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ARTICLES/ARTÍCULOS

The epidemiological transition in Macondo, 1918–1998

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Abstract

In Colombia, there has been very little discussion about the epidemiological transition in the 20th century, therefore, there are few empirical studies, and this mainly focus on the second half of the 20th century, and on the factors associated with improvements in mortality indicators. In this paper, we define three stages of the epidemiological transition in the country during the period 1918–1998, with special emphasis on changes in mortality rates, causes of death and the contribution of different age groups. Likewise, a co-integration analysis is carried out to model the long-term relationship between the mortality rate and the variables of nutrition, public health, education and economic growth. Finally, we show the results of the structural change tests of the mortality rates for pneumonia and tuberculosis to examine the impact of the arrival of sulphonamides and penicillin in Colombia.

Keywords: epidemiological transition; mortality; nutrition; public services; Colombia; 20th century

JEL code: N00; N36; I15

Resumen

En Colombia ha habido muy poca discusión sobre la transición epidemiológica del siglo XX, por lo cual existen pocos estudios sobre los factores asociados a las mejoras en los indicadores de mortalidad, los cuales se centran principalmente en la segunda mitad del siglo XX. En este trabajo definimos tres etapas de la transición epidemiológica en el país durante el período 1918–1998, con especial énfasis en los cambios en las tasas de mortalidad, las causas de muerte y la contribución de los diferentes grupos de edad. Asimismo, se realiza un análisis de cointegración para modelar la relación de largo plazo entre la tasa de mortalidad y las variables de nutrición, salud pública, educación y crecimiento económico. Finalmente, mostramos los resultados de las pruebas de cambio estructural de las tasas de mortalidad por neumonía y tuberculosis para examinar el impacto de la llegada de las sulphonamidas y la penicilina a Colombia.

Palabras clave: transición epidemiológica; mortalidad; nutrición; servicios públicos; Colombia; siglo XX

1. Introduction

> "Many years later, as he faced the firing squad, Colonel
> Aureliano Buendía was to remember that distant
> afternoon when his father took him to discover ice. At that
> time Macondo was a village of twenty adobe houses..."
> Gabriel García Marquez, *One Hundred Years of Solitude*

The 20th century was a century of epidemiological transition in the world. This concept is associated with structural changes in health (or disease) patterns, and their interaction with demographic, economic and sociological determinants and consequences (Omran, 1971). Although the epidemiological transition is closely related to the demographic transition, they differ in that the latter focuses on the change from a pattern of high mortality and birth rates to one with low rates. In contrast, the epidemiological transition, which is a more recent concept, focuses on changes in mortality patterns and causes of death.

In pre-modern societies, life expectancy was short, and mortality was high and highly variable: it moved between mortality peaks due to epidemics and wars, and the usual high levels caused by misery. This trend in mortality only changed in some countries well into the 19th century. Since 1850, there was a decreasing trend in mortality in developed countries that was consolidated in the first decades of the 20th century and then stabilised at very low levels after 1950, especially in the richest countries. In the United States, for example, mortality fell by 40 per cent between 1900 and 1940 (Cutler and Miller, 2005). In European countries such as England, France and Switzerland, the decline in the mortality rate was observed from the end of the 19th century. However, it was not until the 20th century that a generalised decline was observed throughout the continent (Reher Sullivan and Schofield, 1994; Sanz Gimeno and Ramiro Fariñas, 1999; Razzell and Spence, 2007).

During this transition, not only did mortality rates decrease, but also a structural change in the causes of death occurred. Degenerative and chronic diseases (such as cancer and cardiovascular diseases) gradually displaced infectious and gastrointestinal diseases (such as diarrhoea and tuberculosis) as the leading cause of death. The causes of these stages in the epidemiological transition of developed countries have been extensively studied. Some of the most widely accepted hypotheses are improvements in nutrition and hygiene, better public health, increased education and advances in medicine. The extent to which each of these explains the decline in mortality and over what period differs from case to case.

In Colombia, there has been very little discussion on the epidemiological transition in the 20th century, therefore, there are only a few empirical studies, and only for some sub-periods of the 20th century, on the factors associated with improvements in mortality indicators. In this paper, we define three stages of the epidemiological transition in the country over the period 1918–1998, with special emphasis on changes in mortality rates, causes of death and the contribution of different age groups. Likewise, a co-integration analysis is performed to model the long-term relationship between mortality rate and variables denoting nutrition, public health, education and economic growth. Finally, we show the results of structural change tests for the pneumonia and tuberculosis mortality rates to examine the impact of the arrival of sulpha drugs and penicillin in Colombia.

2. Literature review

Cutler *et al.* (2006) conducted a comprehensive review of the literature on the causes of mortality reduction in developed countries. The authors identify at least three phases in this

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process. The first one, between the middle of the 18th century and the middle of the 19th century, when a systematic decrease in the mortality rate began to be recorded, which was mainly explained by the increase in economic growth and improved nutrition. In the second phase, from the end of the 19th century to the first decades of the 20th century, public health played a leading role. At the beginning, the increase in the concentration of people in cities had negative effects on living conditions and mortality. This fact is known in the literature as "Urban Penalty". Later, however, improvements in the provision of clean water, waste disposal and public hygiene (washing food, washing hands, boiling milk) had a positive impact on mortality. Finally, the last phase, after 1930, was characterised by developments in medicine: vaccination, antibiotics, medical technology, among others.

While the literature recognises that each of these factors probably played a role in the decline in mortality, there is no consensus on their relative importance in this transition. McKeown (1976) was a pioneer in arguing that improvement in aqueduct and sewerage facilities, public hygiene and specially nutrition, were the most important factors accounting for the rise of world population since the 18th century and the decrease in mortality. Samuel Preston (1975, 1980, 1990) argued that improvements in public health and social progress were even more important than economic growth in reducing mortality during 20th century, especially in developing countries. According to Preston, even in the absence of economic growth, these countries experienced large improvements in mortality and life expectancy indicators. For example, China, which in 2000 had the gross domestic product (GDP) per capita of the United States in the 1880s, had by that year reached the life expectancy of the United States in the 1970s. Several other authors also have highlighted the role of public services, especially the expansion in the provision of clean water and sewerage, as determinants for the reduction in mortality (Cutler and Miller, 2005; Ferrie and Troesken, 2008; Alsan and Goldin, 2015; Önnerfors 2015, Jaramillo-Echeverri *et al*., 2019; Gallardo-Albarrán, 2020).

Fogel (1986, 1997, 2004) argues that the decline in mortality in the United States is mainly explained by a higher economic growth that allowed access to better nutrition. As evidence of this, the author shows that, since the mid-18th century, there is evidence of an increase in agricultural production and the height of adults in that country. People with better nutrition have greater resistance to diseases, particularly infectious diseases, which were one of the main causes of death during the 19th century and the first decades of the 20th century. McKeown (1976), for example, showed that mortality from tuberculosis was reduced by 80 per cent before there was a medical treatment for this disease. However, Soares (2007) argues that gains in life expectancy for both developed and developing countries were largely independent of improvements in income and nutrition.

Cutler *et al.* explain that, although, in the aggregate, economic growth led to improvements in nutrition, at the microeconomic level, it is not easy to establish the direct link between income and health. Much of the literature supports that better health is what leads to higher incomes. In addition, if there is a causality from income to health, this link goes through education and the differential use of health knowledge and technology. Education, and particularly that of women, is fundamental in the adoption and effectiveness of public health policies, to the extent that they undertake these changes more quickly. Moreover, given that the greatest burden of childcare is on women, mothers that are more educated will also have healthier children.

The role of medicine has become more important in the world since the beginning of the 20th century, with the advances observed in that field in the developed countries. Prior to that century, there were very few medical treatments for infectious diseases that were widely available. Vaccine research made rapid progress in those years, and, during the first three decades of the century, the vaccines for diphtheria (1923), tuberculosis (1927),

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tetanus (1927) and yellow fever (1935), among others, were developed. The most outstanding breakthrough of the following decades was antibiotics. In particular, sulphonamides and penicillin were able to reduce mortality at older ages (Mackenbach and Looman, 1988; Cutler and Meara, 2001; Cutler *et al*., 2006; Lesch, 2007; Jayachandran *et al*., 2010).

In Colombia, empirical evidence on the determinants of the epidemiological transition in the 20th century is more limited. In this country, until the end of the 19th century, there was very little social and economic progress. However, the 20th century was a century of advances in economic growth and in the living conditions of the population (Jaramillo-Echeverri *et al*., 2019). In particular, the first half of the century was characterised by rapid growth in per capita income, while the second half presented greater social investment. Meisel and Vega (2007), using a database of more than 8 million observations for people born between 1910 and 1989, show that the average height of Colombians increased by 8 cm for men and 9 cm for women. According to the authors, this increase was mainly the result of the continuous improvement in nutrition throughout the country because of sustained economic growth.

Studies on mortality, epidemiological transition and demographic transition in Colombia have focused on the second half of the 20th century. Jiménez (2014) compiles a database between 1946 and 2001 to make a descriptive analysis of the health transition and its causes in Colombia. The author also discusses the role of health spending and reforms, regional inequalities, the evolution of public service coverage and school enrolment during those decades. Rosselli *et al*. (2014) also carry out a descriptive analysis of the decrease in total and maternal mortality in Colombia between 1953 and 2013. The authors highlight the increase in the participation of chronic diseases as the main cause of death and the still high levels of maternal mortality. Diaz and Debón (2016) study mortality trends between 1973 and 2005 using data from the Latin American Mortality Database. The authors conclude that the structure of mortality in Colombia in those years was similar to that of developed countries.

Jaramillo-Echeverri *et al*. (2019) examine the evolution in the living conditions in Colombia over the last 100 years and find significant advances, especially in terms of income, health and education. The authors also use the timing and regional variation of sewerage and aqueduct provision to identify the effect of the expansion of aqueducts and sewerage coverage on mortality reduction in the 20th century. To this end, they use data from 14 Colombian departments between 1916 and 2014. The results show that achieving 30 per cent aqueduct coverage in the departments reduces gastrointestinal mortality by 5.5 to 7.3 per cent, while sewerage provision reduces the mortality rate by 11 to 12 per cent.

Jaramillo-Echeverri *et al*. show the positive effect of the provision of aqueduct and sanitary improvements for households in reducing mortality. However, the authors did not examine the characteristics of the epidemiological transition in Colombia nor the behaviour in different age groups.

In this paper, we aim to contribute to this gap in the literature through a descriptive analysis of the epidemiological transition in Colombia by age group and causes of death, as well as a co-integration and structural change analysis to model the long-run relationship between mortality rate and variables denoting nutrition, public health, education, medicine and economic growth.

3. The epidemiological transition in Colombia

In Colombia, as in the rest of the Latin American countries, the epidemiological transition began decades later than in the developed countries. However, it was a much faster process. During the first decades of the 20th century, there was no change in the fluctuating

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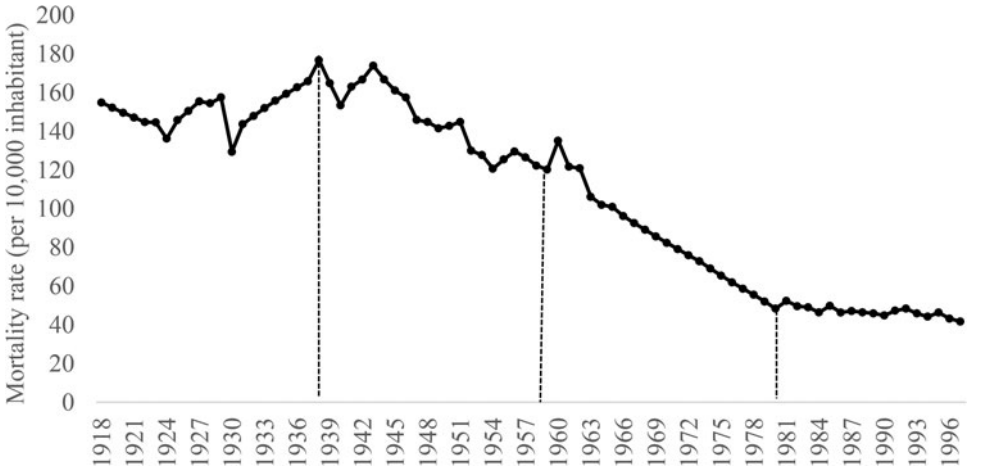

Figure 1. Total mortality rate, 1918–1998.
Source: Calculations by the authors based on sources described in the Appendix.

trend of the mortality rate. It was only until the 1940s that an accelerated decline began. In those 40 years, between 1940 and 1980, total mortality rate fell by 73 per cent. The last years of the century were characterised by low and stable mortality levels. The period of greatest decline was between 1958 and 1978 (see Figure 1 and Table 1).

As in the rest of the world, not only was there a generalised decrease in mortality, but there was also a change in the main causes of death. At the beginning of the century, deaths from infectious and gastrointestinal diseases predominated. Pneumonia and diarrhoea accounted for about 20 per cent of deaths in 1938. Other common causes of death were other highly contagious infectious diseases such as malaria, whooping cough, tuberculosis, typhoid fever and measles (see Table 2). The mortality rate for these diseases began to sharply decline between 1938 and 1958 (see Figure 2). For example, mortality from diseases caused by gastrointestinal infections fell 38 per cent in that period; pneumonia, 56 per cent and tuberculosis, 53 per cent (see Figure 2). On the other hand, mortality from cancer and circulatory diseases began to increase.

Over the next 20 years, the transition accelerated much more rapidly. As we have seen before, between 1958 and 1978, the highest rate of annual mortality reduction was observed (see Table 1). Deaths from pneumonia, tuberculosis and diarrhoea fell from 23 per cent of all deaths in 1938 to only 7.2 per cent in 1978. Deaths due to malaria, diarrhoea, whooping cough, typhoid and measles practically disappeared, with a share of less than 2 per cent of the total number of cases. On the other hand, the importance of circulatory diseases, cancer and homicides rose (see Table 2). This latter fact was even more noticeable towards the end of the century, as in 1998, when 52 per cent of all deaths were due to one of these three causes.

Table 1. Average annual growth in mortality rate by sub-period

1918–1938	1939–1958	1959–1978	1979–1998
0.8%	−1.7%	−3.8%	−1.1%

Source: Calculations by the authors based on sources described in the Appendix.

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Table 2. Percentage of deaths by main causes

Cause of death	1917	1938	1958	1978	1998
Pneumonia	5.06	9.87	6.26	5.15	3.28
Diarrhoea and enteritis	1.96	9.32	10.33	0.27	–
Paludism (malaria)	3.99	3.82	0.86	0.44	–
Circulatory diseases	1.89	3.31	6.24	19.54	21.74
Tuberculosis	3.87	3.18	2.17	1.79	0.85
Whooping cough	3.94	3.13	1.65	0.55	–
Measles	1.26	1.99	0.93	0.54	–
Typhoid fever	3.38	1.71	0.48	0.2	–
Sub-total infectious diseases	**25.4**	**36.3**	**28.9**	**28.5**	**25.9**
Cancer	1.08	1.67	4.45	9.86	16.01
Homicides	2.89	0.85	3.96	4.26	14.07
Sub-total other main causes	**4.0**	**2.5**	**8.4**	**14.1**	**30.1**
Total percentage of main causes of death	**29.3**	**38.9**	**37.3**	**42.6**	**56.0**

Source: Calculations by the authors based on sources described in the Appendix.

The fall in mortality and the increase in life expectancy was followed decades later by the decrease in the birth rate, which changed the age structure of the population in Colombia, especially in the last decades of the 20th century. This progressive and

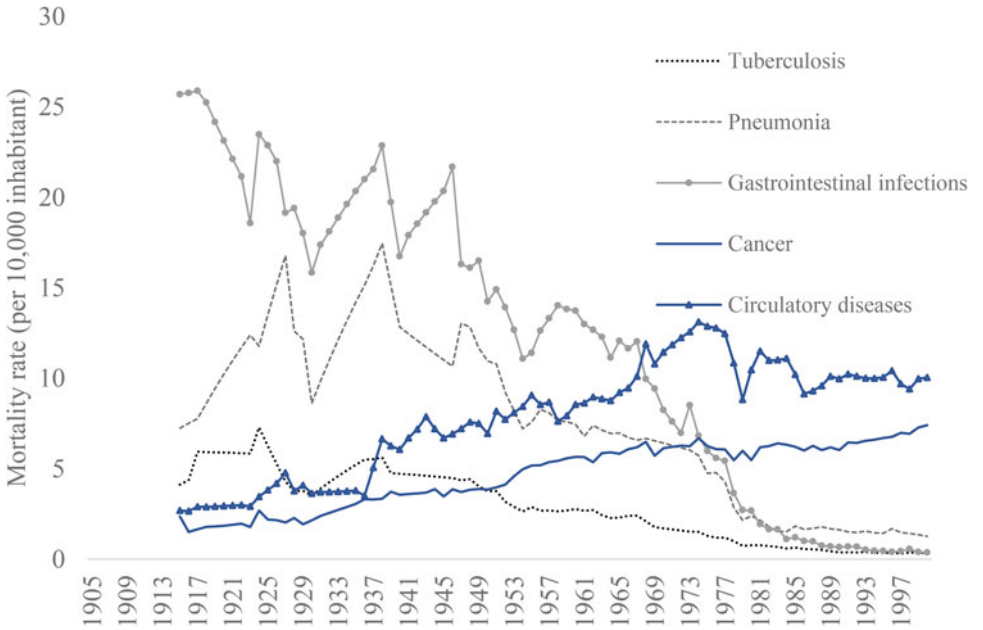

Figure 2. Mortality rate of the main causes of death, 1918–1998.
Source: Calculations by the authors based on sources described in the Appendix.

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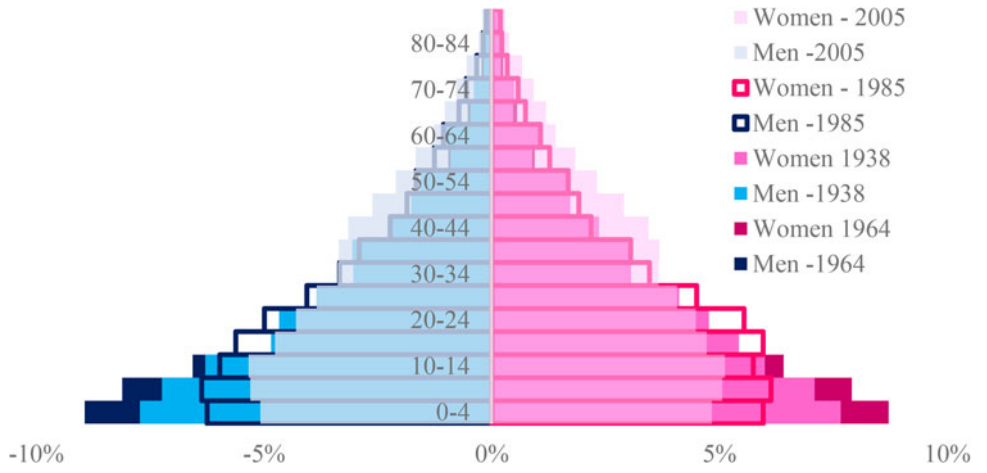

Figure 3. Population pyramid 1938, 1964 and 2005.
Source: Calculations by the authors based on sources described in the Appendix.

accelerated ageing of the population led to a larger participation of cancer and circulatory diseases as main causes of death (see Figure 3 and Table 3).

In line with it, there was also a transition in the age structure of deaths. In 1918, 39 per cent of all deaths were of people under 14 years of age, while, in 1997, it was 10 per cent (see Table 4). In turn, at the beginning of the century, people over 50 years accounted for

Table 3. Average annual growth in mortality rate of the main causes of death

Period	Tuberculosis (%)	Pneumonia (%)	Gastrointestinal infections (%)	Cancer (%)	Circulatory diseases (%)
1918–1938	0.2	4.2	−0.5	4.1	3.7
1938–1958	−3.3	−3.0	−1.9	2.6	3.1
1958–1978	−4.4	−4.4	−5.4	0.2	1.3
1978–1998	−4.4	−2.8	−7.8	1.3	−0.4

Source: Calculations by the authors based on sources described in the Appendix.

Table 4. Percentage of deaths by age group

Age group	1918	1938	1958	1978	1997
Under 5	32	49	52	26	8
5–14	7	7	5	4	2
15–49	30	22	17	22	29
50–69	11	12	12	22	23
Over 69	5	10	14	25	36

Note: The missing percentage accounts for non-specified ages.
Source: Calculations by the authors based on sources described in the Appendix.

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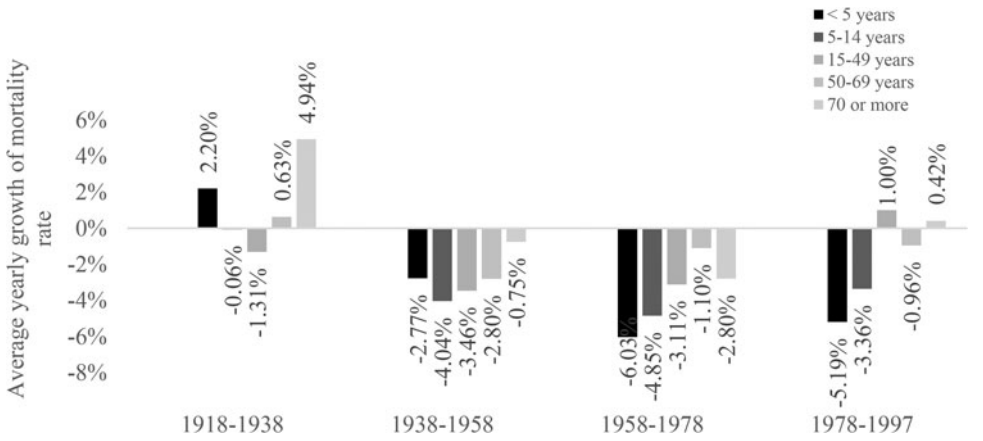

Figure 4. Average yearly growth of mortality rate by age group.
Source: Calculations by the authors based on sources described in the Appendix.

only 16 per cent of deaths, but, by the end of the century, they accounted for more than half of deaths (59 per cent) (see Table 4). These changes in mortality by age were not homogeneous throughout the decade, as shown in Figure 4. During the first decades, the only age group that experienced a slight reduction in its mortality rate was young people between 5 and 14 years of age. For the rest of the age groups, the mortality rate even increased. Between 1938 and 1958, mortality decreased for all age groups, but especially for those between 5 and 49 years of age. The period between 1958 and 1978, as mentioned above, saw the greatest reduction in mortality, marked by the decline in infant mortality (under 5 years of age). In the last decades of the century, mortality continued to decline for the youngest, but slightly increased for the elderly.

From 1948 to 1958, Colombia experience a cycle of political violence as a result of the confrontations between the followers of the Liberal and Conservative parties. After 1958, that level of violence decreased but remained at a higher level that what existed before 1948. However, after the mid-1970s homicides began to increase dramatically as a percentage of total deaths because of drug traffic-related assassinations (see Figure 6).

In this sense, we can identify the stages of the epidemiological transition in Colombia in the following way. The period from 1918 to 1938 corresponds to a pre-transitional scenario characterised by a high and fluctuating total mortality rate. The main causes of death were associated with infectious and gastrointestinal diseases in young people under 14 years of age. Then, three periods of the epidemiological transition in Colombia during the 20th century can be identified:

> *From 1938 to 1958*: characterised by the beginning of the decline in total mortality and the mortality rate due to infectious and gastrointestinal diseases. During this period, mortality in the over 5 age groups declined.
> *From 1958 to 1978*: characterised by the acceleration of the epidemiological transition. Mortality and the share of infectious and gastrointestinal diseases in total deaths drastically decreased. On the contrary, cancer, circulatory diseases and homicides increased as causes of death. In this period, those who benefited most were children under 5 years of age.
> *From 1978 to 1998*: characterised by the stabilisation of the mortality rate at low levels. In this period, about 38 per cent of total deaths were the result of circulatory diseases

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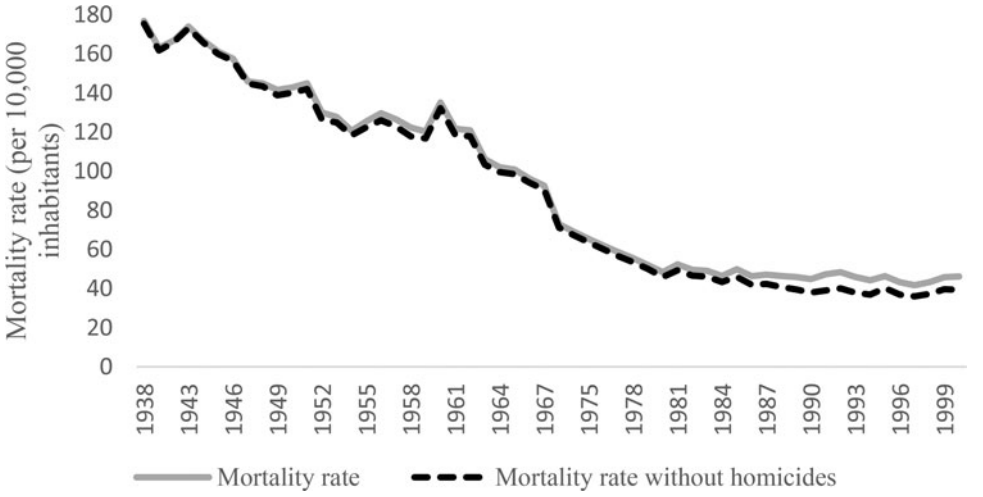

Figure 5. Mortality rates excluding homicides.
Source: Calculations by the authors based on sources described in the Appendix.

or cancer, and 14 per cent from homicides. In fact, in Colombia, during these years, there were almost as many deaths from homicides as deaths from cancer.

As shown in Figure 5, starting in the 1980s, there was a significant difference between the total mortality rate and the non-homicide mortality rate. This difference averaged 5.5 points during the last two decades of the century, and it even exceeded 8 points during the early 1990s. As has been mentioned from 1948 to 1958 Colombia experienced a cycle of political violence. As a result, there was an increase in the participation of homicides in total deaths (3.7 per cent). After 1958, that level of violence decreased (to 2.2 per cent of total deaths) but it remained at a higher level that what existed before 1948 (around 0.7 per cent of total deaths). However, after the mid-1970s homicides began to increase dramatically as a percentage of total deaths (becoming more than 15 per cent) as a result of drug traffic-related assassinations (see Figure 6).

4. Social and economic progress in Colombia during the 20th century

Colombia experienced unprecedented social and economic progress in the 20th century. The GDP per capita quadrupled between 1918 and the end of the century. It went from being a country with a predominantly rural population to becoming a largely urban country. Living conditions improved with better nutrition, more education and greater access to public services.

During the first decades of the period under discussion, per capita GDP doubled, and the average height of Colombians increased at an annual growth rate of 0.08 per cent, reflecting improvements in nutrition levels. The urban population increased by only 10 percentage points, and there was no significant progress in terms of access to primary education, according to the gross enrolment rate (GER). By 1938, few homes had access to water supply (only 11 per cent).

In the following two decades, the increase in height and GDP continued at a lower rate. The primary education GER almost doubled between 1938 and 1963. Moreover, in the latter year, the urban population already represented 50 per cent of the total population.

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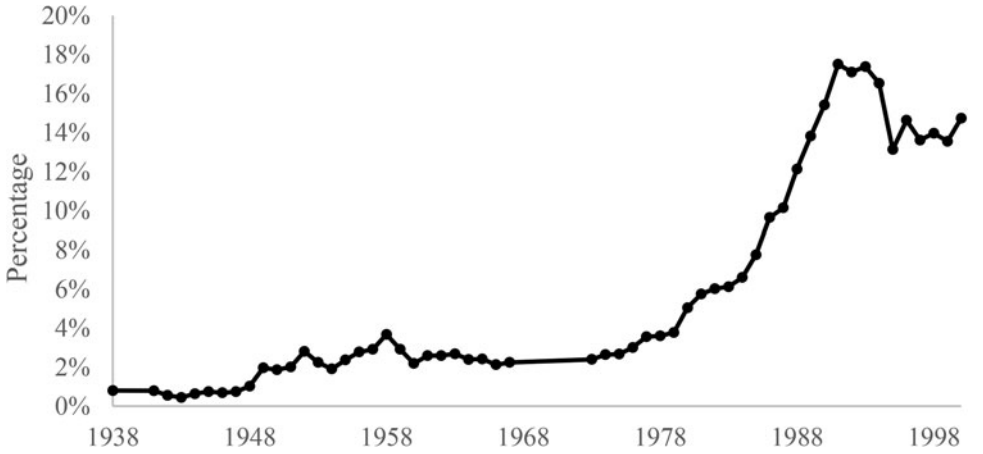

Figure 6. Homicide deaths as a percentage of total deaths (1938–2000).
Source: Calculations by the authors based on sources described in the Appendix.

During these years, the expansion of water supply service also began: from 11 per cent of households to 38 per cent, mainly in urban areas. This social progress was consolidated in the 1960s and 1970s, when there was an expansion in schooling and public services.

As previously noted, the decade of the 1930s and 1940s was particularly important for the progress of medicine in developed countries, with discoveries that quickly moved to developing countries as well. Around 1936, the clinical use of sulphonamide chemical drugs started to grow, and they were effective in reducing mortality from infectious diseases. The development of sulphonamides is known as the pre-antibiotic era, which lasted until the large-scale production and mass application of penicillin in 1941 (Jácome Roca, 2008). Penicillin became the curative treatment for infections such as syphilis, pneumonia, diphtheria, bacterial meningitis and septicemia. According to Jácome Roca (2008), Colombia quickly entered the penicillin era which first arrived around 1947[1].

Finally, although the last two decades of the 20th century in Colombia represented the period of greatest violence in the country, even during these years, there was evidence of positive economic growth and consolidation of social progress (Figure 7).

5. Empirical strategy

The second part of this paper focuses on identifying the factors associated with the decline in total mortality in the period from 1918 to 1998. For this purpose, econometric techniques for the analysis of non-stationary time series are used. Specifically, a co-integration analysis is performed, and a vector error correction (VEC) model is estimated. Finally, a structural change test is conducted, in order to measure the impact of the use of sulphonamide drugs and penicillin on the reduction of pneumonia and tuberculosis mortality.

For this analysis, a database with information on mortality by cause and by age group, schooling, economic growth, water supply coverage and height, for the 1918–1998 period, is compiled. Height is used as a proxy for nutrition levels. For this purpose, population

[1] Vaccines also played an important role in this transition. Between 1937 and 1942, a total of 600,000 Colombians received the vaccine for yellow fever (Abel, 1995).

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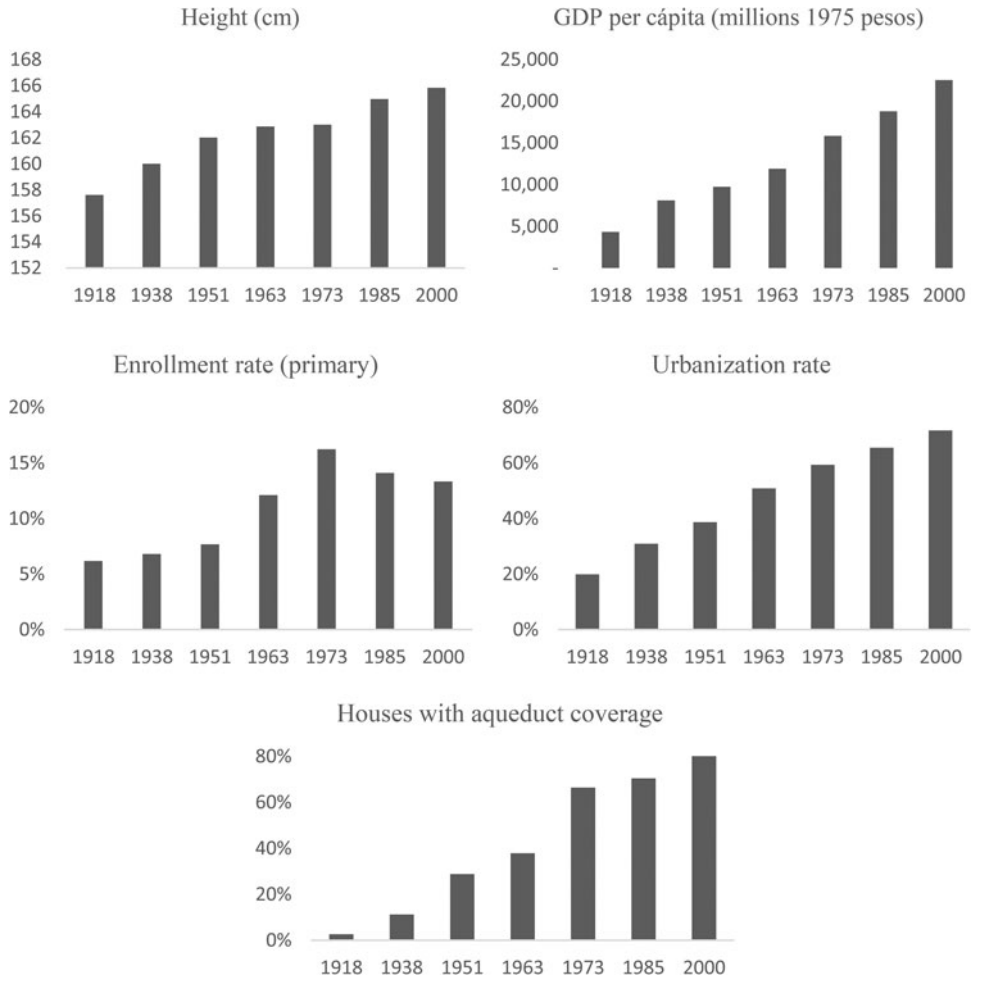

Figure 7. Evolution of variables related to social progress in 20th-century Colombia.
Source: Calculations by the authors based on sources described in the Appendix.

and death and birth records from the 20th-century censuses in Colombia (1938, 1951, 1964, 1973 and 1993 censuses) are used. We also use information from statistical yearbooks since 1918, which consolidate important information on births and deaths by age and cause of death. The series of GDP per capita is estimated by GRECO (study group of Colombian economic growth by its acronym in Spanish) (2002) of the Central Bank. And finally, the height series corresponds to the one consolidated by Meisel-Roca *et al.* (2019) from court certificates.

6. Results

The results of the identification of long-term relationships between mortality rate and different variables that denote the levels of nutrition, public health and economic growth throughout the 20th century are shown below.

The main problem of this analysis is the endogenous character of the variables. To solve this, Johansen's co-integration analysis and the VEC model are used to identify

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Table 5. Time series integration order

	Augmented Dickey Fuller	Phillips-Perron
Total mortality rate	*I*(1)	*I*(1)
Infant mortality rate (per 1,000 births)	*I*(1)	*I*(1)
Mortality rate 15–49	*I*(1)	*I*(1)
Height	*I*(1)	*I*(1)
GDP per capita (millions of pesos)	*I*(1)	*I*(1)
GER primary	*I*(1)	*I*(1)
Aqueduct coverage	*I*(1)	*I*(1)

Source: Calculations by the authors based on sources described in the Appendix.

long-run relationships, in a system with non-stationary integrated variables of order 1, as shown in Table 5 (after performing Dickey Fuller's unit root and Phillips Perron's unit root tests).

Equations are estimated for three dependent variables: the total mortality rate, the infant mortality rate and the mortality rate in adults between 15 and 49 years of age. Additionally, the estimation is performed for the complete period, and for sub-periods between 1920 and 1959 and 1960 and 1999. Table 6 presents the results of the normalised co-integration coefficient for the co-integration equation for each of the mortality rates and sub-periods.

The results of the co-integration analysis show that, overall, the effect of height as a proxy for nutrition has a positive impact on reducing total mortality, infant mortality and adult mortality (the interpretation of the co-integrating coefficient is that of the opposite sign). However, the coefficient for total mortality is not statistically significant for the 1960–1999 period. That is, an improvement in nutrition expressed through an increase in height was associated with decreases in the mortality rate in all age groups, especially in the first half of the century.

Similarly, an increase in the primary schooling rate is also associated with a decrease in mortality for all age groups and periods of the 20th century, except for infant mortality between 1960 and 1999. As argued above, this is mainly due to better health and hygiene habits acquired with increased education.

Regarding aqueduct coverage in housing, the results show that there is a positive relationship only with the reduction of the infant mortality rate, and mainly in the second half of the century, as the effect for 1920–1959 is negative. The coefficient for the total mortality and adult mortality equation, all else constant, is negative. Finally, the effect of economic growth is also negative for mortality reduction, or the coefficient is not statistically significant.

Finally, Table 7 presents the results of the structural change test for the mortality rate series for tuberculosis, pneumonia and gastrointestinal infections. For the first two, the estimated break date is 1953. This suggests a response of the mortality pattern to the use of penicillin, which became widespread in the world around 1950 and was instrumental in treating these diseases.

The estimated date of structural change in the gastrointestinal infection series is 1968. This is consistent with previous findings that show that aqueduct coverage was closely related to the reduction in infant mortality in the second half of the 20th century, when deaths from this type of disease were prevalent.

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Table 6. Normalised co-integration coefficients of the Johansen co-integration method

	1920–1999			1920–1959			1960–1999		
	Total	Infants	Adults	Total	Infants	Adults	Total	Infants	Adults
Height	64.66***	20.62***	18.54***	124.87***	103.46***	6.63***	−5.48	16.83***	16.33***
ln PIB per capita	−223.77	−33.19	−32.45***	−458.30***	−315.59***	4.59	245.50***	−9.53	−29.38***
GER primary	1,710.50***	303.12***	319.49***	2,904.36***	1,706.18***	152.80***	583.86***	−33.83	213.63***
Aqueduct	−203.43**	38.35***	−25.14**	−817.92***	−679.92***	−0.76	−148.32***	75.49***	2.16
Lags	2	2	2	2	2	2	2	2	2
Co-integration rank	4	4	4	4	4	4	4	4	4
Observations	80	80	80	40	40	40	40	40	40

***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Note: The determination of the optimal value of the lags is made by observing the smallest value of the information criteria (AIC HQIC SBIC).

Table 7. Results of the test for structural change in mortality rate by type of disease

Mortality rate by	Statistic	*P*-value	Estimate break date
Tuberculosis	277.7184	0.000	1953
Pneumonia	209.0955	0.000	1953
Gastrointestinal infections	295.3359	0.000	1968

Source: Calculations by the authors based on sources described in the Appendix.

7. Conclusions

In the 19th century, Colombia was one of the least dynamic Latin American economies. Its GDP per capita most probably did not grow during that century as a result of the poor performance of its exports in that period[2]. In 1912, its exports per capita were the smallest in Latin America and only comparable to those of Haiti and Honduras. Since economic growth is a necessary, although not sufficient, condition for economic development, indicators of wellbeing such as height, mortality and life expectancy remained static in the century after Independence. This situation changed completely in the 20th century, when as a result of the success of coffee exports after 1905, GDP per capita grew at an average annual rate of 2.3 per cent between 1905 and 2000, which was one of the highest in Latin America in that period. As a result, such social indicators as average height of the population began to increase, mortality began to fall and levels of literacy started to increase[3]. In this paper, the evolution of mortality and its main determinants for the period 1918–1998 are studied using a database constructed by the authors using primary sources.

The sequence of the reduction in mortality in Colombia, which began towards 1940s, was initially driven by improvements in nutrition because of a rapid expansion of GDP. From 1905 to 1924, GDP per capita grew at an average annual rate of 3.4 per cent, the highest rate achieved in all the country's history for a comparable time period. For the next period, 1925–1950, GDP per capita maintained a good performance, growing at an annual rate of 2.2 per cent (Greco, 2002). This economic success allowed for better nutrition of the population, which resulted in a significant increase in average height along the 20th century, with gains of about 1 cm per decade (Meisel and Vega, 2007). Thus, improvements in nutritional conditions allowed for an initial reduction in total mortality.

Beginning in the 1930s, the advances in medicine, vaccines and antibiotics, and government campaigns for improvements in hygiene, had an impact on the mortality to the reduction of diseases such as tuberculosis, pneumonia and measles[4].

It was only since the beginning of the 1960s that the advances in coverage in aqueducts and modern sewage systems that water related mortality, especially infant mortality, began to fall. Thus, the sequence typical of the first industrialisers of a sequence of reduction in mortality that advanced due to better nutrition, public health (water) and medicine, was different in Colombia. The reason will seem to be that for latecomers to economic development, once medical advances which could reduce mortality were

[2] Edwin López and Salomón Kalmanovitz estimated the annual average growth rate of Colombian GDP per capita between 1800 and 1905 as 0.1% (Kalmanovitz and López, 2010, p. 339).

[3] For the evolution of height in Colombia during the 20th century, see Meisel Roca and Vega (2004).

[4] Harper (2021, p. 491) argues that as a result of the availability of biomedical interventions and insecticides a group of countries that had not experienced a very large reduction in mortality in the beginning of the 20th century, experienced an enormous drop in mortality in the period 1940–1970. Colombia was one of those countries.

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available in the international market, that is beginning in the 1930s, it was cheaper to acquire that knowledge or that medicine than to build water and sewage systems.

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Appendix: Database description

The authors consolidate a database from 1918 to 1998 in Colombia using different sources: The vital statistics of total deaths by age group and by cause were obtained from the Statistical Yearbooks published by the Colombian government (1918–1969), the Registry of Deaths in Colombia (1970–1978) and for the last years from a database on Vital Statistics of Deaths of DANE (National administrative department of statistics for its acronym in Spanish) (1979–1998). The series of GDP per capita (in millions of 1975 pesos) is taken from GRECO (2002) (the Study group of Colombian economic growth for its acronym in Spanish). The height series corresponds to the one consolidated by Meisel et al. (2019) from primary sources found in the National Archives (Archivo General de la Nación). Regarding to the enrollment rate in primary as percentage of total population, it was obtained from Ramirez and Tellez (2007). Finally, we constructed an interpolate series of aqueduct coverage from censuses of edifications and households of 1938, 1951, 1963, 1973, 1985.

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