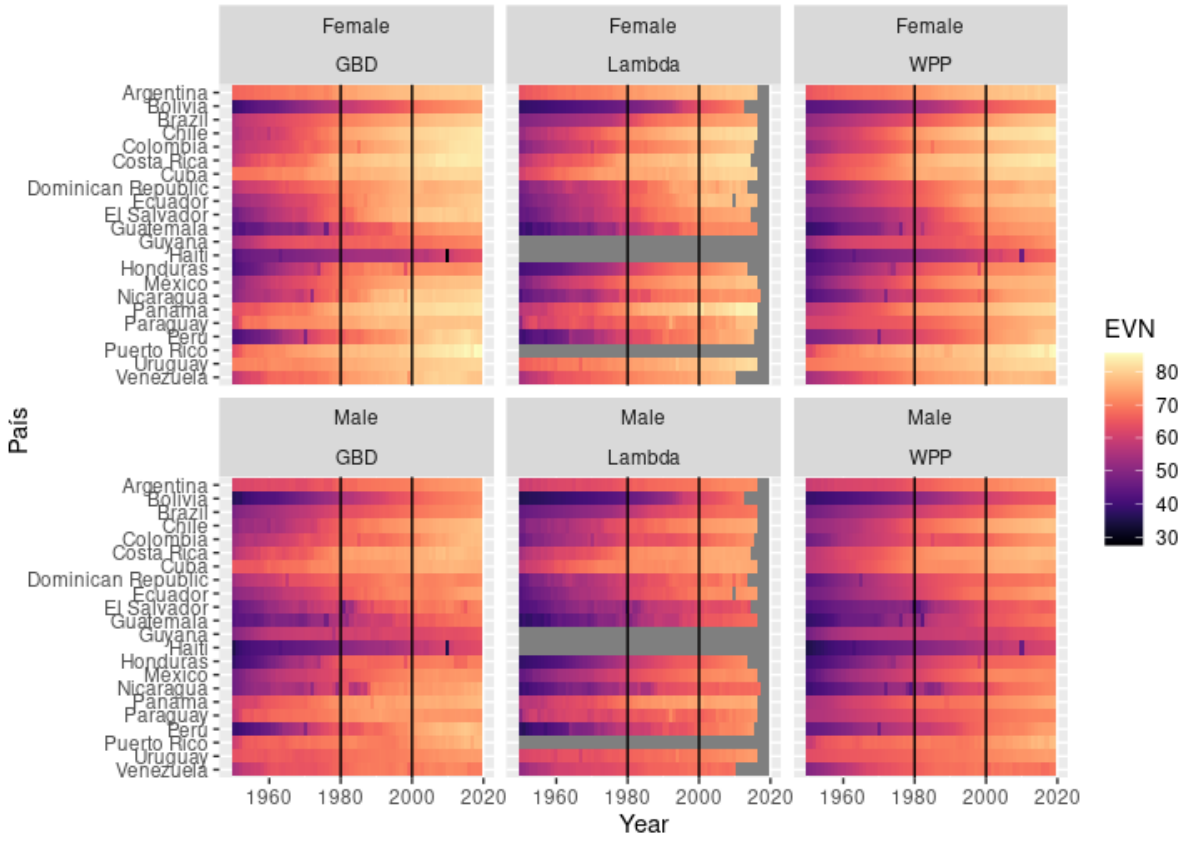


Source: Authors, based on data published by GBD, Lambda and WPP

If we study the VND by country, we can see in Figure 2 that there is a smaller difference between the different VNS at the end of the period. This could indicate that, in general terms, convergence has occurred. This convergence, if we consider the estimates provided by the different sources, seems to be greater in GBD, than in WPP and Lambda

However, in Figure 2, we can see that there are countries such as Haiti and Bolivia that have not undergone this convergence. These countries were identified by Frenk, in the 1980s, as lagging in improvements in mortality. Although the NCD of these countries has increased in recent years, their situation of lag with respect to the rest of the region is still present.

Figure 2: LEB estimated by GBD, Lambda and WPP, by country, sex and year,



Cluster Analysis

Next, a cluster analysis of the different countries is made, based on the value of their LEB, in three time periods: 1980, 2000 and 2016. The stability of the countries over the three years will be assessed, their correspondence with the theories of Omran and Frenk and whether there is a bias based on the sources will be verified.

The classification algorithm consistently places countries in three groups because adding a fourth group does not substantially improve the sum of squares of the distances with respect to the centroids of each group.

The first thing we observe is that although there is a clear division between the most advantaged groups compared to those of countries with lower NCDs, it is also true that all groups have increased their NCDs period by period.

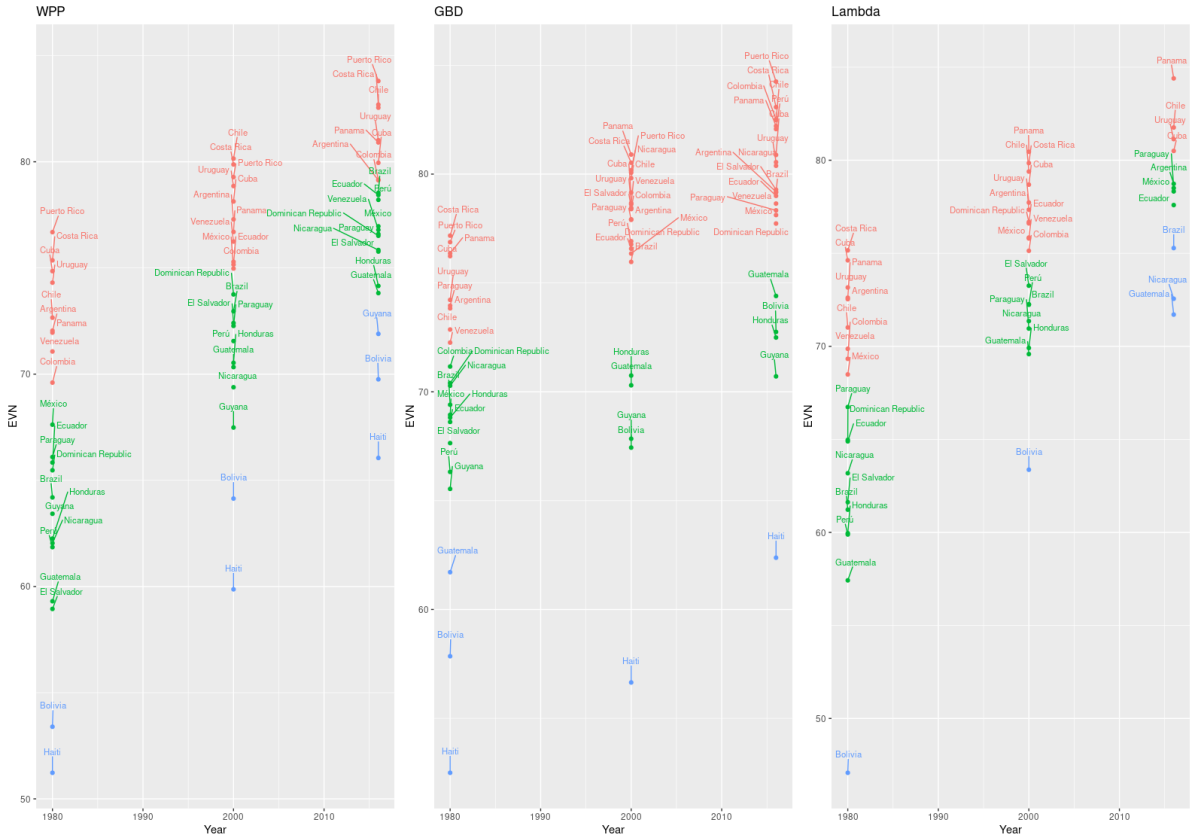
If we analyze the membership of the countries in the different groups, the first thing we observe is that there is a group of lower NCDs, to which very few countries belong: Haiti is located there by all sources, in all years, as is Bolivia in the majority, which corresponds to what was visually analyzed in the previous section. In the case of men in particular, Guatemala also belongs to this group.

The other two clusters have a larger number of countries, and relatively like each other in terms of the gap in which the LEBs vary. It is also possible to observe a certain degree of permeability between them, greater in men than in women, where the groups are perceived

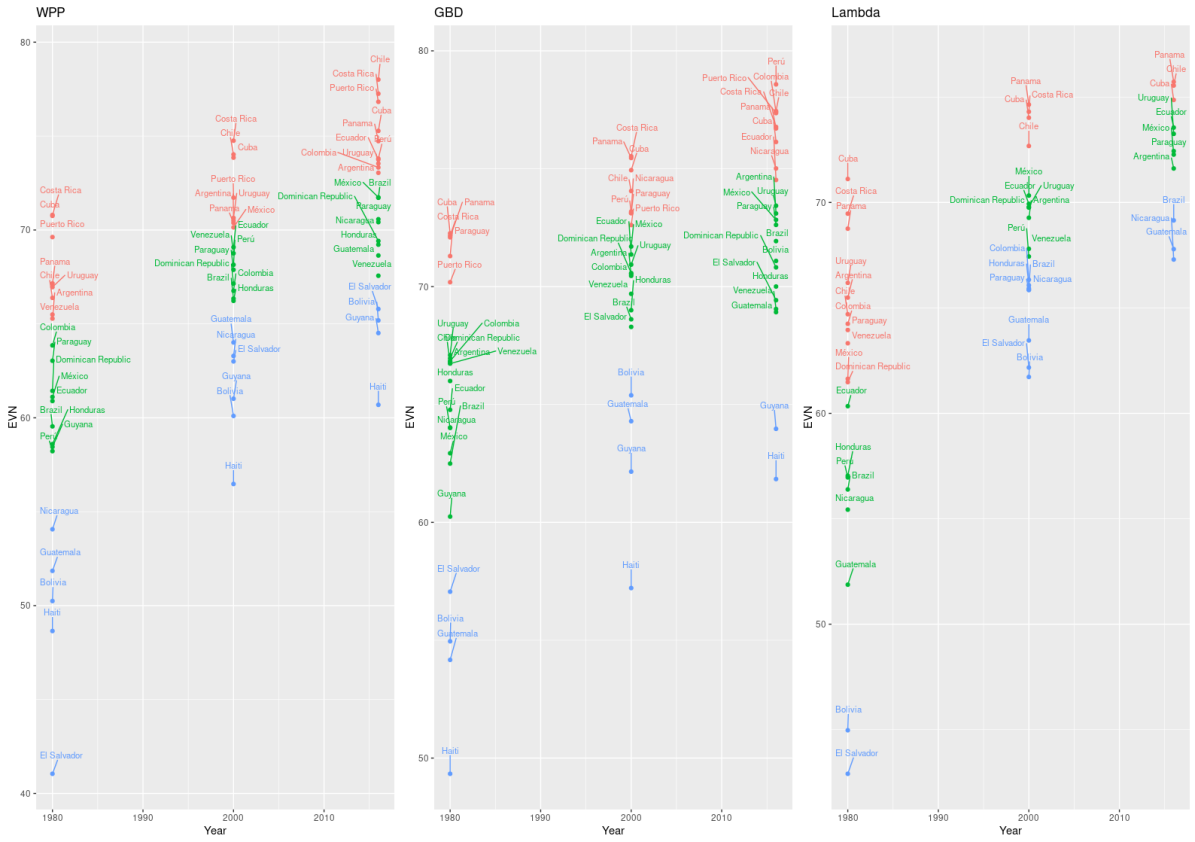
as more stable. Countries such as Brazil, Ecuador and Mexico present greater variability in classification between different years and sources, particularly in Lambda.

Figure 2: Country groups by their LEB, disaggregated by source and sex, for the years 1980, 2000 and 2016

(a) Women



(b) Men



By contrasting these results with Omran's modelling in the year 2000, we can see that Costa Rica, Chile, Cuba and Puerto Rico have, in both sexes, an LEB not lower than that of Argentina and Uruguay, which could lead us to suppose that they would be part of the same set of countries. Panama, on the other hand, is a special case, since it is placed in the upper intermediate group by Omran, while the sources studied place it in the same cluster as the countries with the highest LEBs. The other countries in the upper intermediate range do, in general, seem to share the same intermediate ranking. Finally, in the case of the group classified as slow transition, it seems to share the same countries as in the cluster with the lowest LEB.

Regarding the classification made by Frenk, although the countries cataloged in the late model and early-stage groups seem to coincide with the cluster analysis, it is possible that some other countries could be incorporated into this group of the late model of the classical transition.

If we perform a sensitivity analysis by source of the cluster analysis, we see that the greatest disparities in terms of variability of the VND occur in the group with the lowest VN. This could be linked to lower-income countries with lower registry quality, which are where sources are expected to make greater corrections to the data and therefore the estimates will diverge.

If we consider the evolution of countries in the twenty-first century, the cases of Peru are noteworthy, going from the least advantaged group to the one with the highest LEB

Evolution in the exchange rate of the LEB

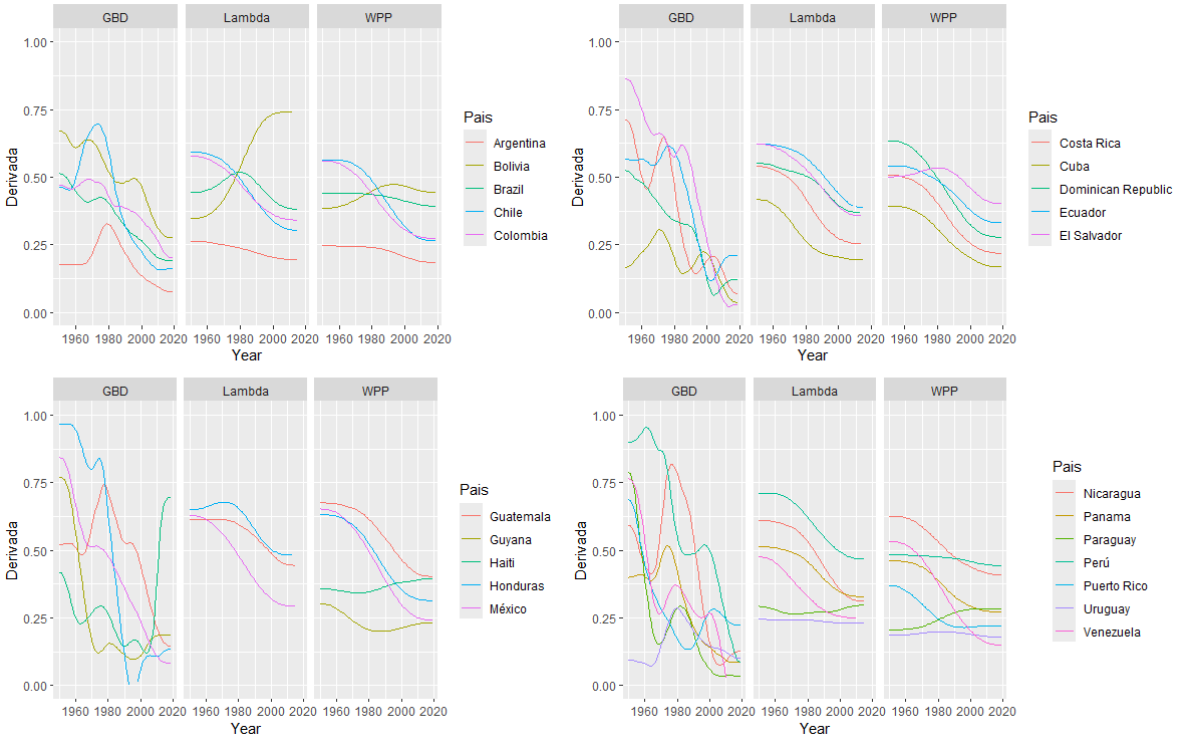
Velocity

The first derivative, applied to the interpolation and smoothing of the LEB values, shows us the rate of change of the LEB. Overall, all values are positive, indicating that the LEB continues to grow. However, a certain transition from high exchange rates can be seen in the 1960s to lower rates in recent years. This could be related to a greater difficulty in continuing to increase the VND beyond a certain limit, unless the dominant diseases in older adults can be dealt with more effectively.

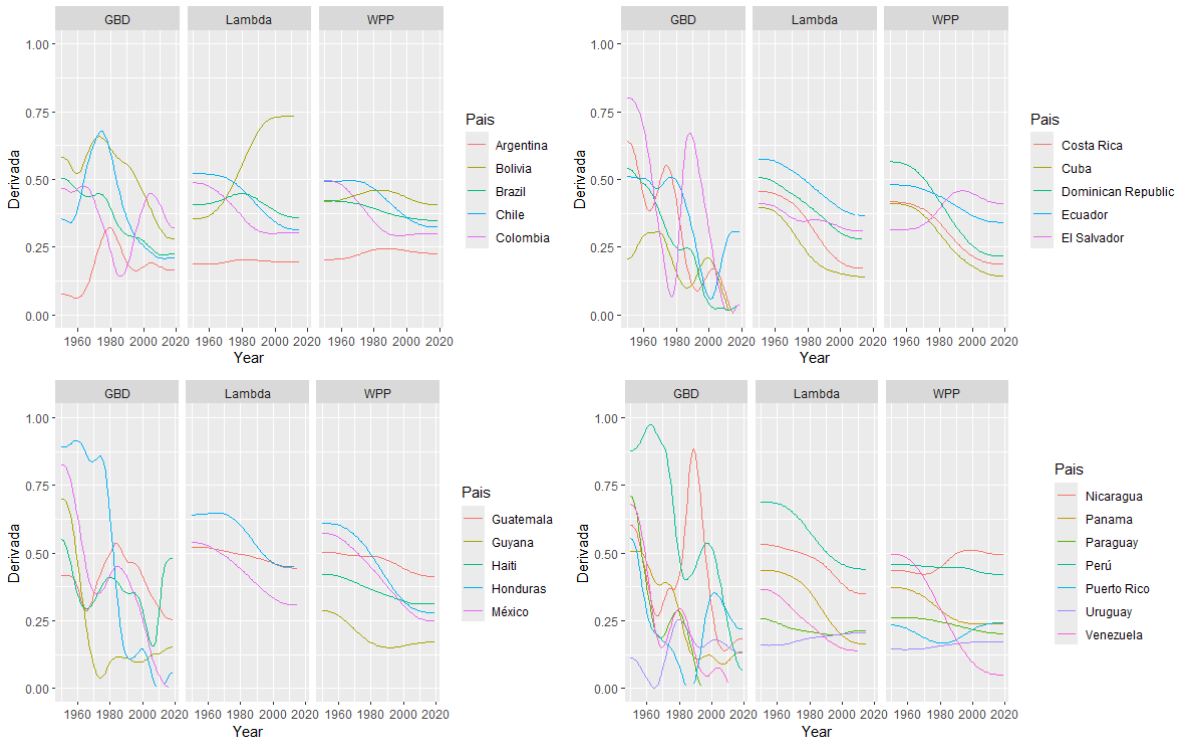
Paraguay and Bolivia, on the other hand, seem to be exceptions, as their exchange rate increases. Uruguay is a particular case given that it does not present major changes in this indicator, although it is to be expected if one considers that it was one of the pioneers in the various transitions (Omran, 1998)(Miglionico,). It should be noted that if we analyze by source, the behavior of the exchange rate, although it is still downward, presents greater oscillations in GBD over time. The fall in this exchange rate in Venezuela is remarkable, higher than that of other countries. When analyzing differences by sex, this rate of change appears to be higher in men compared to women, suggesting that the evolution of male VND has been more irregular in some countries. One of the possible explanations for these differences may lie in mortality from external causes, which particularly affects young men.

Figure 3: First derivative of the smoothing of the LEB, by country, source and sex, for the period 1950-2019

(a) Women



(b) Men

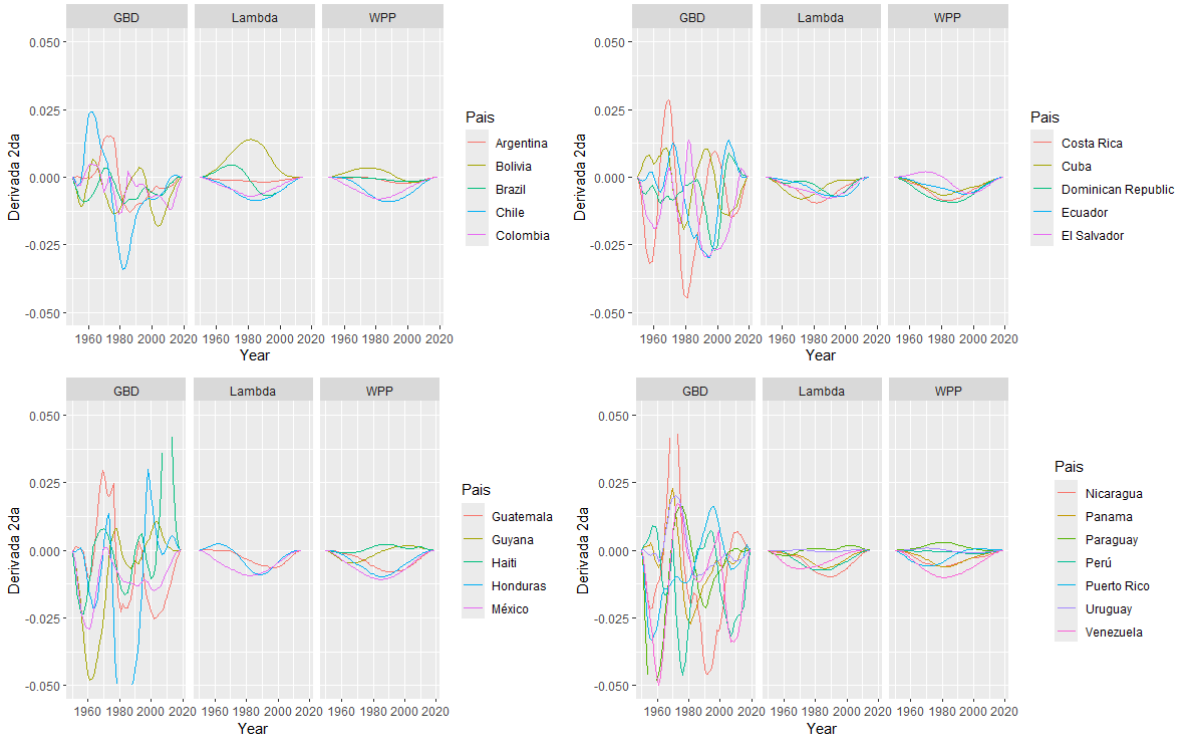

GBD
Lambda
WPP
Derivada
Year
Pais
Argentina
Bolivia
Brazil
Chile
Colombia
Costa Rica
Cuba
Dominican Republic
Ecuador
El Salvador
Guatemala
Guyana
Haiti
Honduras
México
Nicaragua
Panama
Paraguay
Perú
Puerto Rico
Uruguay
Venezuela

Acceleration

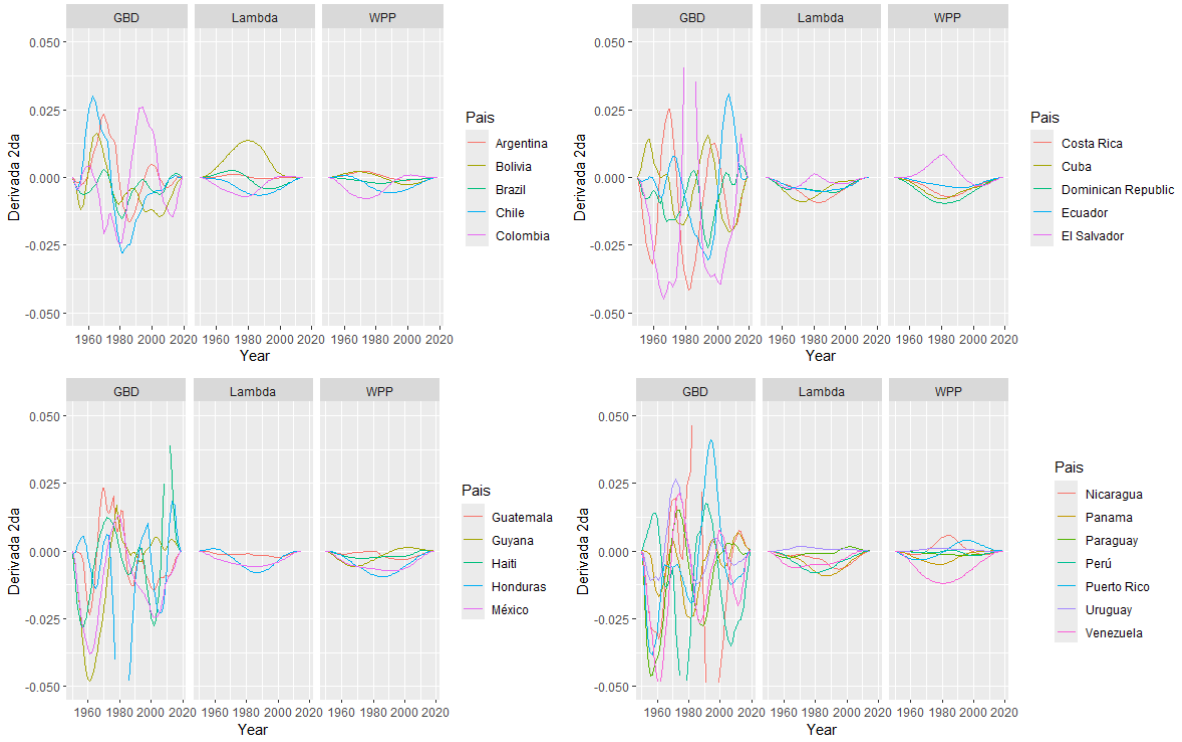
Below we will analyze the acceleration or deceleration of the rate of change of the LEB, we can observe in general a negative concavity, which can reveal that the rate of change has slowed down. In any case, it is interesting to note that this indicator has grown in recent years to almost zero in most countries. This suggests that although the growth rate continues to decelerate, it does so with less intensity than in the last decades of the twentieth century.

Figure 4: Second derivative of the smoothing of the LEB, by country, source and sex, for the period 1950-2019

(a) Women



(b) Men



Breadth in NVD estimates

Regarding the range of variation of the LEB by country and year, we can observe that this gap, if we consider the average of all Latin American countries, tends to decrease over time, possibly due to better data quality.

Figure 5: Range of the LEB, between GBD, WPP and Lambda, between 1950 and 2019, for all of Latin America

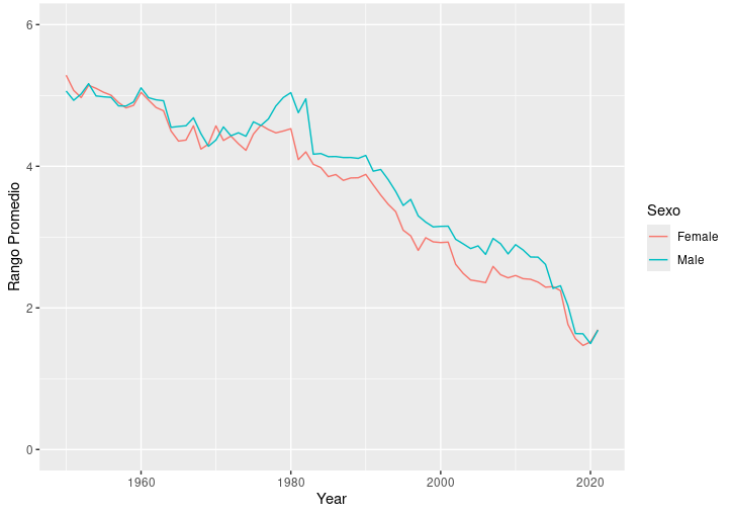
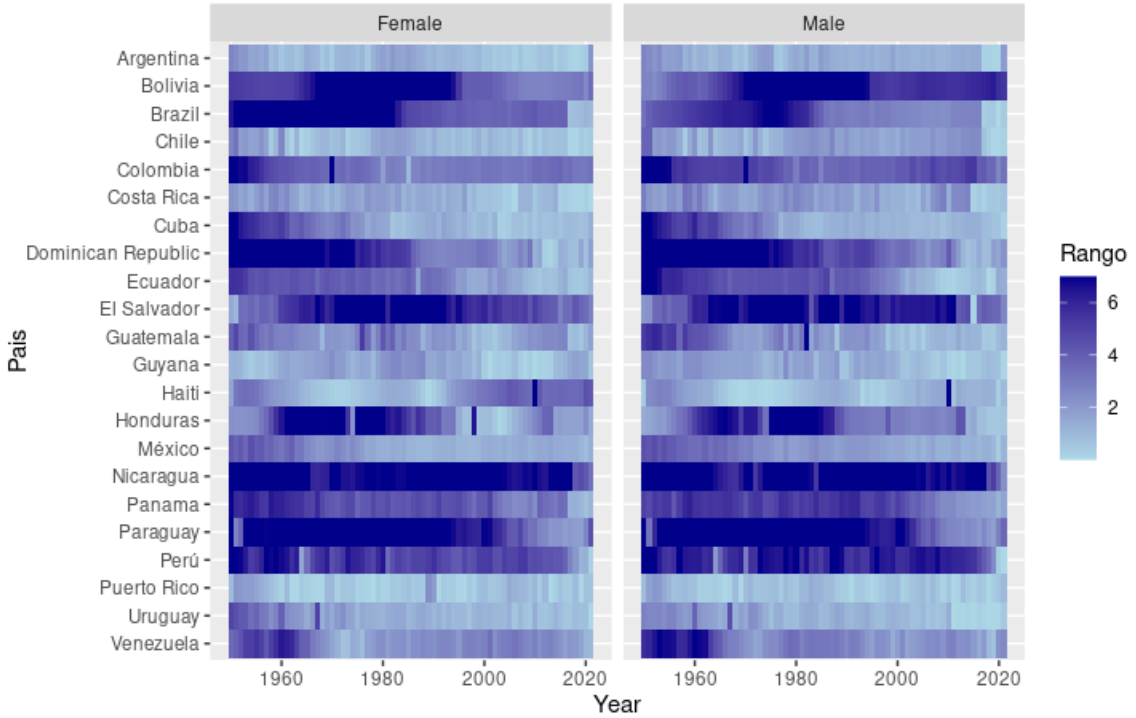


Figure 6: Range of the LEB between GBD, WPP and Lambda, for Latin American countries, in the period 1950-2019.



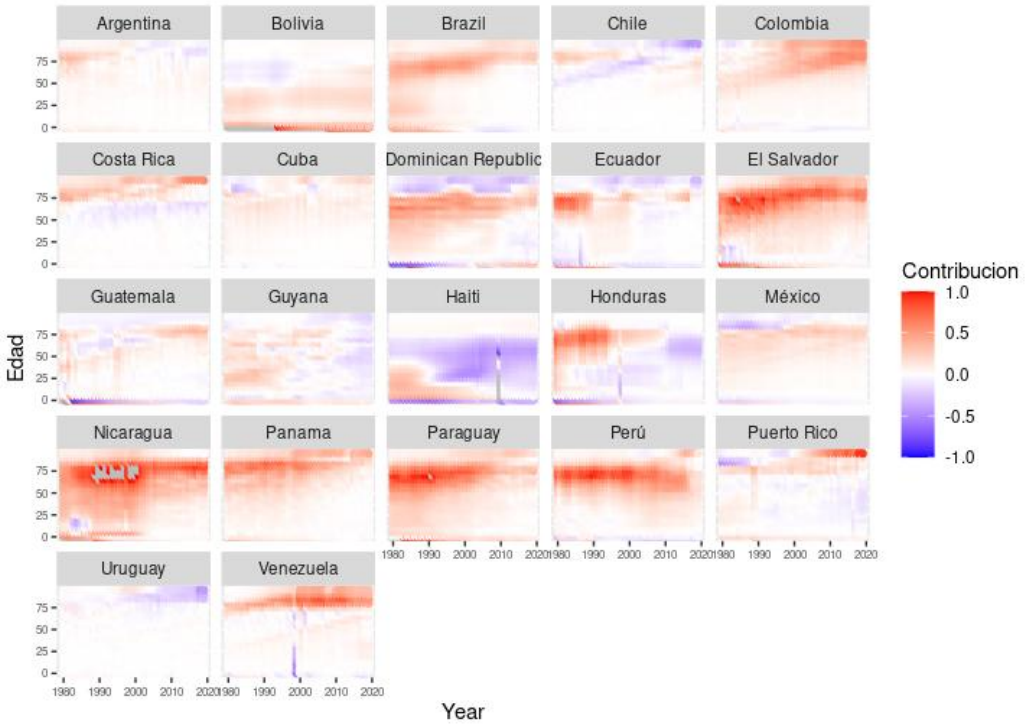
Source: Authors' elaboration based on data published by GBD, WPP and Lambda

However, if we disaggregate country by country, it is possible to see that this reduction in the range does not occur uniformly throughout Latin America. Although, in general terms, the discrepancies were greater in the past, in some lower-income countries such as Bolivia, El Salvador, Nicaragua, and Peru, it is possible to observe that the sources do not end up reducing the differences between them.

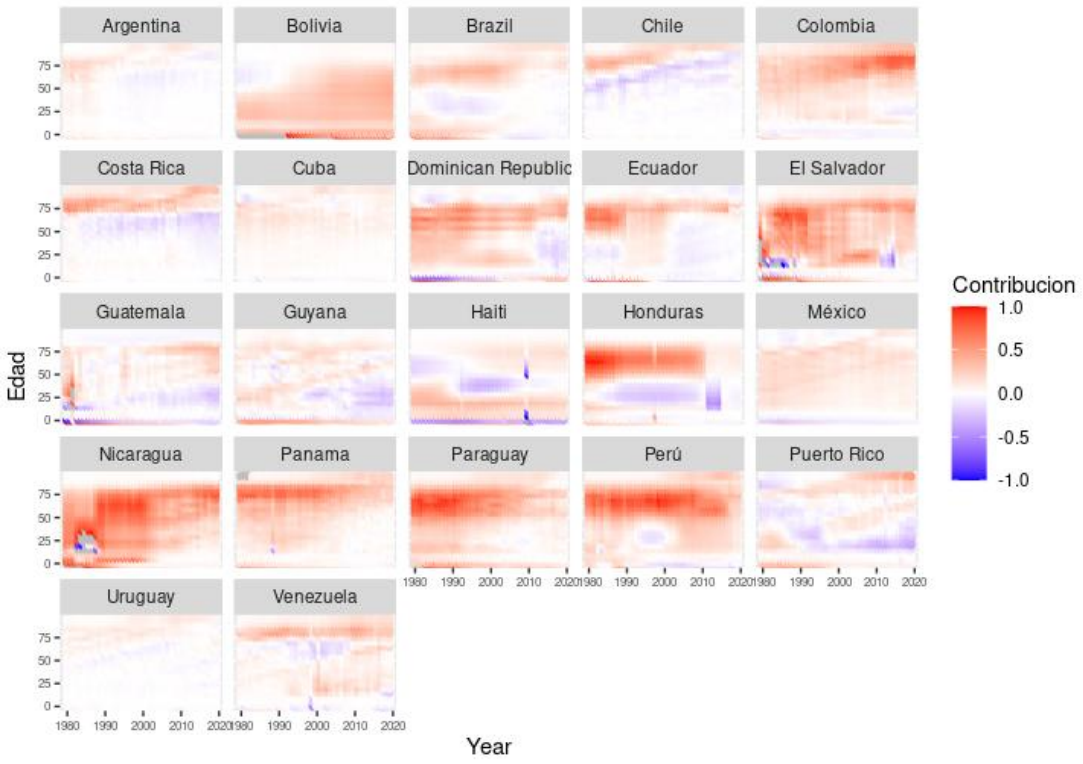
We are now interested in trying to explain whether this difference in estimates is based on any age group. To this end, the contribution of each age to the difference in the VNS is presented, disaggregated by year and sex. Positive contributions (red) indicate that these ages support a higher LEB estimate in GBD, and negative contributions (blue) indicate a similar behavior in favor of WPP. In general terms, we can observe that it is at older ages, where GBD estimates greater survival of people. However, within these ages, a cohort effect may be observed in some countries. In Brazil and Colombia, we can see that this effect has been transferred to the higher age ranges.

Figure 7: LEB difference decomposition

(a) Women



(b) Men



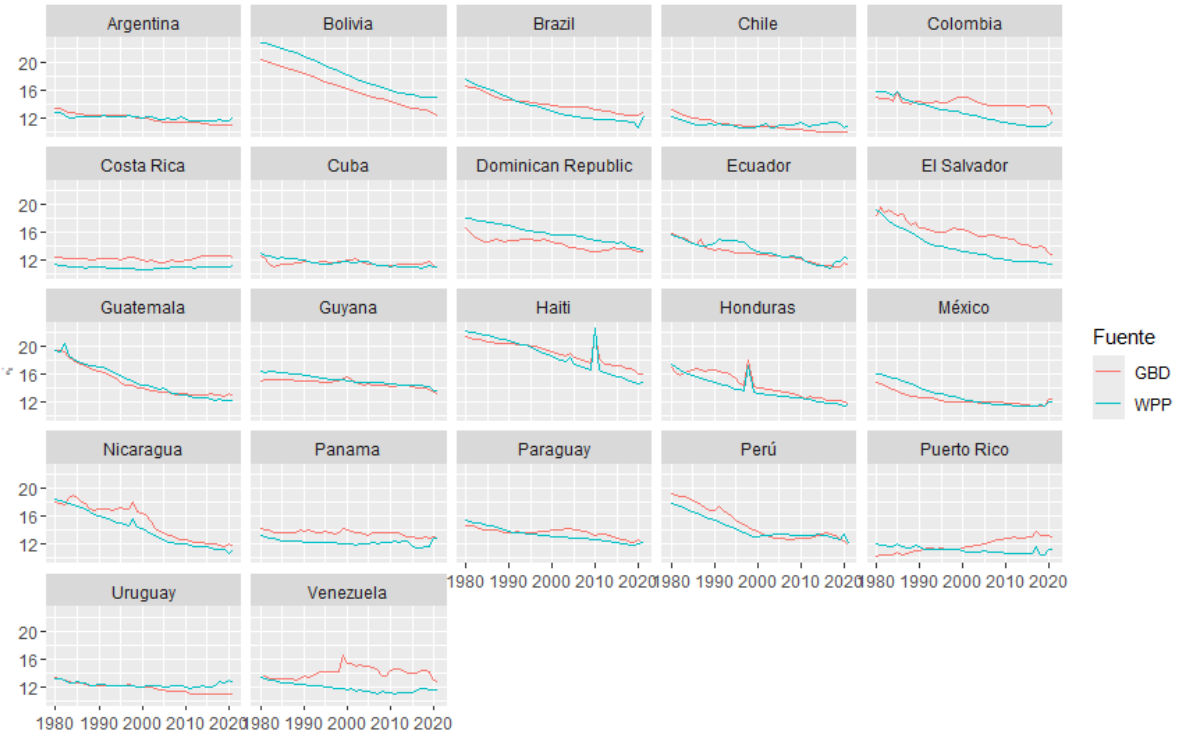
Source: Authors' elaboration based on data published by GBD, WPP and Lambda

Inequalities in life span

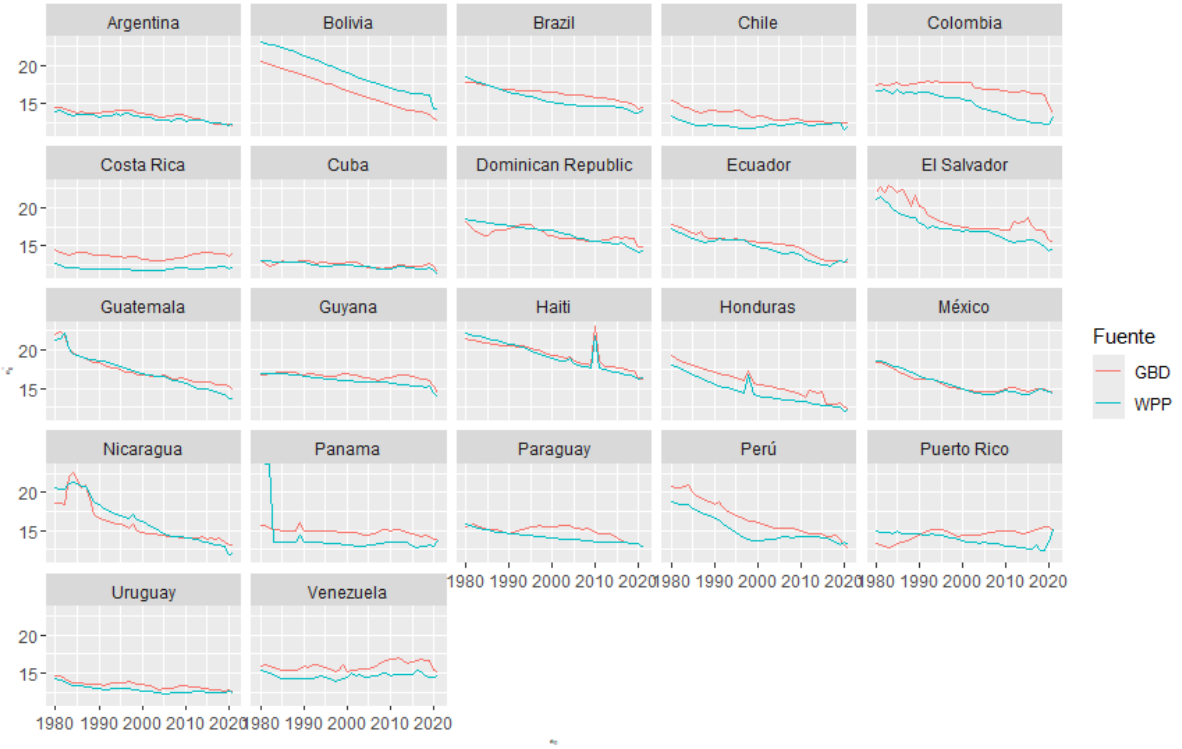
If we want to analyze how homogeneous mortality is at different ages, the e-dagger indicator is a measure of the dispersion of the VN. In Latin America, the e-dagger generally seems to decline over time. This could be explained by a greater number of people reaching older ages, while there is a reduction in infant mortality. In general terms, this indicator is higher in GBD than in WPP, possibly due to the overestimation of survival at older ages compared to WPP, reported in the previous section.

Figure 8: Life span inequality, according to VNS; By source, 1980-2019

(a) Women


Argentina
Bolivia
Brazil
Chile
Colombia
Costa Rica
Cuba
Dominican Republic
Ecuador
El Salvador
Guatemala
Guyana
Haiti
Honduras
México
Nicaragua
Panama
Paraguay
Perú
Puerto Rico
Uruguay
Venezuela
20
16
12
1980 1990 2000 2010 2020
Fuente
GBD
WPP

(b) Men


Argentina
Bolivia
Brazil
Chile
Colombia
Costa Rica
Cuba
Dominican Republic
Ecuador
El Salvador
Guatemala
Guyana
Haiti
Honduras
México
Nicaragua
Panama
Paraguay
Perú
Puerto Rico
Uruguay
Venezuela
20
15
1980 1990 2000 2010 2020
Fuente
GBD
WPP

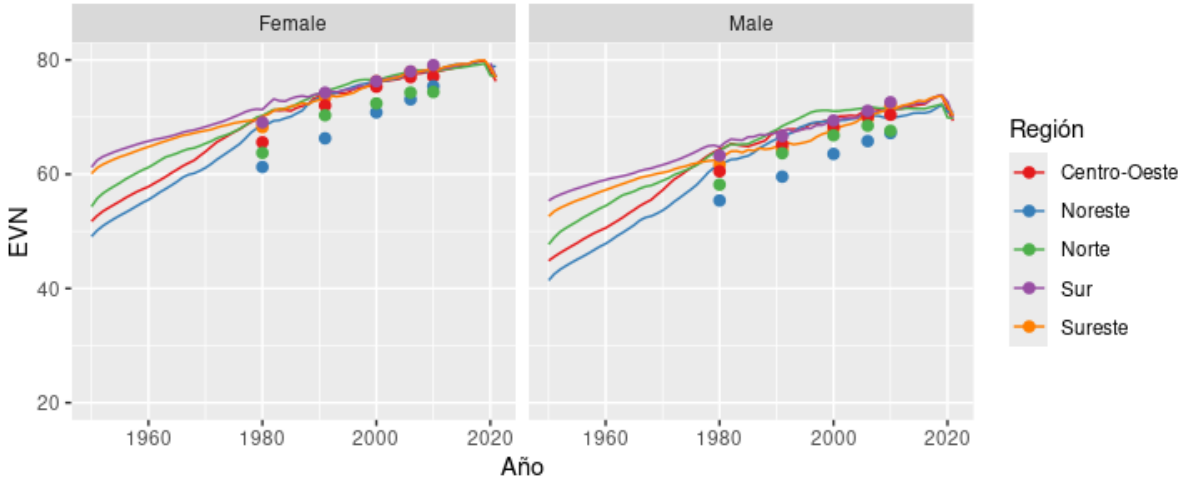
Subregional inequalities

It is worth asking whether these differences observed at the country's level are also reproduced at a lower level of aggregation. According to Frenk and Omran, one of the problems of transitions in mortality is polarization at the subnational level. Since GBD presents this type of data from the LEB in Brazil, we compare these estimates with the official adjusted estimates presented by IBGE.

The LEB estimates published by GBD between 1950 and 2020 are then compared with the estimates published by the IGBE in the years 1980, 1990, 2000, 2006 and 2010.

By analyzing the estimates provided by GBD, the convergence of the LEBs of all regions of Brazil can be confirmed, as proposed by Vallin and Mesle. This convergence is more evident in women than in men. However, if we contrast the GBD estimates with the official IBGE data, not only have the LEBs not yet fully converged in recent years, but for the North and Northeast regions, the LEB estimates presented by GBD are higher than the IBGE data. This convergence does not seem to be happening in the case of women, where the gap with the northern regions does not seem to be closing. It is important to note that this discrepancy in lower-income regions may condition the public policies to be applied if only GBD data are taken.

Figure 9: LEB of the subregions of Brazil, according to GBD (lines) and IGBE (points), for selected years



Source: Authors, based on data published by GBD and IBGE

Methodologies applied by sources for data tuning

Global Burden of Disease

GBD makes different adjustments (GBD, 2021) in countries with good and poor coverage of vital records, on the other hand, different methods are also applied in countries with good coverage in child mortality and adult mortality.

Although GBD presents diagrams where the procedures are carried out and the source codes are proposed. However, the plurality of languages used, and the number of codes presented, makes it completely difficult to study them at the level of an individual researcher.

Table 4: Data and methods of adjustments made in GBD

Age	Good coverage	Cover case
Under 5 years old	Regression model on crude estimates of deaths from different sources	● Nonlinear mixed models with covariant variables ● Gaussian Process Regression Model
Between 15 and 59 years old	● Vital record and sample data are adjusted using death distribution methods. ● Sibling Story Technique	

Lambda

The adjustments made by Lambda (Palloni et al, 2014) focus on (a) adjusting the coverage of the registries, (b) an age adjustment for an erroneous declaration of age at death, where the reported age is usually higher than the real one, and (c) adjusting for causes of death[2]. In mortality by cause and age, when the ill-defined causes are less than 10% of the total, a proportional redistribution is made, otherwise, a regression model is proposed to make this adjustment.

Table 5: Data and Adjustment Methods Performed in Lambda

	Age	Good coverage	Cover case
Before 1950	Under 5	Gompertz (3 parameters)	Gompertz (3 parameters)
	Over 5	Adjusting Ratios with Brass or BH[3]	Generalized warhead (W, S, and UN LA)[4]
After 1950	Under 5	Lowess/Splines	Lowess/Splines
	Over 5	Adjusting Ratios	Generalized

[2] While adjustments for redistribution of ill-defined causes are well documented, they are not available for download from this source's website currently.
[3] Bennett-Horiuchi
[4] Model mortality tables

		with Brass or BH	warhead (W, S, and UN LA)

Although the methodologies applied to evaluate the completeness of the data have the implicit assumption of zero migration, according to the authors, migration is considered when estimating adult mortality. To this end, the age-by-age migration pattern proposed by Reymar, J. & Rogers, A. (2006) in Palloni et al. (2014) is used. From there, this pattern is compared with data from countries where complete population records are kept and this pattern is adjusted.

World Population Prospects

The WPP proposes a set of adjustments (United Nations, Department of Economic and Social Affairs, Population Division, 2024b) on the original data, based on a partition: in countries with mortality registry coverage of more than 60% (ALAP, 2024), empirical adjustments are made, and countries with lower coverage, model-based adjustments are made. In addition, WPP adds a mortality crisis adjustment.

Table 6: Data and Methods of Adjustments Made in WPP

	Empirical adjustments	Model-based settings
Infant mortality	Consistency with IGME	Coordinates with IGME
Adult mortality	Adjust mortality rates according to the estimated completeness of the records Smoothing out mortality rates using moving average with 3-, 5- and 7-year intervals Conversion of grouped ages to simple ages. Interpolations of missing data by Lee-Carter To evaluate adjustments in mortality in older adults for	Log Data Incomplete data, to which are added estimates of deaths in the household from census Indirect estimates Evaluation of the probability of survival between two censuses Demographic surveys of siblings, parents, and spouse survival

	implausible rates (age, sex, and/or year) Smoothing Time Series for Year-Period or Year-Period-Cohort Extend mortality tables to age 130+ Other adjustments in older adults: ○ Replace death rates with age extrapolation laws ○ In countries with rates skewed in the past (not in the present) by unbiased mortality table data ○ Replace mortality rates with HMD tables	Bayesian Hierarchical Models for Probability of Death Prevalence of HIV infection and use of antiretrovirals An association between childhood and adult mortality is assumed to be like that of neighboring countries
Overall Fit	Mortality crises added	

Based on this information, we can see that WPP adjusts for older ages, even correcting rates considered "implausible", while Lambda makes a downward correction for age. On the other hand, it is not clear which methodology GBD uses in the estimates of advanced ages, because its documentation only specifies, broadly speaking, the methodology applied up to the age of 59. In the case of countries with poor coverage, we can assume that GBD applies the models, WPP, on the other hand, uses different sources such as surveys, censuses and vital records to make empirical adjustments or models, depending on whether the coverage is greater than 60%. In the cases of countries whose LEB estimation differs from GBD (Bolivia, El Salvador, Nicaragua) we can observe that numerous adjustments are applied to the data, such as adjustments for underreporting, adjustments for deaths in the home, sibling survival through surveys, intercensal survival, parental orphanhood and inputs from international estimates.

Conclusions

At the regional level, Latin America has seen its NVA increase systematically between 1950 and 2019. In general terms, there is a convergence of the indicator over time, depending on the health improvements developed in the different countries. Notwithstanding the above, all the sources studied indicate that Haiti and Bolivia are two countries that remain lagging behind in the improvement of the LEB. This increase and convergence in the LEB, which was explosive in the twentieth century, seems to be beginning to slow down in the twenty-first century, because of the difficulty of gaining more years of life at older ages.

Contrasting the groups proposed by Omran and Frenk with respect to the transition models, no differences are found that invalidate the theories or present biases due to the source used. However, there are specific cases that may have been underestimated and may have been in more advanced stages of the transition.

In recent years, the groups classified in previous years by the cluster algorithm do not seem to have found significant changes in their composition, although there has been an improvement in the VNS in all groups.

If a sensitivity analysis is done by source, the classification by groups does not appear to differ to such a magnitude that the conclusion is biased by the source. When calculating the range in which the VNS varies, by country, year and sex, we can observe that this value decreases over time, possibly because of a better quality of the vital records of the different countries. However, lower-income countries tend to show a higher range, as a result, as mentioned, of higher estimates of the LEB in GBD.

On the other hand, if this phenomenon is analyzed at the subregional level in Brazil, we can see that GBD makes us think that there is a convergence in the LEBs in the twenty-first century, contrary to IBGE data, where lower-income regions continue to be relegated in their LEB. It is particularly noteworthy that GBD estimates a higher LEB in the Northern region than in other regions in the first decade of the 21st century, which is surprising given that it is a lower-income region.

Considering the evidence presented by several authors, it is unlikely that lower-income countries or regions have the same development in their LEB as their higher-income counterparts.

When analyzing which ages support these differences in favor of GBD, in general, it is in the survival of older adults (generally in the 65 to 80 age group) where GBD overestimates the survival of these age groups compared to WPP or Lambda. This is corroborated by a higher value in the inequality of the life span obtained in this source.

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