

Mortality inequality among older adults in Mexico: the combined role of infectious and chronic diseases

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ABSTRACT

Objective. To assess the effects of education and chronic and/or infectious disease, and the interaction between both variables, on the risk of dying among Mexicans 60 years and older.

Methods. Using data from the Mexican Health and Aging Study (MHAS), logistic regressions were performed to estimate the risk of mortality for older Mexicans between 2001 and 2003. Estimated mortality risks associated with chronic disease, infectious disease, and a combination of both were used to estimate additional life expectancy at age 60.

Results. Compared to the group with some schooling, the probability of dying over the two-year inter-wave period was 26% higher among those with no schooling. Not having at least one year of formal education translated into a shorter additional life expectancy at age 60 by 1.4–2.0 years. Having chronic and/or infectious disease also increased the risk of mortality during the same period.

Conclusions. These results indicate that 1) a mixed epidemiological regime (the presence of both chronic and infectious disease) adds to the mortality health burden experienced by older people, and 2) there are persistent inequalities in mortality risks based on socioeconomic status.

Key words

Mortality; aging; life expectancy; health inequalities; Mexico.

The demographic processes experienced in most countries in Latin America over the last century are characterized by changes in mortality and fertility compressed into a very short period. As a result, population aging has increased at an unprecedented pace that might be sustained well into the middle of the 21st

century. Evidence for this change can be seen in increases in the proportion of people more than 60 years old. In Mexico in 2010, this population subgroup comprised about 10 million people and represented 9.1% of the total population. According to projections from the National Population Council (*Consejo Nacional de Población*, CONAPO), the population in this age group will increase to about 17.1% and 27.7% in 2030 and 2050 respectively (1). Parallel to the aging of the population, many developing countries also experience an epidemiological transition in which chronic

degenerative diseases gain ground while infectious diseases lose relative importance as causes of mortality (2).

During these two transitional processes, Mexico and other low- and middle-income countries (LMICs) have experienced institutional fragility, macroeconomic reversals, and political upheavals coupled with only small improvements in poverty alleviation and income inequality. As a result, within certain populations, sharp inequalities in health and mortality risks may continue to prevail at the same rate, or even increase, as those with higher socio-

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economic status experience conditions associated with advanced stages of the epidemiological transition, while the poorest groups remain locked in pre-transition stages (3).

A vast body of research on the unequal distribution of health demonstrates that factors shaped by individuals' relative socioeconomic position in society account for most of the health status and mortality differences between groups. The most disadvantaged are more likely to become ill, to experience longer and more frequent episodes of sickness, and to benefit less from advances in medical technology that attenuate the impact of diseases, and thus tend to experience the full impact of excess comorbidity and higher mortality risks, whereas people in better social positions do not.

Other factors mediate these disparities in health and mortality, including 1) time of disease onset, 2) level of education, 3) quality of disease control, 4) overall life expectancy (time spent with disability), and 5) government health investments (resources spent on training health personnel, and new treatments and technologies, among others).

The emergence and dominance of chronic versus infectious conditions and diseases during an epidemiological transition is more evident among older age groups. In Mexico in 2010, the main cause of death for men 65 years and older was cardiovascular disease, representing 23.8% of all deaths, followed by diabetes and malignant tumors (14.2% and 13.0% of all deaths respectively). A similar trend was found for women in the same age group, for whom cardiovascular disease was the leading cause of mortality, representing 25.1% of all deaths, followed by diabetes mellitus (17.3%) and malignant tumors (10.9%) (4).

Although infectious diseases have lost importance as leading causes of death in Mexico across all age groups, particularly among older adults, they are still prevalent and have not been diluted to the same extent as in high-income countries. Influenza and pneumonia are the seventh most common cause of death among older Mexicans, followed by intestinal infections and various parasitic diseases. With a few exceptions, as noted by Sampedro-Ternent et al. (5), the consequences of the double burden of both chronic and infectious disease, which have been classified in two separate categories throughout the history of medicine, and

the degree to which health deterioration, disability, and mortality are exacerbated by the interaction between them, have not been assessed. This report describes this double burden and its effect on Mexican elderly, highlighting its impact on health and mortality inequalities and addressing the following questions: 1) Are the health disparities referred to above exacerbated, attenuated, or otherwise modulated by mixed epidemiological regimes? and 2) In countries such as Mexico, does the interaction between infectious and chronic diseases exact a much higher toll among disadvantaged groups and thus reinforce health disparities?

In most studies of health and mortality disparities, socioeconomic status (SES) is captured by indicators such as occupation, income, and education, either in combination or alone. This method has well-known deficiencies but establishes a benchmark for comparisons by SES. Of all the indicators used to determine social position within a hierarchy, educational attainment is the most defensible. This indicator best captures early- and late-life exposure and the cumulative nature of the associated effects of education on adult health and mortality risks. One remarkable and unexplained finding about education level is that its effects on health and mortality disparities are persistent, ubiquitous, and robust when tested using controls and modeling strategies (6–8). For this reason, and to ensure the ability to compare the results to other, similar research findings, this study used education level as the metric for assessing social class rank.

Assuming educational attainment is a good albeit limited proxy for social and economic standing, the question remains as to whether the joint occurrence of infectious and chronic comorbidities exacerbates mortality risks more among those with low levels of education versus those with more schooling. Determining if 1) infectious and chronic diseases occurring in tandem increase the mortality risk beyond the additive effects of each of those conditions taken separately and 2) the associated excess mortality risk differs by educational attainment is not a common objective in the literature but is one of several ways to identify the mechanism(s) through which education creates health and mortality disparities in societies that are experiencing the double burden of chronic and infectious diseases (9, 10).

In addition to employing a different theoretical lens with which to study educational disparities, and in contrast to the bulk of research on the double burden of infectious and chronic disease, this report is based on panel data rather than cross-sectional information. This method allows for 1) tracking of specific individuals over time, 2) identification of the main causes of death, and 3) estimation of years of life lost (YLL) due to disease while simultaneously accounting for initial conditions, including health status, family circumstances, and general socioeconomic conditions (10). The study, which focused on individuals 60 years and older, estimated the effects of education on subsequent mortality rates and life expectancies over a two-year follow-up period, and separated educational disparities into two categories, one associated with the prevalence of infectious and chronic diseases and the other with antecedent demographic attributes. The objective was to assess the impact of 1) schooling (classifying participants as “with education” or “without education”); 2) chronic and infectious diseases; and 3) the interaction between the two sets of variables. Two main theories were investigated: 1) individuals without schooling experience higher mortality risk and burden of disease (both chronic and infectious) than those with some or high levels of education and 2) the joint occurrence of chronic and infectious disease raises mortality risks beyond their additive effects, particularly among individuals at the lower end of the educational attainment spectrum. Confirmation of these theories has important implications in terms of both policy and research. Health policymakers should be vigilant in monitoring infectious diseases as part of the disease profile of the elderly, even when faced with the rising prevalence of chronic diseases, and evidence of interactions between chronic and infectious disease should prompt and encourage epidemiological and clinical research to identify the processes through which their joint occurrence augments mortality risks. In the realm of research, demographers and health specialists may want to reconsider established paradigms and acknowledge that an epidemiological transition stage in which a mixed regime of infectious and chronic disease prevails may have a longer duration and more consequences than previously thought.

MATERIALS AND METHODS

The data source for the current research was the Mexican Health and Aging Study (MHAS), a nationally and urban-rural representative sample of adults aged 50 years and older residing in Mexico in 2001. Designed to examine the aging process and evaluate the impact of disease on health outcomes such as functional capacity and mortality, the MHAS consisted of two waves of data collection: the baseline interview in 2001, and the follow-up period in 2003. This report uses information from both waves to construct the demographic, health, and socioeconomic variables for 2001 and establish their association with mortality for 2003. The information for 2003 was obtained using two different questionnaires, a direct interview for survivors and an exit interview completed by a proxy for those who died between 2001 and 2003. The analyses covered adults who were 60 years or older at baseline and had complete information for both waves of data collection. A total of 6 827 records, representing 6 970 771 individuals, were used. There were 6 377 records for individuals alive in 2003, and 450 records for individuals who died between 2001 and 2003. A total of 339 individuals with missing data for vital status were excluded from the analyses.

Logistic regression models were employed to estimate odds ratios (ORs) and the probabilities of death between 2001 and 2003. The latter metric was used to calculate standard life table functions and life expectancies of subgroups with different combinations of educational attainment and prevalence of chronic and infectious disease. The dependent dichotomous variable, "survival status in 2003," was coded as "0" if individuals were alive in 2003 and "1" if they were known to have died in the inter-wave period (between 2001 and 2003). Various independent variables were used as controls for confounders, treatment (educational level), and status of infectious and chronic disease in 2001, including: 1) a dichotomous variable for education, coded as "1" if the individual reported no schooling ("0 years of formal education") and "0" otherwise ("1 or more years of education"); 2) dichotomous variables to flag the self-reported occurrence of chronic disease (coded as "1" if at least one disease was reported (hypertension, diabetes, heart

TABLE 1. Distribution of the population 60 years and older by self-reported disease, demographic characteristic, and vital status, Mexico, 2001–2003

Self-reported disease/ demographic characteristic	Vital status (2003)				<i>P</i> ^b
	Alive (6 377)		Dead ^a (450)		
	No.	%	No.	%	
Self-reported disease (2001)					
Chronic	3 903	63.81	333	76.03	0.000
Infectious	701	10.06	84	16.36	0.000
Chronic and infectious	548	8.54	71	13.60	0.000
Demographic characteristic					
Age (years, mean) (SD) ^c	69.1 (7.3)		75.4 (9.7)		0.000
Men (%)	46.2		51.1		0.041
Education (years, mean) (SD)	3.5 (3.9)		2.9 (3.6)		0.002
More urban (%)	41.3		40.8		0.925

Source: author calculations based on data from the Mexican Health and Aging Study (MHAS), 2001–2003.

^a Information for the deceased was obtained by proxy.

^b Chi-square test for categorical variables and ANOVA for continuous variables to test differences across categories of vital status.

^c SD: standard deviation.

attack, cancer, lung disease, stroke, or arthritis) and "0" otherwise), and infectious disease (coded as "1" if at least one disease was reported (liver or kidney infection, tuberculosis, or pneumonia) and "0" otherwise);^{4,5} and 3) controls for demographic traits evaluated at baseline, including gender, age (continuous), marital status (with or without spouse or partner), urban/rural residence, income (a dummy indicator coded as "1" if the individual received less than two Mexican minimum wages and "0" otherwise), and assets (a dummy indicator coded as "1" if the household possessed fewer than two of four assets (refrigerator, washing machine, telephone, and water heater) and "0" otherwise).

RESULTS

Table 1 shows health and demographic characteristics of older adults in 2001 by survival status in 2003. An initial comparison between survivors and decedents shows that those who survived had on average more years of education. Statistically significant differences were found in the percentage of people

reporting chronic and infectious diseases by survival status. Not surprisingly, survivors were younger and more likely to be women. Despite the well-known differences by type of locality in prevalence of chronic diseases such as hypertension, diabetes, heart attack, cancer, and lung disease, no statistically significant differences were found in the survival rate by urban versus rural residence. Statistically significant differences were found for the education variable ($P = 0.002$) with regard to survival rates: of those who died between 2001 and 2003, 67.2% had no formal education, and 57.7% of those who survived had no education. However, no statistically significant differences were found in self-reported chronic and infectious diseases by education level (data not shown). There are also certain socioeconomic, demographic, and lifestyle factors that could have affected participants' health (e.g., tobacco consumption (56% had never smoked, 29% were former smokers, and 15% were current smokers) and alcohol consumption (9% had never consumed alcohol, 66% were former drinkers, and 25% were current drinkers)), with clear differences by sex.

Table 2 includes the results of regression models for mortality over the two-year inter-wave period. Model 1 included education level only. Model 2 added baseline socio-demographic characteristics. Model 3 added indicators for the presence of chronic and infectious disease as well as an indicator for interaction between chronic and infectious disease. More complicated models

⁴ For chronic diseases, the survey question was: "Has a doctor or medical personnel ever told you that you have [...]" For infectious diseases, the survey question was: "In the last two years, has a doctor or medical personnel told you that you have [...]"

⁵ Initially, every disease was coded as a single dichotomous variable, but because some diseases were rarely reported, the resulting prevalence rate was low and the sample size small. Therefore, the selected diseases were grouped together, regardless of severity.

TABLE 2. Logistic regression model odds ratios (ORs) for mortality over a two-year period among the population 60 years and older, by explanatory variable and model, Mexico, 2001–2003

Explanatory variable	OR		
	Model 1	Model 2	Model 3
No schooling (ref ^a : 1–19 years)	1.505 ^b	1.225 ^c	1.261 ^c
Men (ref: women)		1.409 ^b	1.573 ^b
Age (continuous)		1.085 ^b	1.086 ^b
With spouse/partner (ref: without)		0.675 ^b	0.699 ^d
More urban (ref: rural)		1.098	1.049
With chronic disease (ref: without)			1.749 ^c
With infectious disease (ref: without)			1.747
With chronic and infectious disease (ref: without)			1.018
<i>n</i>	6 755	6 755	6 755
Chi-square test	442.091 ^b	507.814 ^b	705.822 ^b
BIC ^e	2 925.13	2 885.861	2 749.579

Source: Author calculations based on data from the Mexican Health and Aging Study (MHAS), 2001–2003.

^a ref = reference.

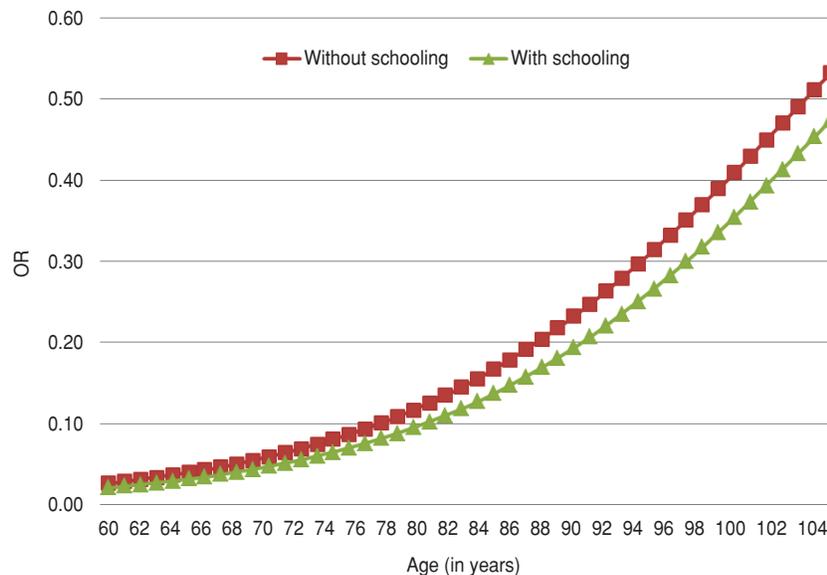
^b *P* < 0.001.

^c *P* < 0.05.

^d *P* < 0.01.

^e BIC = Bayesian information criterion.

FIGURE 1. Probability of death for the population 60 years and older, by education, Mexico, 2001–2003^{a-c}



Source: author calculations based on data from the Mexican Health and Aging Study (MHAS), 2001–2003.

^a Predicted probabilities of death were calculated using logistic regression odds ratios for mortality over a two-year period.

^b For each model the variables “age,” “sex,” “with partner,” and “urban/rural” were held at the mean value.

^c “Without schooling” = 0 years of formal education; “with schooling” = ≥ 1 year of formal education.

that included indicators for interaction between education and chronic disease and between education and infectious disease did not yield interesting results and were therefore omitted.

Results for Model 1 revealed evidence of a positive and statistically significant effect on mortality for no education (“with-

out schooling”): the OR was 1.505 (95% confidence interval (CI): 1.23, 1.83). Model 2 showed evidence that controlling for demographic characteristics does not dilute the effects of a lack of education, which continues to have a negative and statistically significant effect on mortality at advanced ages. These results also showed

that the odds of dying 1) increased with age and with the absence of a spouse or partner, and 2) were higher for males than females (OR = 1.085; 95% CI: 1.07, 1.09), as expected.

Estimates from Model 3 suggested that the effect of education on mortality persisted and remained strong even after controlling for demographic variables and the prevalence of chronic and infectious disease. For example, the probability of dying in the two-year inter-wave period was 26% higher among those with no schooling compared to those with one or more years of formal education.

To clarify the magnitude of the identified effects, age-specific predicted probabilities of dying associated with the estimated ORs were calculated (Figure 1). The results indicated the conditional probability of dying during the first wave of the survey for an individual 60 years old with no schooling was 0.03, whereas that for a person of similar age but with some schooling was 0.02. These predicted conditional probabilities of death were converted into standard life table functions and conditional additional life expectancy for a number of subgroups defined by educational attainment and the presence of chronic and/or infectious disease using estimates associated with Model 3.

The predicted probability of death was calculated for education (“with schooling” and “without schooling”); presence of chronic disease (“no” and “yes”); presence of infectious disease (“no” and “yes”); and a combination of both sets of variables, keeping all other variables in the model at their mean values. Table 3 shows that at age 60, individuals with schooling and no chronic or infectious disease experienced mortality risks that yielded an additional life expectancy of about 20.3 years, whereas individuals with the same lack of disease prevalence but no schooling experienced mortality risks producing an additional life expectancy of 18.3 years, equal to two YLL. Having chronic diseases further reduced additional life expectancy: individuals with schooling and with chronic disease but no infectious disease had an additional life expectancy of 15.7 years, with 4.6 YLL (20.3–15.7). While not statistically significant, the estimates indicated that those with the same education status who experienced both chronic and infectious disease lost a substan-

TABLE 3. Predicted probability of death (estimated additional life expectancy) by education, age, and self-reported chronic and/or infectious disease, Mexico, 2001–2003^{a-c}

Education/age	No chronic or infectious disease	Chronic disease; no infectious disease	Both chronic and infectious disease
With schooling			
Age (years)	Model 1	Model 2	Model 3
60	20.3	15.7	11.6
70	13.7	10.1	7.2
80	8.6	6.2	4.3
90	5.1	3.7	2.6
Without schooling			
Age (years)	Model 4	Model 5	Model 6
60	18.3	14.0	10.2
70	12.1	8.8	6.2
80	7.5	5.3	3.7
90	4.5	3.2	2.3

Source: author calculations based on data from the Mexican Health and Aging Study (MHAS), 2001–2003.

^a Predicted probabilities (estimated additional life expectancies) in each model were calculated using logistic regression odds ratios for mortality over a two-year period.

^b For each model the variables “age,” “sex,” “with partner,” and “urban/rural” were held at the mean value.

^c “With schooling” = ≥ 1 year of formal education; “without schooling” = 0 years of formal education.

tial number of years of additional life expectancy at age 60. For cases with chronic disease, the joint occurrence of infectious disease led to an additional 3.8 YLL for those with no schooling (14.0–10.2) and an additional 4.1 YLL for those with schooling (15.7–11.6). Therefore, although low statistical precision must be acknowledged, the occurrence of infectious disease seemed to reinforce mortality disparities by education.

DISCUSSION

As in other countries and age groups, educational attainment in Mexico plays an important role in mortality differences. Based on the results of this study it was estimated that older adults with lower levels of formal education experienced higher mortality risks, and not having at least one year of formal education translated into a drop in additional life expectancy at age 60 of 1.4–2.0 years, depending on health status. This represented a reduction of 10%–12% in estimated average additional life expectancy at age 60 in the Mexican population.

Although chronic diseases are the leading causes of death, the epidemiological transition in Mexico and other LMICs creates conditions in which infectious and chronic diseases coexist in the population and potentially interact with each other in certain individuals, thus worsening conditions that would have been otherwise produced by each of them separately. Infectious diseases

continue to 1) be widespread, 2) influence morbidity, and 3) remain important causes of death. This new ecology of diseases creates a situation in which educational disparities can exacerbate and entrench existing disparities in health (11, 12).

In contrast with previous studies (13, 14), the current analyses focused directly on the role of chronic and infectious disease interactions, utilizing data from a uniquely suited national longitudinal study on mortality conducted in Mexico and its connection to socioeconomic status (education), health status (antecedent chronic and infectious disease), and demographic characteristics. The results identified statistically significant associations between chronic and infectious disease and mortality among older Mexicans and highlighted the additive effect of each type of disease. The resulting estimates translated into numerically significant differences in estimated additional life expectancy for older adults, but had large standard errors, and thus provided little significant evidence to support the theory of an interaction effect between the two variables or the idea that such interaction effects differed by level of education.

Chronic diseases alone are one of the biggest challenges faced by the Mexican health system. Several factors are involved, including the large number of cases, their contribution to overall mortality, their association with premature disability, and the complexity and high

cost of their treatment. Their emergence as a public health problem was the result of social and economic changes that altered the lifestyle of a large percentage of the population (15). While the current results show that when combined with infectious disease, chronic disease influences mortality levels, they fail to explain a large fraction of the mortality differentials by education, as the latter disparities remained even after controlling for the presence of antecedent chronic and infectious disease. This means that mortality disparities by education level are not due to differential prevalence of chronic or infectious disease but rather to inequalities in the fatality rates associated with each type of disease.

Although the data used in this study were collected 10 years ago, the results remain relevant and appropriate for analysis because schooling, morbidity, and mortality, as well as several of the social determinants, have not changed substantially for the target age group (adults 60 years or older). According to data from Mexico’s national population census, the average number of years of formal education in 2000 was 3.3 (versus 4.6 in 2010). Chronic diseases remain the leading causes of death, with diabetes mellitus, ischemic heart disease, and cerebrovascular disease the three principal diseases in 2001 and 2011. In addition, there is no other study available to establish the association between mortality, education, and disease in the elderly population in Mexico.

Educational differences were not explained by the differential impact of the joint occurrence of infectious and chronic conditions. Although plausible, the argument that joint occurrence of chronic and infectious disease may be more prevalent and entail higher mortality risks among disadvantaged groups was not supported by the available evidence. Therefore, the authors of the current study can only confirm the existence of an education gradient and verify its slight attenuation after accounting for the prevalence of chronic and infectious conditions. There is no evidence that more complex mechanisms are emerging from the type of epidemiological transition currently occurring in Mexico and other LMICs.

Limitations

This study had several limitations. First, two years of follow-up for longitudinal data is a relatively short study period for analysis of health events; significant chronic-infectious disease interactions might require more time to

manifest. If so, the study reported here is unsuitable for revealing those types of effects. Second, the lack of empirical evidence of higher-order chronic-infectious disease interaction effects might not be as meaningful as the absence of such effects due to one crucial limitation of this study, namely, the inability to make robust inferences about interaction effects because of the small number of health events. The total number of observed deaths in the inter-wave period (2001–2003) was 450: even under simple logistic models this level of frequency does not provide enough power for hypotheses testing because the number of cases in each cell induced by additive and interaction terms becomes very small or nil. A longer follow-up of the MHAS cohorts of older adults would increase the possibility of tracing 1) a higher number of deaths and 2) the expression of high-order interaction effects for the diseases.

Conclusion

The results of this study indicate that 1) mixed epidemiological regimes (the

presence of both chronic and infectious disease) adds to the mortality health burden experienced by older people, and 2) there are persistent inequalities in mortality risks based on socioeconomic status. Based on these findings, the authors conclude that social determinants of health, in this case educational attainment, play an important role in explaining differences in mortality. Further research should include a longitudinal perspective to better understand the root causes of health disparities in older adults.

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Conflicts of interest. None.

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RESUMEN**Desigualdad en cuanto a mortalidad en adultos mayores de México: el efecto combinado de las enfermedades infecciosas y las enfermedades crónicas**

Objetivo. Evaluar los efectos del nivel de educación y de las enfermedades crónicas o infecciosas, y de la interacción entre ambas variables, sobre el riesgo de muerte en mexicanos de 60 años o mayores.

Métodos. Mediante la utilización de datos del Estudio Nacional de Salud y Envejecimiento en México (ENASEM), se llevaron a cabo análisis de regresión logística para calcular el riesgo de mortalidad en mexicanos de 60 años o mayores entre el 2001 y el 2003. Se usaron los riesgos calculados de mortalidad asociada con enfermedades crónicas, enfermedades infecciosas y una combinación de ambas para calcular la esperanza de vida adicional a los 60 años.

Resultados. En comparación con el grupo con cierto grado de escolaridad, la probabilidad de muerte en el período de dos años entre las dos fases de recopilación de datos fue 26% mayor en las personas sin escolaridad. La carencia de como mínimo un año de educación formal se tradujo en una esperanza de vida adicional a los 60 años de 1,4 a 2,0 años más corta. La presencia de una enfermedad crónica o infecciosa también aumentó el riesgo de mortalidad durante el mismo período.

Conclusiones. Estos resultados indican que 1) un régimen epidemiológico mixto (la presencia de una enfermedad crónica y de una enfermedad infecciosa) incrementa la carga sanitaria en forma de mortalidad experimentada por las personas mayores y 2) siguen existiendo desigualdades en cuanto al riesgo de mortalidad basadas en el nivel socioeconómico.

Palabras clave

Mortalidad; envejecimiento; esperanza de vida; desigualdades en la salud; México.