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ORIGINAL RESEARCH

Inequality Crossroads of Mortality: Socioeconomic Disparities in Life Expectancy and Life Span in Mexico Between 1990 and 2015

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Abstract

The Mexican health system has been characterized by a mixture of progress and pitfalls, resulting in persistent inequalities. The main causes of death are related to socioeconomic factors reflecting the lack of opportunities regarding access to education, employment, income, and public health services. In this paper, we study the association between social inequality and mortality to assess how population composition by socioeconomic level shapes overall mortality. Socioeconomic information from vital statistics of mortality is used to estimate life expectancy (LE) and lifespan variability by age, sex, and socioeconomic status using three variables: educational attainment, occupation, and access to social security. We also use a decomposition method to separate the effect of changes in population composition by socioeconomic status from changes in mortality by education over changes in LE and lifespan variation. We find that increasing educational attainment and health coverage impact LE positively. The population without formal education and those without access to social security are the worst socioeconomic positions for mortality. The effects of changes in population composition by socioeconomic status is greater for men than for women. Given the amount of contribution from the population structure by socioeconomic status, the implementation of social policies focused on broadening access to tertiary education—which incentivize formal employment and seek to achieve universal health coverage—could boost an increase in the survivorship of Mexican population.

Keywords Mortality inequality · Life expectancy · Lifespan variation · Socioeconomic inequality · Mexico

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Introduction

Mexico faces several challenges related to its health system. The most important challenges are access to health care and social security, but quality of health services, polarization of health systems, persistent health inequalities, and the double burden of disease are also relevant (Doubova et al., 2018; Gutiérrez & García-Saisó, 2016; World Health Organization et al., 2020). Mortality by contagious diseases prevails in rural and indigenous populations and among those living in poverty; and at the same time, mortality from noncommunicable diseases has increased in the rest of the population (Gómez-Dantés et al., 2016). The main causes of death are strongly related with socioeconomic factors reflecting the lack of opportunities in access to education, employment, income, and public health services. The heterogeneity in health indicators reveals the conditions of poverty, inequality, and social segregation that prevail in Mexico (Fuentes, 2018). Important structural changes took place in Mexico post-1990: increases in school enrollment and average educational attainment, the introduction of the *Seguro Popular* program, and the shift of occupations that transformed into more specialized professions. These structural changes are reflected in a shifting population structure by education, occupation, or access to social security over time, which may contribute to changes in overall mortality (Luy et al., 2019; Sauerberg, 2021).

Since 2006, life expectancy (LE) in Mexico has stagnated after a half century of continuous growth, attributed to increases in homicides in young adults and mortality by endocrine diseases in old ages. Between 2000 and 2010, the negative impact of deaths by diabetes mellitus and homicides stopped the increase in male life expectancy at birth at 72 to years (Canudas-Romo et al., 2015). Additionally, between 2005 and 2014, LE at age 20 remained stagnant, for females it only increased from 59.2 to 59.5, while for men it remained at 54.4 (Canudas-Romo et al., 2017). Moreover, from 2005 to 2015, LE at age 15 decreased in the Northern region as a consequence of the raise in homicides among young adults, and the lifespan variation has remained stagnant since 2005 (Aburto & Beltrán-Sánchez, 2019).

Regarding the relationship between socioeconomic inequality and mortality in Mexico, men working at low-skilled, nonmanual occupations and women working in low-skilled, manual occupation have the highest LE (Román Sánchez et al., 2019). These findings contradict the observed patterns for European countries, where the population working in high-skilled, nonmanual occupations have the highest LE and the lowest lifespan variation (van Raalte et al., 2014). Concerning healthcare access, the population aged 60 and above without access to social security had higher mortality rates by causes associated with social inequality, such as homicide, suicide, and malnutrition. Moreover, completing elementary education was identified as having a threshold effect on old-age mortality, meaning that those with less educational attainment had higher mortality rates (Muradás Troitiño, 2010).

However, these previous results do not shed light on how differential mortality by socioeconomic status affects overall mortality in Mexico. The interacting conditions of health and social inequalities would suggest that changes in the mortality level and the population distribution by SES influence total mortality. Thus, in this paper, we analyse the relationship between socioeconomic status and mortality in Mexico. Mexican vital statistics of deaths do not provide information on income of the deceased. Instead, it includes information on three variables of socioeconomic status (SES): educational attainment, occupation, and access to social security. We exploit this data source to analyse the evolution of mortality by SES in Mexico from 1990 to 2015, and we assess how changes on the distribution by SES affects changes in LE and the standard deviation of the ages at death (lifespan).

Literature Review

Population health can be assessed through measuring average levels of mortality. LE is one of the most frequently used indicators for this purpose. Nevertheless, it should not be used as the only health and well-being indicator because by itself, LE does not capture socioeconomic inequalities nor the variation in the ages at death. For example, two countries with the same LE may have different distribution of the ages at death, especially at older ages (van Raalte et al., 2018). To overcome this limitation, some indicators of heterogeneity and variation in health and well-being have been proposed, such as the standard deviation, the interdecile range, lifespan disparity, and the Gini coefficient, among others; all of which are highly correlated (Aburto et al., 2020; Németh, 2017; van Raalte & Caswell, 2013).

Inequality in mortality is one of the most fundamental inequalities that affects population well-being. Like any other social inequality, it is conditional to being alive. It is measured by the lifespan variation that allows analyzing heterogeneity of life duration in a populational aggregate. Such heterogeneity is determined by factors that range from genetic diversity and lifestyle to socioeconomic conditions. Regular monitoring of lifespan variation helps understanding micro and macro health conditions of the population (van Raalte et al., 2018).

The last century saw an increase in LE and a decrease in mortality inequality worldwide (Aburto et al., 2020). However, in recent years and in many countries, the relation of increasing LE and decreasing lifespan variation has been reversed or does not follow the expected gradient (Vaupel et al., 2011). In some countries it has been attributed to increases in young adult mortality. For example, in Venezuela increases in LE slowed down while lifespan variation increased for males at the start of the twenty-first century (García & Aburto, 2019). While in other countries, such as Sweden, the change in the relation between LE and lifespan variation has to do with mortality improvements occurring at ages above the threshold age for lifespan variation (Aburto et al., 2020). This threshold age is an age above which reductions in mortality lead to increased lifespan variation, so saving lives above the threshold age causes both LE and lifespan variation to increase.

Given that lifespan variation is a type of inequality, its association with other health inequalities has been studied (Bramajo et al., 2022; Permanyer et al., 2018; Seaman et al., 2019; van Raalte et al., 2011, 2014). All these studies concluded that the lower socioeconomic groups have the shortest life expectancies and the highest variation in the ages at death, giving place to a double burden (Seaman et al., 2019).

Along the same lines, recent studies have shown that groups with higher life expectancies have the least lifespan inequality (Aburto et al., 2020).

According to Ware (2019), there is not a consensus on the definition of SES, nor on how to measure SES properly. Education, occupation and income of the parents are the most common measures for SES (Ware, 2019). The effect and timing that each of these factors has over health varies. Income determines the access to material assets, while education defines the access to information and the degree of usability that may be gained from new knowledge, especially in health matters (Braveman et al., 2005). Occupation provides technical abilities that may prompt social privileges. Moreover, in mortality research occupation is an indicator of the exposure to occupational hazards (World Health Organization, 2010). Health care access is an enabling mean to improve the health of the population, as it allows individuals to seek medical attention, and the exclusion and social segmentation processes in access to health services may influence the timing at which health policies impact each social group (Solís & García-Guerrero, 2019).

Latin America is one of the most socioeconomically unequal regions in the world, where simultaneous unequal health transitions have led to growing differences in health between extreme social groups (Manzelli, 2014). According to data from the World Bank, Latin American countries have a Gini Index above 0.45, while most European Countries have a Gini below 0.35 (World Bank, 2023). Brazil, Colombia, Panamá, Costa Rica, Nicaragua, and Guatemala are the most unequal countries of the region with a Gini Index above 0.5; Mexico is close to the regional average with a Gini Index of 0.45 (CEPAL, 2023), although Mexico and Costa Rica are the most unequal countries among the OECD (OECD, 2023).

Existing studies of the relation between mortality and socioeconomic disparities in Latin America have limited their analyses to average indicators, such as LE or to ecological analysis using area-level socioeconomic status (Bilal et al., 2019; Fantin et al., 2023; Mena & Aburto, 2022). For Brasil, Turra et al. (2016) estimated that 38% of the increase in LE at age 30 for women between 1960 and 2010 may be due to the increase in average years of schooling. Unfortunately, the advancement in LE was accompanied by an expansion in gaps of mortality levels between education groups. Similarly, for Argentina, Manzelli (2014) found a clear gradient between the specific mortality rates and the educational level, with greater inequalities found for men than for women. For Chile, Sandoval and Turra (2015) identified a negative gradient between mortality and education, with an increase in the relative differences between social groups. Finally, for Colombia, an association between premature mortality and educational attainment was found, showing that people with lower education had a higher risk of premature death (Arroyave et al., 2014).

Trends in LE and variability in ages at death in Latin America have been used to assess whether Latin American mortality trends are approximating the mortality regime of developed countries. A study comparing the trends in Europe and Latin America found similar patterns of increase in LE accompanied by a reduction in lifespan variation in both regions (Solís & García-Guerrero, 2019). However, within the Latin American region there are great disparities. Álvarez et al. (2020) identified four groups of countries according to their mortality regimes and closeness to the developed world standard. The two extreme groups are the *forerunners* (e.g., Argentina, Costa Rica) and the *lagging behind* (e.g., Bolivia, Haiti), the later have the largest differences to the mortality of the developed world. Mid-way are those countries affected by amenable diseases with (e.g., Mexico, Venezuela) and without the impact of external causes (e.g., Guatemala, Peru).

Specifically for Mexico, a number of studies have found that the relationship between mortality and SES is contrary to what is found elsewhere. Román Sánchez et al. (2019) showed that in Mexico low-qualified occupations have the highest LE and that mortality is higher among high-qualified occupations, partially attributed to globalization and job precariousness. Moreover, when exploring mortality by SES among older adults and looking at LE at age 60, Rosero-Bixby (2018) found that the educational gradient is reversed for males and non-existent for females. Muradás Troitiño (2010) found that access to health services is an important determinant of mortality from causes related to social inequality among older adults, where those without social security have higher mortality rates. Although these findings are telling, these studies have focused on mortality for specific age groups or causes of death, and only describe differences by occupation, education and access to social security. Therefore, this study contributes to the literature by assessing how changes in SES and mortality affect overall LE and lifespan variation over the period of 1990 and 2015.

Data, Measures, and Methods

We use microdata from the Mexican vital statistics of deaths along with census data. For the population and death counts, we obtain the proportion of deaths by age, sex, and socioeconomic status from the microdata of the Mexican vital statistics of deaths. Similarly, we use the 1990, 2000, and 2010 Mexican Population Census, the Population Counts of 1995 and 2005, and the 2015 Intercensal Survey to estimate the proportion of population by age, sex, and socioeconomic groups. To preserve the overall exposures and death numbers, both proportions were applied to the *Demographic Conciliation*, a demographic exercise that harmonizes the trends in fertility, mortality, and migration to have a complete time series of population by age and sex from 1950 to 2015 according with all the demographic information available (surveys, vital statistics, population census, and counts) (CONAPO, 2017). To ensure a proper representation of the socioeconomic variables, we group exposures and deaths into 5 year age groups starting at age 30.

We estimate LE and standard deviation of the ages at death for ages 30 and above from standard abridged period life tables by age, sex, and socioeconomic status. Standard deviation was chosen over other mortality inequality measures (such as the Gini index or Keyfitz' entropy) due to its simplicity for interpretation and the fact that is expressed in years. Among the usual variables of SES, vital statistics of death provide information on education and occupation of the deceased. Additionally, it includes information on access to social security, which we use as proxy of SES. Thus, we aggregate the population by three variables of SES: (1) educational attainment, (2) occupation, and (3) access to social security. Although these variables may correlate, each variable was analyzed separately to capture the different structural changes that took place during the study period. Educational attainment is classified into six categories: (1) no formal education, (2) incomplete primary school, (3) complete primary school, (4) secondary school (complete), (5) high school (complete), and (6) tertiary education (complete) (INEGI, 2016). Occupation was categorized using the hierarchical groups proposed by (Solís, 2007)[1]: (1) low-skilled, manual; (2) high-skilled, manual; (3) low-skilled, nonmanual; (4) high-skilled, nonmanual, and (5) unemployed.

The Mexican healthcare system is divided into the public and private sectors. The public sector includes the social security institutions—such as the Mexican Social Security Institute (IMSS), the Institute for Social Security and Services for State Workers (ISSSTE), or the institutions for those working in the state oil company, army, or navy (PEMEX, SEDENA, or MARINA)—, and the Health Secretariat. The provision of health services from social security institutions is conditional to the employment status and payment capacity of the worker, although the coverage and benefits of social security may extend to dependent family members of the beneficiary. In other words, beneficiaries are not necessarily currently working or involved in the formal labor market. Those without access to social security rely on health care provided by the Health Secretariat. This fragmentation of the health system generates duplicity of affiliation, inefficiency of healthcare and inequity in the quality of health services (Gómez Dantés et al., 2011). In 2004, the *Seguro Popular*, a public health insurance program, was implemented with the goals of achieving universal health coverage, reducing out-of-pocket health expenditure, and reducing the gap between affiliated and non-affiliated population. *Seguro Popular* mainly provided access to healthcare services to families in the lower six income deciles (Colchero et al., 2022). Because of the nature of the Mexican healthcare system, we refer to it as access to social security, although we do not hint to other services included in social security such as retirement pensions. To represent the fragmentations of the Mexican health system, the variable on access to social security institutions distinguishes between access to (1) social security,[2] (2) *Seguro Popular*,[3] and (3) no access to social security.[4] Because Seguro Popular was introduced in 2004, we limit

[1] Solís proposed four occupational categories based on whether the occupation was manual, and on the degree of specialization and level of authority that it requires. Each group contains the following categories: Low-skilled manual (workers in agriculture, fishing, farming, armed forces and security, assistants in industrial activities, paid domestic workers and craftsmen); high-skilled manual (machine operators, drivers, control staff for industrial production and workers in the transformation industry); low-skilled nonmanual (office workers, sales agents and employees, and control workers); high-skilled nonmanual (officers, directors, specialized technicians and professionals, workers in educations, sports, and arts); unemployed (not working, looking for a job, non-economically active population).

[2] Social security includes the public institutions of IMSS, ISSSTE, PEMEX, SEDENA, and MARINA, as well as private insurances. Although private insurances are not formally a part of social security institutions, they are considered in this category since its clients have payment capacity.

[3] The *Seguro Popular* ran from 2004 until 2019. Its effect is greater among the population with lower income given that it targeted families in the lower six deciles of income and because the population with higher income are mostly affiliated to social security or private institutions.

[4] No affiliation to social security, private health insurance or *Seguro Popular*.

the analysis of the effects of access to social security for the period 2010–2015, for which we have both vital statistics and census data.

We assume that age-specific mortality rates are the weighted average of the group age-specific mortality rates, where the weights correspond to the proportion of population in each subgroup. Therefore, any change in LE or lifespan variation would be a consequence of a change in either the mortality levels or the distribution of the population by socioeconomic group. We refer to the first as M effect, and to the latter as P effect. Our aim is to decompose the change in the LE and standard deviation of the ages at death of the total population (by sex) between 1990 and 2015 into M and P effects. Several demographic decomposition techniques have been developed for this purpose (Andreev et al., 2002; Horiuchi et al., 2008). We apply the stepwise replacement algorithm proposed by Andreev and others (Andreev et al., 2002; Shkolnikov, 2006), which have been widely used for the decomposition of any life-table-based quantity (see the supplementary material for details of the decomposition technique). We implemented this decomposition using the DemoDecomp R package (Riffe, 2018). From this point forward, unless stated otherwise, the mortality indicators conditional to age 30 will be referred simply as life expectancy or lifespan (standard deviation of the ages at death) without explicitly mentioning they are conditional to survival up to age 30.

Results

Between 1990 and 2015, LE increased while lifespan variation decreased. LE increased from 43.3 to 44.8 for males and 47.8 to 49.5 for females, while lifespan variation decreased by around half a year for both sexes. Table 1 shows that in 2015, LE by level of education had a positive gradient, with greater LE among groups with higher educational attainment. A notable exception is the group of women with tertiary education, which showed lower LE than women with high school education. Lifespan inequality—measured using the standard deviation of the ages at death—has a negative gradient with education. Unfortunately, this shows a double burden on the population with lower educational attainment: Not only they have shorter lives, but might face greater potential disparities within them. Females with high school are the exception, with a lifespan variation similar to the females with no formal education. In other words, regardless of educational attainment, women face high disparities in mortality.

Table 1 Life expectancy and lifespan variation at age 30 by education, occupation, and access to social security: Mexico, 2015

Categories	Life expectancy		Lifespan variation	
	Male	Female	Male	Female
Total population	44.83	49.45	15.17	13.39
Education				
No formal education	42.05	47.23	18.30	15.80
Incomplete primary school	41.52	47.06	16.17	14.16
Complete primary school	42.94	49.22	15.91	13.85
Secondary school	46.41	50.30	17.57	13.87
High school	46.57	54.10	16.24	15.30
Tertiary education	48.98	52.56	14.04	13.04
Occupation				
Low-skilled, manual	41.30	64.40	12.60	17.90
High-skilled, manual	39.30	57.72	11.67	14.17
Low-skilled, nonmanual	39.72	51.26	12.37	11.67
High-skilled, nonmanual	43.46	45.46	11.21	9.34
Unemployed	47.73	48.01	19.84	14.38
Access to social security				
Social security	44.60	48.60	13.96	13.21
No social security	41.92	47.98	15.56	12.33
Seguro Popular	47.35	52.02	16.58	14.60

Source: Own calculations based on INEGI (INEGI, 2020)

Access to social security indicates whether the individuals have access to formal social security institutions

Occupation was classified in a hierarchical way (Román Sánchez et al., 2019), so we expect a positive gradient between occupation and LE, and a negative gradient between occupation and the standard deviation of the ages at death. However, results shown in Table 1 do not follow this pattern. Instead, we see a negative gradient among occupational categories on both mortality indicators for females and an unclear pattern for males. Among the working population, men performing high-skilled, nonmanual occupations exhibit the highest LE, followed by the low-skilled, manual occupational class. The unemployed population stands out for having very similar LE (for both men and women) and for having high lifespan variations. LE among women in low-skilled manual occupations (64.4 years) is much higher than other occupations. These results raise concerns on data quality issues of the occupation variable, an issue that we expand on later in the discussion section.

Results show that those without access to social security have the lowest LE. However, the group with the highest LE is the one with affiliates to *Seguro Popular*. Regarding lifespan variation, women without access to social security have the lowest uncertainty about the age at death, whereas women affiliated with *Seguro Popular* have the greatest uncertainty. For men, the lowest and the highest lifespan variations are found among those with access to social security institutions and those affiliated with *Seguro Popular*, accordingly.

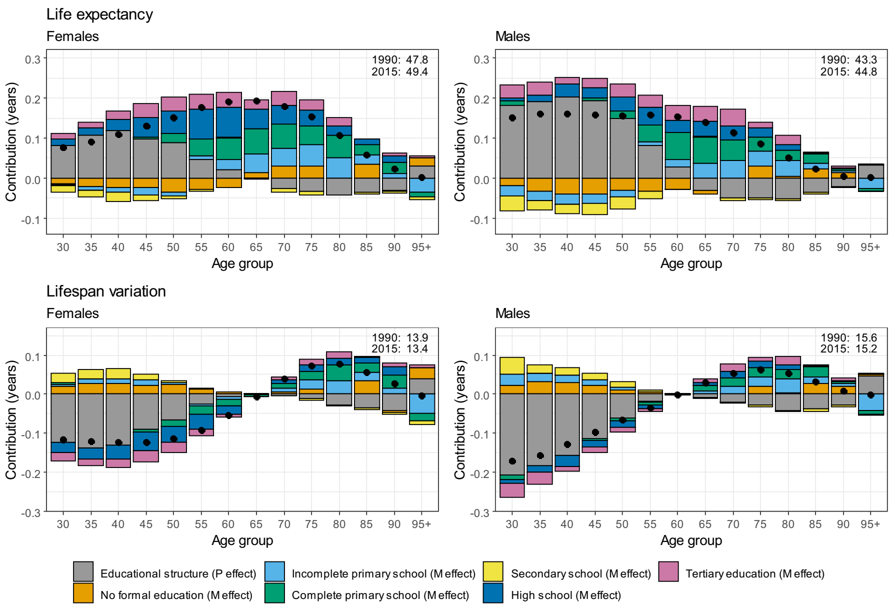

Fig. 1 Mortality and population composition by educational attainment effects over change in mortality indicators at age 30 between 1990 and 2015, Mexico. The figure shows the effects of the change in mortality levels (M effect) and the change in population composition by education level (P effect) over the change in LE (upper row) and lifespan variation (lower row) between 1990 and 2015. Positive values indicate a contribution to the increase in LE/lifespan variation, while negative values indicate a contribution to the reduction in LE/lifespan variation. The points represent the total contribution of each age group, which is the sum of all the bars with their corresponding positive or negative sign. The values in the top right corner are the LE and lifespan variation at age 30 on each year. Source: Own calculations based on INEGI (INEGI, 2020)

Tables 2, 3, and 4 show the results of the decomposition of this increase in LE and decrease in lifespan variation during the study period, into the contribution of mortality changes within each socioeconomic group (M effect) and the contribution of changes in the proportion of population in each of these subgroups (P effect).[5] Positive values indicate a contribution to the increase in LE/lifespan variation, while negative values indicate a contribution to the reduction in LE/lifespan variation. Note that for life expectancy it is desired for contributions to be positive, while for lifespan variation negative. Figures 1, 2, and 3 present the further decomposition of the M and P effects by age group. The total contribution of a given age group (shown by the points) is the sum of its respective M and P effects (e.g., in Fig. 1 the age group 30–34, has a positive contribution on overall LE change as it has more positive than negative effects). The sum of the bars of all age groups, with their corresponding positive or negative value, is equal to the total change in LE/lifespan variation shown in Tables 1, 2 and 3.

Reductions in mortality will always have a positive effect for LE, regardless of the age at which they occur. However, in the case of lifespan variation, there

[5] The decomposition for education and occupation is performed for the period 1990–2015. The decomposition for the access to social security variable is performed for the period 2010–2015.

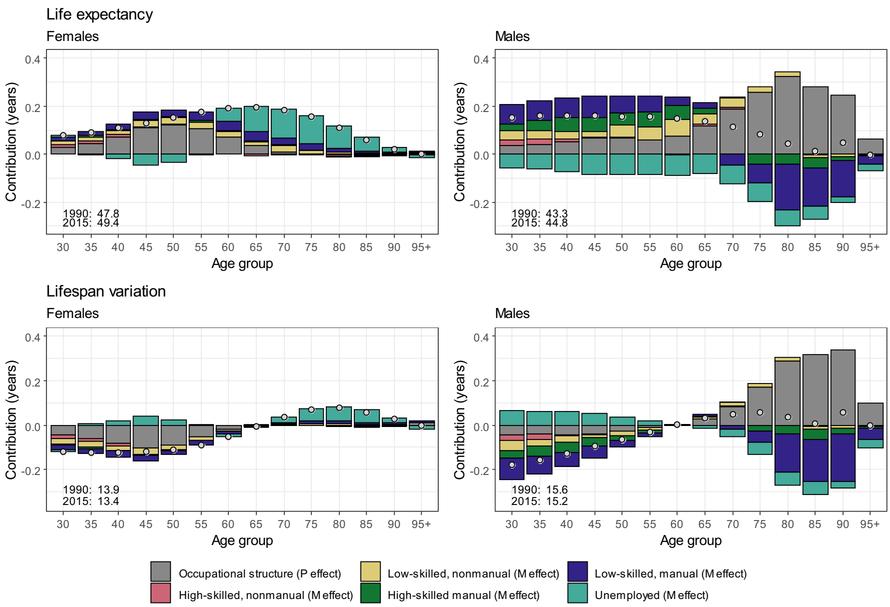

Fig. 2 Mortality and population composition by occupational class effects over change in mortality indicators at age 30 between 1990 and 2015, Mexico. The figure shows the effects of the change in mortality levels (M effect) and the change in population composition by occupation (P effect) over the change in LE (upper row) and lifespan variation (lower row) between 1990 and 2015. Positive values indicate a contribution to the increase in LE/lifespan variation, while negative values indicate a contribution to the reduction in LE/lifespan variation. The points represent the total contribution of each age group, which is the sum of all the bars with their corresponding positive or negative sign. The values in the top bottom corner are the LE and the lifespan variation at age 30 on each year. Source: Own calculations based on INEGI (INEGI, 2020)

is a threshold age above which reductions in mortality lead to increases in lifespan variation (Aburto et al., 2020). The lower row of Figs. 1, 2, and 3 show evidence of the threshold age for certain groups. For example, in lifespan variation for men by access to social security, the P effect has a negative contribution up to about age 60 and a positive contribution after this, while for LE the P effect is always positive. It is important to mention that the shifting of effects, from positive to negative or vice versa, before and after the threshold age, is a consequence of how lifespan variation weights mortality reductions after the threshold age. It does not mean that after certain ages mortality conditions worsened. For example, for the population with tertiary education, mortality decrease in all age groups, which had a positive impact over LE for all age groups. In the case of lifespan variation, this decrease in mortality lowers lifespan variation before the threshold age (approximately 65 for females and 60 for males) and increases lifespan variation after this age.

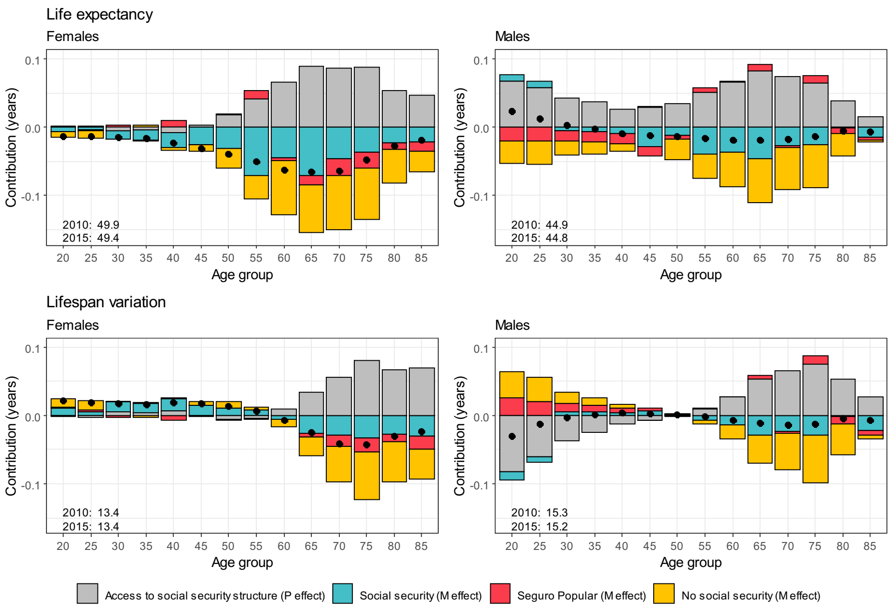

Fig. 3 Mortality and population composition by access to social effects over change in mortality indicators at age 30 between 2010 and 2015, Mexico. The figure shows the effects of the change in mortality levels (M effect) and the change in population composition by access to social security (P effect) over the change in LE (upper row) and lifespan variation (lower row) between 2010 and 2015. Positive values indicate a contribution to the increase in LE/lifespan variation, while negative values indicate a contribution to the reduction in LE/lifespan variation. The points represent the total contribution of each age group, which is the sum of all the bars with their corresponding positive or negative sign. The values in the bottom right corner are the LE and the lifespan variation at age 30 on each year. Source: Own calculations based on INEGI (INEGI, 2020)

For males, the change in population composition by educational attainment (P effect) had a greater contribution to the increase in LE than the change in mortality levels (M effect) (see Table 2). Focusing on the M effects, the increase in male LE was driven mainly by mortality reductions of the population with tertiary education. For women, the main contributor was the mortality of the population with complete primary and with more than high school education. In contrast, the group with secondary school education had a negative contribution to the change in LE. Death rates of this group increased from 1990 to 2015, and this might have been a consequence of changes in population composition. With the increase in educational attainment, middle school education became more common among the Mexican population. Consequently, the association between educational attainment and SES shifted, causing the middle school education group to represent a lower SES than it did before.

Table 2 Contributions of changes in population composition by educational attainment (P effect) and mortality (M effect) over change in mortality indicators at age 30 between 1990 and 2015, Mexico

	Life expectancy		Lifespan variation	
	Male	Female	Male	Female
Education				
P effect (composition)	0.83	0.42	– 0.86	– 0.67
M effect (mortality)	0.70	1.22	0.44	0.18
No formal education	– 0.15	– 0.04	0.20	0.22
Incomplete primary school	0.06	0.18	0.15	0.09
Complete primary school	0.35	0.39	0.08	0.05
Secondary school	– 0.18	– 0.12	0.10	0.07
High school	0.30	0.51	– 0.04	– 0.16
Tertiary education	0.33	0.31	– 0.04	– 0.09
Total difference	1.52	1.65	– 0.42	– 0.48

Source: Own calculations based on INEGI (INEGI, 2020)

The P effect over the lifespan variation is negative, showing that the increase in national educational attainment contributed to reduce mortality inequalities. Nonetheless, among males, high mortality among young adults with less than high school education cancels out some of the previous effect (Fig. 1), while the death rates of the population with more than high school education favors the reduction in the lifespan variation. Hence, an increase in the proportion of population with high school would have a positive impact in decreasing the inequality in the length of life.The positive effect of population composition (P effect) by educational attainment is concentrated in the age group under age 60. After this age, the contribution becomes negative, thus, indicating that the increase in educational attainment is a recent phenomenon still not present in the mortality trends of the older age groups. On the contrary, the contribution of old-age mortality to the increase in LE is caused by the decrease in death rates of the lower education groups, which can be explained by a cohort effect—meaning that in older ages, it is common to have a low educational attainment, and therefore, education as a social determinant of health loses strength. Some authors have identified that educational attainment and occupation have less impact on health after retirement, suggesting that during the later-life stage, the accumulated wealth over the working years becomes more relevant as a determinant of health (Hoffmann et al., 2019). Another factor that may be at play here is the crossover in mortality among education categories. A positive gradient between mortality and educational attainment in older ages may reflect selectivity of survival. Similar patterns have been found in Japan, Denmark, the United States, and Finland (Hoffmann, 2011; Hoffmann et al., 2019; Liang et al., 2002).

The P effect for the distribution by occupation over the increase in LE from 1990 to 2015 was higher for men than for women (see Table 3). Men gained 1.9 years of LE because of the shifts in distribution by occupation, with a loss in the proportion of manual workers and an increase in nonmanual and unemployed population. The growth of the latter occupational class may be a consequence of the increase in population at retirement. The unemployed population had the biggest contribution to the M effect. Among women, this class accounted for almost half a year of the raise in LE. Instead, the LE of the unemployed men worsened during the period (see Fig. 2).

Table 3 Contributions of changes in population composition by occupation (P effect) and mortality (M effect) over change in mortality indicators at age 30 between 1990 and 2015, Mexico

	Life Expectancy		Lifespan Variation	
	Male	Female	Male	Female
Occupation				
P effect (composition)	1.88	0.60	1.11	– 0.44
M effect (mortality)	– 0.35	1.04	– 1.53	– 0.04
Low-skilled, manual	– 0.13	0.32	– 1.03	– 0.10
High-skilled, manual	0.24	0.03	– 0.34	– 0.03
Low-skilled, nonmanual	0.40	0.23	– 0.12	– 0.12
High-skilled, nonmanual	0.07	0.01	– 0.06	– 0.06
Unemployed	– 0.94	0.46	0.01	0.27
Total difference	1.52	1.64	– 0.42	– 0.48

Source: Own calculations based on INEGI (INEGI, 2020)

During 1990–2015, lifespan variation decreased around 0.5 years for both men and women. The P effect of the unemployed population contributed to a reduction of 0.5 years in the case of women. For men, the P effect increased the lifespan variation, mainly due to mortality at older ages. As shown earlier, unemployed men have the highest lifespan variation. Thus, an increase in the proportion of the total male population, as the one observed with an increase from 19 percent in 1990 to 23 percent in 2015 (see Fig. S2 in supplementary material), may explain the impact of the P effect over the increase in the standard deviation of the ages at death.The *Seguro Popular* program started in 2004, steadily absorbing the population without access to social security and consequently increasing year by year (see Fig. S3 supplementary material). Thus, access to social security institutions changed during our study period. To control for this structural transformation, the decomposition for this socioeconomic variable was performed for the period 2010–2015 only. The shorter period allows for modest changes, so we expect to find smaller M and P effects than those presented earlier for educational attainment and occupation. For comparison, in the supplementary material we present the results of educational attainment and occupation restricted for the period 2010–2015.

Table 4 Contributions of changes in population composition by access to social security (P effect) and mortality (M effect) over change in mortality indicators at age 30 between 2010 and 2015, Mexico

	Life expectancy		Lifespan variation	
	Male	Female	Male	Female
Access to social security				
P effect (composition)	0.69	0.48	0.08	0.32
M effect (mortality)	– 0.78	– 0.97	– 0.18	– 0.36
Social security	– 0.23	– 0.43	– 0.12	– 0.06
No social security	– 0.45	– 0.47	– 0.13	– 0.22
Seguro Popular	– 0.09	– 0.07	0.08	– 0.08
Total difference	– 0.09	– 0.49	– 0.09	– 0.04

Source: Own calculations based on INEGI (INEGI, 2020)
Access to social security indicates whether the individuals have access to formal social security institutions

In this short period of time, LE stagnated for men and decreased one-half year for women. Nevertheless, the P effect over these differences shows the impact of the introduction of *Seguro Popular* program over the stagnation of the mortality indicators. The share of population affiliated to *Seguro Popular* doubled from 2010 to 2015, from 20 to 40 percent, absorbing the population without access to social security institutions. This shift accounted for a gain of 0.7 years in male LE and 0.5 years in female LE (see Table 4).However, adverse mortality conditions (M effect) nullified the progress obtained from the health coverage provided by *Seguro Popular.* Death rates of population without access to social security had the greatest negative effect over LE (see Fig. 3)—thus, demonstrating the growing inequality for those who remained without health coverage, who not only lacked access to health services, but also experienced higher mortality rates.

Discussion

The decomposition of the change of mortality during 1990–2015 in M and P effects contributes to understanding socioeconomic inequalities of mortality in Mexico. The effect of the changes in population composition by socioeconomic status (P effect) is greater for men than for women. Evidence shows that it may be due to smaller shifts in SES for women or because of a small influence of SES over women's mortality. On either case, it confirms that the mechanisms by which SES impacts individual health varies by sex. Previous studies for European countries have shown that the size of the gap between health and mortality indicators by sex depends on the variables characterizing SES, with smaller differences found when using educational attainment and greater ones when using income (Hoffmann et al., 2019). Some authors have suggested that the different effects of socioeconomic variables reflect how these indicators associate with gender roles and other socially constructed processes (Borrell et al., 2014). As a result, scholars have suggested to broaden the spectrum of socioeconomic indicators to include those that reflect better gender and social organization (such as household resources, level of support at home, and division between paid and unpaid work), as well as other social determinants of health (Cambois, 2016). Unfortunately, the Mexican death registry does not collect data on such variables and does not allow record linking to other data sources.

Our results show that educational attainment (P effect) impacts LE positively, and this is consistent with similar studies for European countries (Enroth et al., 2022; Luy et al., 2019). Moreover, secondary school education represents a threshold level for health, meaning that attaining this level of education enhances the duration of life and decreases the uncertainty associated with the age at death. Given the magnitude of the benefits of the increase in educational attainment over the increase in LE, some authors have recommended the implementation of health policies that aim to broaden the offer to formal education and, thus, increase educational attainment (Deboosere et al., 2009; Hendi, 2015; Marmot, 2005). In this regard, special care should be taken with the social programs that seek to raise higher education enrollment because without the proper support of multisectoral policies focused on improving the social conditions of certain population groups, such as those without formal education, the educational gradient may actually increase (Cárdenas, 2010).

Another important finding from the present study is that the population without formal education and those without access to social security are in the worst socioeconomic positions for mortality. Both groups showed the greatest adverse effects over mortality at the national level, decreasing LE and increasing the standard deviation of ages at death. These are not very encouraging findings for the population without formal education and those without access to social security. With the introduction of *Seguro Popular* and with the increase in average educational attainment, the numbers of population in these two groups have decreased, which in turn may lead to an invisibility that will only worsen the marginalization to which they are already subject to. Thus, as a consequence of two simultaneous processes, we see an inverse selection towards worse health conditions and becoming a more vulnerable group (Deboosere et al., 2009).

It is important to note that we do not claim a causal relationship between affiliation to the *Seguro Popular* and mortality, as our study does not allow for this. Rather, we show different mortality patterns between those with and without *Seguro Popular*. This may be due to several factors, ranging from a selection mechanism—those who affiliated tend to take better care for their health or have better access to health services—to an actual protective mechanism of the program, which we cannot test. Other studies have looked at the effect of *Seguro Popular* on the use of health services and on health outcomes, and the results show mixed evidence (Colchero et al., 2022). The most supported finding is that the effects of *Seguro Popular* are larger in areas with greater supply of health services or health professionals (Parker et al., 2018). Our results contribute by showing the differential patterns of mortality caused by a fragmented health system. The fact that the *Seguro Popular* ended in 2019 by President López Obrador opens the venue for future research on the potential impacts of this closure to the program as well as future policy implications on how to design health programs that help reduce inequalities in mortality.

The P effect suggests that the introduction of *Seguro Popular* program contributed to the rise of LE by about one-half year. However, adverse mortality conditions—M effect—nullified such progress. We also found that individuals affiliated to *Seguro Popular* have higher LE than those who remained without social security. However, the higher LE was accompanied by a higher lifespan inequality. Thus, affiliates to *Seguro Popular* faced favorable conditions in one dimension of mortality—life expectancy—and adverse conditions in another—the dispersion of age at death. On the one hand, the expansion of *Seguro Popular* enlarged the percentage of the population with access to health services, which seems to have a positive effect on LE. On the other hand, a segment of the population was left out of this program—probably the most vulnerable groups—therefore, adding another layer of vulnerability for them. One of the initial goals of *Seguro Popular* was the universal health coverage for Mexican population, so inequalities in mortality will persist as long as that goal remains unfulfilled. This highlights the importance of coupling the adoption of structural changes, such as the introduction of *Seguro Popular*¸ with adequate public policies that target specific problems and generate expected results. If not, we find negative results, where improvements on one front—such as greater health coverage—are slowed by decays or stagnations in other fronts—such as the prevalence of high mortality rates.[6] The present study suggests that the provision of health services has a positive impact on mortality reductions, and without a proper continuation, all the progress made on this front may be lost.

The use of different variables to represent the socioeconomic position of individuals is a strength of our study. Each variable helps understanding different aspects of health inequalities. Educational attainment highlights the educational gradient in Mexico and the importance of increasing educational enrollment to improve the health of the population, while access to social security shows unequal health conditions in a fragmented health system. Unfortunately, in our study, occupation does not show a clear pattern for us to draw clear conclusions, although our findings allow for identifying the more marginalized groups.

However, there are a number of issues on occupation that deserve future research and thought. First, the unexpected results for occupation raise questions on the data quality for this variable. By recording the occupation at the time of death, older individuals who are retired get registered without occupation and are, therefore, grouped with the unemployed, which is not indicative of their lifetime occupation. A further analysis of the age distribution of population by occupational class shows that the younger and older age groups have the greatest proportion of unemployed population, causing the death distribution curve for the unemployed male population to be bimodal. There is a higher accumulation of deaths on the older age groups and this causes high LE found for unemployed males (see Fig. S2 in supplementary material). Because the two extreme age groups coincide in the same occupational category, the standard deviation of the ages at death is high. In Mexico, the age distribution of the unemployed group has been attributed to two factors: the raise in educational attainment that delays the entrance to the labor market and the retirement age set at 65 (Pérez Amador, 2006). Second, mortality indicators for women segmented by occupational class are unstable through time because of the small

6 In 2019, the *Seguro Popular* program was replaced by the Institute of Health for Well-being (INSABI by its acronym in Spanish).

percentage of the female working population, especially in nonmanual occupations. Mexico has one of the lowest female labor force participation rates among OECD countries. In Mexico, female labor force participation rate is 45 percent. Therefore, according to the available occupation categories in death certificates, more than half of the women would be cataloged as unemployed. It is unclear whether increasing labor force participation would impact positively on mortality among women in a context of high informal employment, high precariousness, lack of policies balancing family and work, and other social policies with/without a gender perspective affecting work in Mexico. Third, occupation is a time-varying characteristic that is particularly responsive to changes in the structural conditions of the labor market and, thus, occupation at death might reflect a heterogeneous set of experiences of job precariousness and vulnerability over the life course. For all these reasons, findings on occupation should be taken cautiously and these shortcomings should encourage to improve the quality of the occupational information on death registries to conduct future research (Román Sánchez et al., 2019). Another limitation of our study refers to the lack of individual-level register data that can be linked to death registries. Consequently, the socioeconomic information of the deceased is reported by a third party who may report the information with different degrees of error.

Final Remarks

Between 1990 and 2015, important structural changes took place in Mexico: school enrollment and average educational attainment increased, the *Seguro Popular* program was introduced, and some occupations became more specialized through technological change. The present study sheds some light on the positive effects of these structural changes regarding the increase in LE and, to a lesser extent, the reduction in the standard deviation of the ages at death. Our findings, thus, support the idea that an optimal strategy to reduce health inequalities should change the population composition so that more individuals have access to a better quality of life or well-being (Deboosere et al., 2009). Along with this, it is important to control the negative selectivity and the marginalization of the most vulnerable that will result from the reduction of the weight of such groups on the total population (Hendi, 2015).

This study contributes to the research of lifespan inequalities by elaborating in the differences among SES using socioeconomic characteristics of the individuals instead of area-level socioeconomic information. It also identifies some of the factors that contribute to the socioeconomic inequalities in mortality in Mexico, especially the population composition effects. In this study we adopted an analysis by sex at the national level. We hope these findings spur future research exploring geographical variations that might shape mortality (i.e., rural or urban residence, state or regional geographic differences in development and marginality) as well as other social processes affecting health and mortality in Mexico (i.e., internal or international migration, or ethnicity). This would allow us to understand whether heterogeneous health conditions at a subnational level (already documented in Gómez-Dantés et al., 2016; Stevens et al., 2008)), are associated with differential patterns of mortality inequalities. It would also be interesting for future studies to analyze the differential effects of the various mortality causes in each socioeconomic group. Today, the SARS-CoV-2 virus, responsible for the COVID-19 disease, is triggering a turning point in the epidemiological history of humanity. The economic and health consequences of such disease are still unimaginable and, more than ever, research on the inequality in the length of life and its differential effects by SES is fundamental to develop strategies for better health of the population.

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Data Availability Data are available at https://www.inegi.org.mx/programas/mortalidad/. The code is available upon request.

Declarations

Conflicts of interest All authors declare no support from any organization for the submitted work, no financial relationships with any organizations that might have an interest in the submitted work in the previous three years, and no other relationships or activities that could appear to have influenced the submitted work.

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