

**Violence and mortality from external causes in Colombia:
Analysis of demographic costs during the period 1979-2016**

**Violencia y mortalidad por causas externas en Colombia:
Análisis de los costos demográficos durante el periodo 1979-2016**

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23 23 campesinos fueron asesinados por las AUC en un recorrido que duró dos días por las veredas del municipio de Yolombo. Días después los habitantes del municipio, rindieron homenaje a las víctimas organizando un sepelio colectivo. Fotografía: Jesús Abad Colorado © 1998.

Picture taken from the Report of the armed conflict in Colombia Basta Ya! (CNMH 2013)

Abstract

This article analyses the distinctive characteristics of external causes of death during different historical phases of violence in Colombia within the period 1979-2016. For this purpose, for each phase death-rates and years of life lost were analyzed by cause of death and sex, using micro-level Colombian's mortality records and period-life tables from the Latino American Mortality Database (LAMBdA).

Results suggest that the context of each historical phase of violence had important implications on external mortality, but only for some causes: whereas accidental mortality did not seem to be related to the sociohistorical context, mortality by aggressions and suicides differed considerably. The different forms of violence exerted during each historical phase seemed to have different implications on the age structure and sex composition of homicide and suicide mortality.

To conclude, this analysis underscore the need of further research analyzing the different mechanisms linking contexts of extreme violence and suicide. Moreover, this study highlights the important implications of considering the sociohistorical context in the analysis of mortality from external causes. It provides significant information for the adjustment of the registered causes of death, as well as for the interpretation of the results, offering some insights about the mechanisms behind the observed changes in mortality.

Resumen

El presente artículo analiza las características distintivas de las causas de mortalidad externa en diferentes fases históricas de violencia en Colombia durante el periodo 1979-2016. Para ello, al interior de cada fase, se analizaron las tasas de mortalidad y los años de vida perdidos por causa de muerte y sexo, utilizando los registros individuales de mortalidad de Colombia y tablas de mortalidad de la Base de Datos de Mortalidad en Latinoamérica (LAMBdA).

Los resultados sugieren que el contexto de violencia de cada fase histórica tuvo importantes influencias en la mortalidad externa, pero sólo para algunas causas: mientras que la mortalidad accidental no parece estar relacionada por el contexto sociohistórico, la mortalidad por agresiones y suicidios difiere considerablemente. Las diferentes formas de violencia que sufrió la población parecen haber tenido importantes implicaciones en la estructura de edad y la composición por sexo de la mortalidad por agresión y suicidio.

Para concluir, este estudio recalca la necesidad de llevar a cabo más investigaciones sobre los mecanismos que conectan contextos de violencia extrema y la mortalidad por suicidio. Adicionalmente, este análisis destaca la importancia de considerar el contexto sociohistórico en el análisis de la mortalidad externa. Por una parte, brinda elementos para la corrección del registro de las causas de mortalidad externa, y por otra parte, proporciona información valiosa para la interpretación de los resultados, contribuyendo con importantes pistas acerca de los mecanismos implicados en los cambios observados de mortalidad.

Keywords: *Mortality, External Causes of Death, Violence, Demographic Cost, Colombia*

1. Introduction

Various demographic and epidemiological studies have analyzed the evolution of mortality by external causes in Colombia, either grouped or disaggregated into specific causes, such as homicides, suicides, or traffic accidents (Cardona et al. 2013; Moreno and Cendales 2011; Acosta and Romero 2014). For the most part, those studies have been approached from a public health point of view, focusing mainly on describing the dynamics of mortality in different periods, and providing elements of discussion for decision-making regarding prevention and control of intentional and unintentional injuries.

However, in most of those studies, the definitions of both the groups of causes of death and the periods of analysis have been made without considering the particularities of the sociohistorical context of Colombia, especially in relation to the different phases of violence that the country has suffered during its recent history. Yet, the characteristics of those phases could possibly have an impact on the way in which deaths are recorded, as well as on the intensity of different forms of mortality by external causes. Indeed, while the impact of a context of violence on mortality—specifically on homicide dynamics—is evident and has been studied for numerous cases, its effect on other external causes of death has rarely been considered. Nevertheless, it is possible that the experience of extreme violence—including forced displacement, destruction of road infrastructure, and psychosocial traumas of war, among other disruptive/destructive incidents—may have an important impact on other causes of external mortality, such as suicides and accidents.

Besides affecting mortality, a context of violence can alter significantly other demographic events, as shown by other studies. With regards to fertility, Lindstron and Berhanu (1999) and Agadjanian and Prata (2001, 2002) argue that this influence is due to both the general deterioration of health in contexts of violence and the impacts left by traumatic experiences on people's sexual and reproductive lives. In the case of Colombia, the *Grupo de Memoria Historica* (GMH, 2013) suggests that fertility would also be marked by the absence of reparation and the depth of the trauma. As for migration, Grove and Zwi (2006) and Toole and Waldman (1993, 1997) point out that, by forcing those affected to leave their homes, violent contexts reduce the access to basic goods and services.

Considering the above, we argue that the analysis of the dynamics of both accidental and violent (intentional) mortality in Colombia *should* take into account the sociopolitical context for two

main reasons: first, unlike other causes of death—for which the largest influence is given by sanitary, technological and/or economic contexts—, external mortality is mainly shaped by the sociopolitical environment. Second, the Colombian population has lived in a state of generalized violence since the middle of the 20th century, registering the world's highest homicide rates and forced internal displacement rates, respectively during the early 1990s and the first decade of the 21st century. This particular situation has generated "a reversal of the epidemiological transition, in which typical diseases of the advanced stages of the transition, such as cancer, coexist with a significant number of deaths due to homicides." (Acosta and Romero 2014, p.2)

Given the influence of the sociopolitical context on mortality by external causes in a society, it is possible that major changes in the former will be reflected in the latter. For instance, scenarios in which urban violence predominates among drug trafficking groups and against State forces (marked by selective assassinations and attacks aimed at destabilizing society's State apparatus), may not have the same impact on accidental and violent mortality in rural areas. Such a scenario would manifest differently on external mortality, when compared to situations where attacks with military weapons predominate in rural population centers, including massacres, displacements, enforced disappearances, the installation of antipersonnel mines, and the destruction of infrastructure.

The importance of this study goes beyond pure scientific curiosity and the desire to improve the precision in data counts. Contexts of violence penetrate every space, time, and scenario of individual and social life (Franco Agudelo 2003). Thus, for a society to mitigate and to repair some of the damage caused to the victims in the short and the long terms, it is indispensable to identify *who* the victims are, the actual extent of collateral damages caused by violent contexts, as well as the mechanisms in which these contexts affect the population.

2. Historical context: phases of violence in Colombia and definition of periods of analysis

Since the middle of the 20th century, the Colombian population has lived in conditions of generalized violence, although with varying intensity. According to the sociopolitical context, the actors involved, the strategies used, and the level of victimization of the civilian population, five periods of violence can be identified as of the 1940s.

First, during the period known as *La Violencia* (1946-1958), the Colombian population got immersed in a civil war as a consequence of the confrontation between traditional parties in the

government and the opposition. This conflict, which was characterized by high doses of ruthlessness and terror, left more than 220,000 deaths, as well as unprecedented levels of forced displacement in rural areas (Guzmán et al. 2010).

The second period (1958-1979) was characterized by permanent and relatively low-intensity violence. Various subversive guerrilla groups were formed during this period, such as FARC (1964), the ELN (1964), the EPL (1967), and the M19 (1970). Initially, those groups acted according to some objectives and their strategies were predominantly defensive (Pizarro, 2007).

During the third period (1980-1995), violence intensified as a result of three main components. The first component was a change of strategy by the guerrillas, who moved from defensive to massive offensive actions. The second component was the formation of paramilitary groups, whose activities ended the monopoly of the State in the fight against subversive guerrilla groups (GMH, 2013). The paramilitary groups mounted violent attacks against unions and leftist activists in urban areas, and against rural individuals accused of being accomplices or extensions of the guerrilla groups. The third and last crucial component leading to increased violence during this period was the international positioning of Colombia as a top cocaine producer during the 1980s (Pécaut, 2008). Apart from generating larger financial resources for the guerrilla groups and from being indispensable for the formation of paramilitary groups, the illegal economic boom created by drug trafficking led to the strengthening of drug cartels. Initially, the cartels confronted the State with violent attacks against police forces and judicial institutions, as well as against the civilian population, as a means of political destabilization. Violence decreased slightly towards the end of this period as a result of parallel events¹.

The fourth period (1995-2005) was the most aggressive against the civilian population (GMH, 2013; Pécaut, 2008). It was a phase of territorial expansion and struggle between guerrilla and paramilitary groups, largely financed by the economic boom generated by the traffic of cocaine. The dispersed paramilitary forces multiplied on a national scale, with the legal support by the State of the Rural Cooperatives of Security, denominated *Convivir* (1995), which later consolidated as the *Autodefensas Unidas de Colombia* (AUC) in 1997. Faced with the impossibility of militarily confronting the guerrillas, the AUC adopted the philosophy of “leaving the fish [the guerrillas] without water [the civilian population]” (Ronderos 2014). In

¹ The following events took place during the early 1990s: the partial disarticulation of major paramilitary groups; peace processes whereby some guerrilla groups (M19, MRQL, and PLA) disarmed their forces; and the death of Pablo Escobar (Ronderos 2014).

their process of territorial expansion, the AUC and the guerrillas exerted diverse forms of violence against the civilian population, who became an object of control, suffering selective assassinations, massacres, sexual crimes, forced disappearances, forced displacement, forced recruitment, and attacks on populations and infrastructures, among others². According to figures collected by the *Centro Nacional de Memoria Histórica* (CNMH), 64.2% of the victims of the armed conflict are concentrated in this period (see Fig. A1 in Appendix³).

Finally, the fifth period (2006-2016) was characterized by a considerable reduction in most forms of violence (see Fig. A1). This development was largely a consequence of the demobilization and partial disarticulation of most paramilitary groups, as well as of strong State investments in counter-insurgency. Towards the end of this period, peace negotiations started with major guerrilla groups (FARC and ELN). In 2016, FARC (the biggest guerrilla group) demobilized.

The brief presentation above indicates that, although violence in different forms was a common factor to all periods, the conflict acquired disproportionate dimensions from the late 1980s until the early 2000s, albeit not in a uniform way. Consequently, it is possible to expect that the largest socio-demographic impacts of violence on the Colombian population will be observed during that period.

Although the armed conflict in Colombia dates back to the middle of the 20th century, the necessary mortality data by sex, age and cause of death for demographic analysis is only available since 1979. Considering this limitation and based on the historical phases of violence in Colombia presented above, we defined four periods of analysis, temporally equidistant 10-years from each other. These periods represent four different phases of violence (see Table 1): a pre-extreme violence phase, two phases of extreme violence (EV) with preponderance of drug cartels and political armed conflict, respectively, and a post-extreme violence phase. The differences in the sociohistorical circumstances and forms of violence that predominated during each EV period (2nd and 3rd in Table 1) allow studying the way in which contextual factors had an impact on external mortality.

² At least 10 forms of violence have been distinguished in the context of the Colombian armed conflict (CNMH 2018a)

³ **Please note that all figure and table numbers containing the letter A, e.g. Fig. A1, are in the Appendix. The other figures and tables (without the letter A), are included in this document.**

Table 1. *Definition of periods of analysis*

Phase	Period	Characteristics
1	[1981, 1985)	Pre-EV
2	[1991, 1995)	Cartels-related EV
3	[2001, 2005)	Conflict-related EV
4	[2011, 2015)	Post-EV

3. Research question and objective

Considering the different phases of violence suffered by the Colombian population, it is worth asking *who* the fatal victims have been from a demographic point of view. Does each historical phase of violence have distinctive characteristics in terms of external mortality, with regard to potential demographic costs and contributions by sex and age? To answer this question, this paper describes and compares the main characteristics of external mortality (intentional and accidental) between consecutive sociohistorical phases of violence (as defined in Table 1). Within each phase, we analyze the characteristics of external mortality, focusing on the differences by sex, age and causes of death, as well as their contributions to changes in life expectancy at birth (e_0) and potential demographic costs in terms of life-years lost.

Answering the above question is important not only because it can bring new scientific knowledge to the study of demography in Colombia, but also because it can help to humanize the statistical figures, highlighting the characteristics of the main victims during each phase. The latter point has important implications, as we provide evidence that the victims of violence in Colombia require attention and effective measures of support by the State and the society.

4. Data

4.1. Data types and sources

Various types of data and sources were used. First, individual mortality data was obtained from the civil registration system through the website of the *Departamento Administrativo Nacional de Estadísticas* (DANE). The files of microdata used here are annual (from 1979 to 2016) and anonymized; they provide information about characteristics of the deceased such as sex, age, cause of death, place of death, etc. From those files, the number of deaths for the total population

was computed (for each year and for each period of analysis), by sex, age, and cause of death⁴. Some corrections and imputations were performed on these aggregate data; those procedures are explained in the next subsection.

Another important type of data used are reliable estimates of mortality for the entire Colombian population, which were obtained from the Latin American Mortality Database (LAMBdA, Palloni et al. 2016)⁵. From this source, all available period life-tables for Colombia were used (for Colombia, LAMBdA provides seven period-life tables for each sex, corresponding to seven scattered years within the period 1944-2008) to estimate annual rates. For consistency, data on population size by age and sex for the year 2005 was also obtained from LAMBdA, which was used as reference for estimating age-standardized crude death rates (ASDCR).

Finally, besides the two main sources of demographic data mentioned above, we used information from the *Observatorio de Memoria y Conflicto* (CNMH 2018a), which provides detailed qualitative and quantitative data about ten forms of violence related to the armed conflict in Colombia during the period 1958-2018 (e.g. slaughter, selective killings, and sexual crimes). This and other sources are used in our documental analysis, which complements the statistical analyses explained in the Methods section.

4.2. Preliminary data preparations

Life-tables: Annual estimates of age-specific death rates (m_x) and the average number of years lived by those who die within an age-interval (a_x) were computed by applying P-spline interpolation to the corresponding values from the LAMBdA life-tables. The Akaike Information Criterion (AIC) was used for the selection of the smooth parameters. P-spline interpolation was performed using the R package *mgvc*. Based on those annual estimates of m_x and a_x , life-tables for each year between 1944 and 2016 were computed (see Fig. A2). Additionally, a life-table was built for each period of analysis, by aggregating and averaging the corresponding annual m_x (see Fig. 1). Besides being a necessary input for the application of some of the methods used here, these life-tables allowed to solve part of the problem posed by the high under-registration

⁴ The causes of death in the original files of micro-data are coded according to the ICD-9 and ICD-10 schemes. DANE has produced a variable that harmonizes the coding of the causes of death between files. Based on that variable, we aggregated the deaths in the major groups of causes shown in Table A1.

⁵ We compared life-table measures from different sources, including those produced by DANE, LAMBdA, CEPAL and WHO, among others (see Fig. A2 in appendix). From that comparison, we concluded that the LAMBdA estimates were the most precise, since their methodology adjusts jointly for completeness of death registration, enumeration of censuses, and age overstatement (Palloni and Pinto-Aguirre 2011; Palloni et al. 2016).

of deaths in Colombia, which was estimated around 20% between 1990 and 2013 (PAHO/WHO, 1998, 2002, 2005, 2010, 2015).

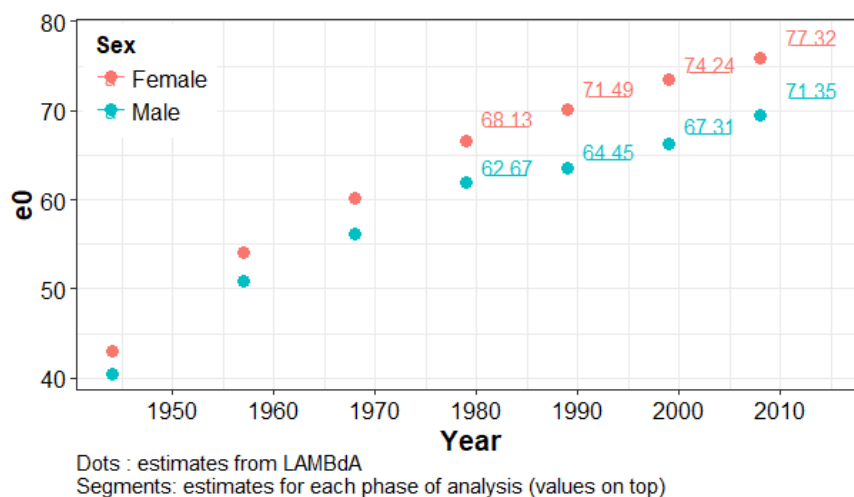


Figure 1. Estimates of life expectancy at birth (e_0) by sex, Colombia, 1944-2014

Death counts by age and cause: The aggregate death counts by sex, age and cause introduced in the previous subsection went through a series of imputations to include as many cases as possible, within relevant categories of analysis regarding the causes of death (see Table A1).

First, 73,604 deaths had no declared age at death between 1979 and 2016. Those cases were not equally distributed among the causes of death: homicides, for instance, included a large proportion of them (26.16%). Thus, excluding these individuals from the analyses would produce a slight underestimation of homicides rates. Under the assumption of similar age-structures between complete and incomplete registers within each cause of death, we attributed an age to those deaths, based on the known distributions of age at death by sex, period-year, and cause of death.

Second, according to the vital statistics, during the period of observation there were 7,566 deaths in legal operations and war situations. However, that number is far from reasonable considering the extreme violence that took place during an important part of that period. Indeed, when contrasting that information with at least three other sources, it becomes clear that the category in question (i.e. death by legal operations and war) suffers from massive under-registration in the vital statistics system: according to data reported by the Ministry of Defence (Codhes 2008), at least 19,263 casualties of fighters from different armed groups were registered in legal operations

during the 6-year period 2002-2008. In contrast, only 4,213 casualties are registered in the vital statistics system during the same period. Another source reports more than 10,000 deaths between 2002 and 2008, corresponding to civilians murdered by the Colombian army (Silva et al. 2018). These murdered civilians, known as the *falsos positivos*, were declared as rebel fighters by the army in search of rewards and promotions. Clearly, not all those extrajudicial killings were registered as casualties during legal operations, as their number alone exceeds the total registered cases in the whole death registration system. The CNMH (2018a) estimates that 39,238 fighters were killed in violent events related to the armed conflict between 1979 and 2016. Thus, since deaths by legal operations and war seem to be substantially underestimated in the registration system, and homicides overestimated, we aggregated both causes in a wider category called *Aggressions*.

Finally, during the study period 1979-2016, 70,761 cases were registered as violent deaths with undetermined intent. This is not a negligible amount; it even exceeds the total number of deaths by suicide (61,278). In 1997, for instance, for each death by suicide there were 3.7 violent deaths with undetermined intention. We examined the evolution of this cause of death over time, as well as the form of death (e.g. the kind of object that caused the death) and two aspects stood out: first, there were two sudden increases of around 700% (followed by proportional decreases), which occurred precisely in the first year of each phase of extreme violence. Second, most of those increases (90%) corresponded to deaths involving weapons (either fire arms or sharp objects). Excluding those two aberrant increases, we estimated a mortality baseline corresponding to around 2.1% of deaths by homicides and suicides combined for each period. From that baseline, we estimated an excess of 14,305 deaths, which were imputed to aggressions. Thus, the category *Aggressions* represents all violent deaths intentionally inflicted, since it was obtained by adding the original counts of registered homicides, and the imputed deaths from the three types described above. It includes a total of 746,922 deaths, of which 40,053 were imputed (5.4%, see Fig. A3 and Table A1).

5. Methods

Various methods were used for measuring the impact of mortality by external causes on general mortality levels and changes in Colombia during the study period and for each phase of analysis. First, death-rates and proportions (total and age-specific) for each cause of death were calculated.

Approximations to the death-rates for the cause i within the age-group $x, x+n$, ${}_n m_x^i$, were obtained by,

$${}_n m_x^i = {}_n m_x \cdot {}_n R_x^i = {}_n m_x \left(\frac{{}_n D_x^i}{{}_n D_x} \right) \quad (\text{eq.1})$$

where ${}_n m_x$ is the all-cause mortality rate for the age-interval $x, x+n$, and ${}_n R_x^i$ is the proportion of deaths by cause i within the same age interval.

Age-standardized crude death rates by cause the cause i at time t , $ASCDR_t^i$, were estimated as

$$ASCDR_t^i = \sum_{x=0}^{\infty} {}_n m_x^i \times {}_n C_x^i \quad (\text{eq.2})$$

where ${}_n C_x^i$ is the proportion of the population in the age-interval $x, x+n$ in the standard population, which in this case is the population in 2005 (from LAMBdA).

And another measure of interest is the average age at death by cause i within the age-interval $x, x+n$ in the year t , $AA_{x,t}^i$, defined as

$$AA_{x,t}^i = \frac{\sum_{x=0}^{\infty} d_{x,t}^i \times (x + a_{x,t})}{\sum_{x=0}^{\infty} d_{x,t}^i} \quad (\text{eq.3})$$

where $d_{x,t}^i$ is the number of deaths by the cause i within the age-interval $x, x+n$ in year t , and $a_{x,t}$ is the average number of years lived by those who died within that age-interval.

The impact of mortality due to external causes was measured with two different approaches: 1) Arriaga's (1984) age- and cause-decomposition method of differences in life expectancy, and 2) Andersen et al.'s (2013) method for calculating the life-years lost due to different causes of death. Although other decomposition methods of changes in life expectancy exist (e.g. Pollard 1988; Vaupel and Canudas-Romo 2003; Andreev 1982; Jdanov et al. 2017), we use Arriaga's approach because of its simplicity and accuracy (these decomposition methods provide approximately the same results). Complete explanations and examples using this method can be found in Arriaga (1984) and Preston et al. (2000). Given that the method measures the contributions by age and cause to the differences in life expectancy between two populations, the following pairs of populations are compared in our analyses: males vs. females in each period of analysis (e.g. males vs. females during the first phase, 1981-84), and consecutive phases for each sex (e.g. phases 1 vs. 2 for males). Thus, sex-differences and historical changes are taken into account in our methodological strategy.

For the second analysis, we calculated the average number of life-years lost by cause of death on each period of analysis, separately for each sex. Although similar analyses have been conducted using alternative procedures (e.g. the study by Moreno and Cendales 2011), here we use the method proposed by Andersen and colleagues, which provides numerous advantages. For instance, given its reliance on life-table data, this method allows a straightforward relationship with the life-table of the population under study (e.g. the life lived and lost is represented respectively by the areas below and above the survival curve, l_x). Additionally, the method allows great flexibility, as the life-years lost by cause can be calculated within each age-category, as well as cumulatively from birth until a given age of interest. It must be kept in mind, however, that given the direct dependence on life-table data, the results obtained correspond to the synthetic cohort whose mortality experience is summarized by the life-table.

6. Results

6.1. Aggression

All the analyses performed in this study where comparisons between males and females are made indicate a large male-disadvantage in survival⁶. That disadvantage was primarily driven by exceedingly high levels of aggression-related mortality among males: proportions (Fig. A4), rates (Fig. A5), contributions to changes in e_0 (Figs. 2 and 3, Table A2), and potential life-years lost (Figs. 4 and A6) show in different ways the heavy burden imposed by violence on male survival in Colombia. For instance, in 1991 (the most violent year), more than one in four male-deaths were due to aggressions (27.2%, vs. 3.3% among females, see Fig. A4).

The differences between males and females regarding the role of aggressions within the category of external causes of death is also illustrated by the ASCDR (see Table 2). For males, aggression stands out as the single most important external cause of death during the entire study period, especially during the years of extreme violence (see Fig. A5). For instance, between the early 1990s and the early 2000s, the aggression-ASCDR for males more than quadrupled the ASCDR of any other external cause for that sex, and exceeded the aggression-ASCDR for females by a factor of about 11.3. Such high levels were, however, not always the case. In 1979, aggression-

⁶ For example, Fig. 2 shows that for almost all causes of death and in almost all age-groups, Colombian males experienced a clear disadvantage when compared to their female counterparts. The only exceptions were cancer between the ages 35 to 65 (which can possibly correspond to increased cancer mortality among females due to breast cancer towards the end of their reproductive life) and the category “other” around the age of 20.

related mortality was “only” 28% higher than other accidents among males, and in 2016 it was 72% higher than traffic accidents. In strong contrast, among females, aggression became more important than the other external causes of death only during the early 1990s and then between 1995 and 2012. In some years during the study period, traffic and other accidents were more important than aggressions as causes of death among females.

Table 2. Age-standardized crude death rate (ASCDR) by external cause of death during each phase of analysis

Phase	Period	Sex	Aggression	Suicide	Violence (UI)	Accident (traffic)	Accident (Other)
1	[1981, 1985]	Female	6.704	1.913	1.668	9.586	12.578
2	[1991, 1995]	Female	15.847	1.683	0.691	8.381	10.052
3	[2001, 2005]	Female	13.022	3.013	1.808	7.704	3.838
4	[2011, 2015]	Female	6.019	1.803	1.477	4.942	2.506
1	[1981, 1985]	Male	89.011	7.643	7.006	37.419	51.291
2	[1991, 1995]	Male	172.834	5.873	3.514	29.039	36.876
3	[2001, 2005]	Male	134.363	9.741	8.442	28.346	18.299
4	[2011, 2015]	Male	61.415	7.629	6.413	21.840	13.396

NOTE: Population of the year 2005 used as reference. Phases of extreme violence are highlighted in grey.

The results of the decomposition analysis also show clearly that aggression was the main responsible for the large sex-gap in e_0 , especially during the phases of extreme violence (Fig. 2 and Fig. A7 for a comparison with other Latin American countries): during those periods, the gap in e_0 between males and females reached an unprecedented size of about 7 years, to the disadvantage of males. Excess male mortality due to aggression alone was responsible for about half of the total disadvantage in e_0 for that sex compared to females during the most violent phases (i.e. 3.79/7.08 years in 1991-94, and 3.15/6.93 years in 2001-04, see Table A2). In the other two “less violent” phases, aggression also contributed significantly to the total male disadvantage in e_0 (34% in 1981-84 and 26% in 2010-14).

Besides contributions to sex-differences, we performed the decomposition by ages and causes of death to consecutive pairs of periods of analysis (see Fig. 3 and Table A2). The results of those analyses indicate that the category of aggressions has had a notorious impact on the changes in male e_0 , as most of the differences in the gaps for females and for males are attributable to that cause alone. For example, the total gains in e_0 by all causes between the first and the second phase (1981-84 vs. 1991-94) were considerably lower for males than females (1.79 vs. 3.36 years

respectively), which was largely due to the increase in aggression-related mortality among men during the early 1990s. On the contrary, between the second and third (1991-91 vs. 2001-04) and the third and fourth (2001-04 vs. 2011-14) phases, the total gains were higher for males than for females, which occurred mainly as a result of larger positive effects of reductions in mortality due to aggression among males. Although the early 2000s were also a very violent period in Colombia, the results shown in Figure 3 indicate that the early 1990s were worse in comparison, as aggressions had a positive contribution to the changes in e_0 between the second and third phases.

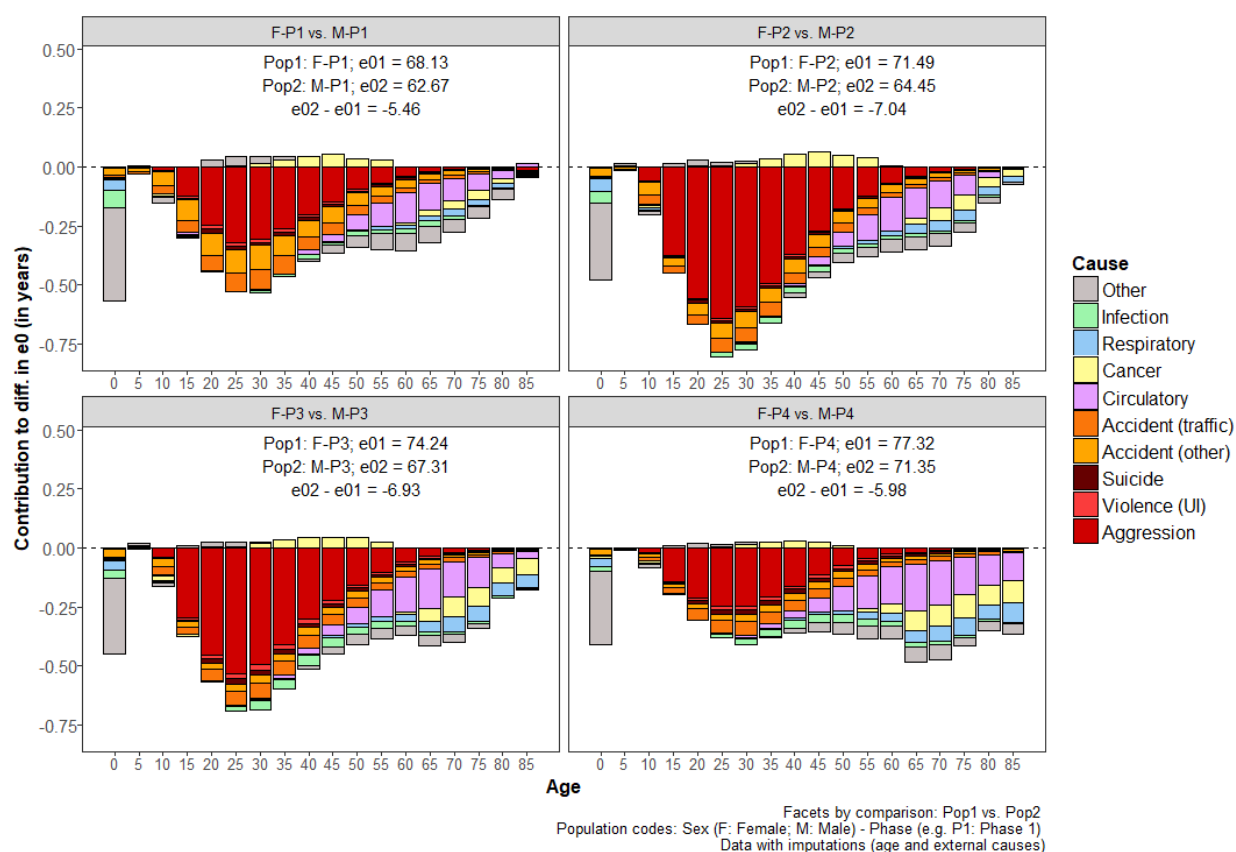


Figure 2. Age- and cause-specific contributions to the differences in e_0 between males and females, by period of analysis

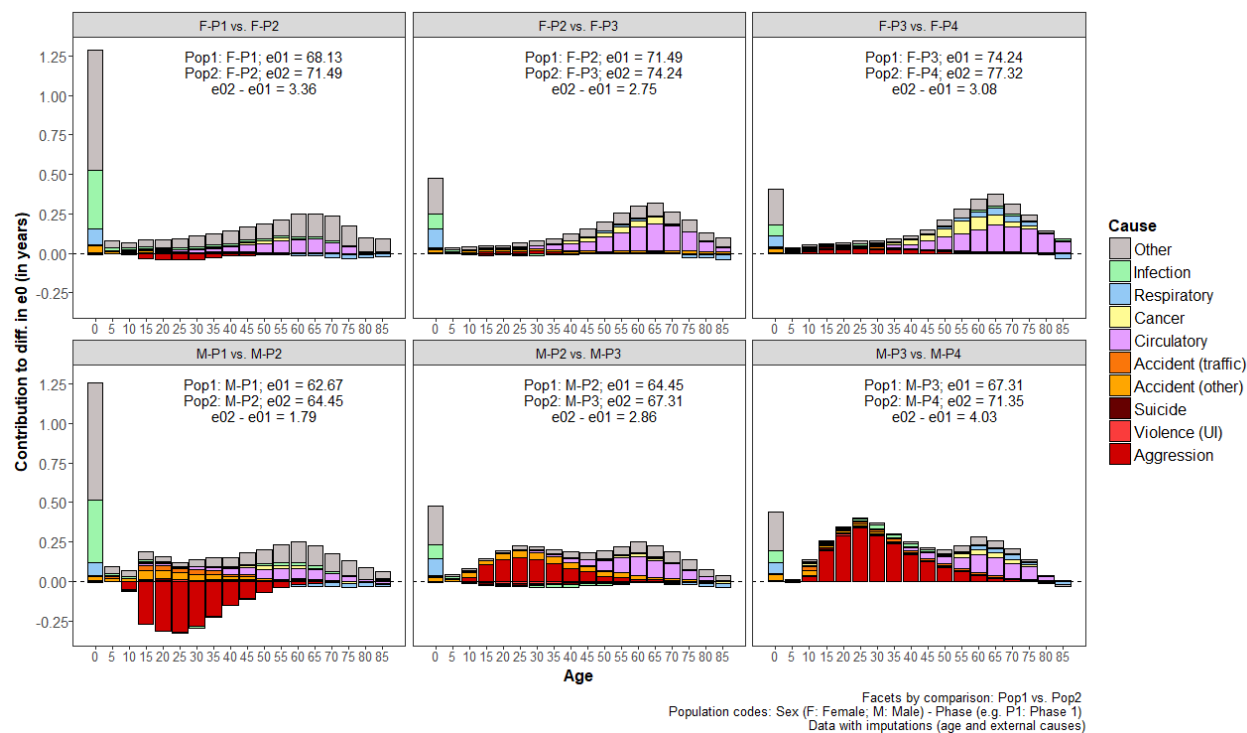


Figure 3. Age- and cause-specific contributions to the differences in e_0 between two consecutive periods of analysis, by sex

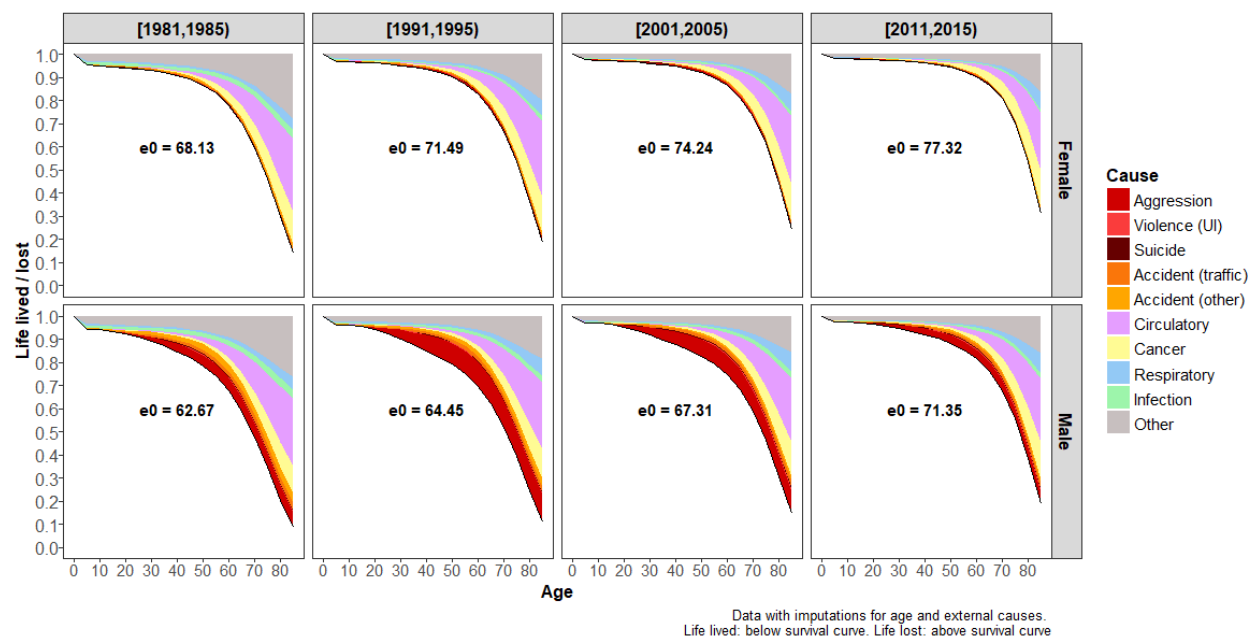


Figure 4. Life lived and lost (by cause of death) up to age 85 on each phase of violence, by sex

The heavy burden of aggression on male mortality is also evident in Figure 4 and Figure A6, which show the results of the life-years lost analysis. Figure 4 summarizes the mortality experience of males and females in Colombia up to age 85 during the period under study, based on life-tables for each period of analysis. The colored area (above the survival curve) represents the potential amount of life that was lost, by cause of death. Once again, it is clear that aggression alone was the main responsible for the different profiles by sex, as the area occupied by that cause is significantly larger among males than among females. In particular, the rapid decline of the survival curve among males during the periods 1991-94 and 2001-04 indicates that during those phases, a considerable amount of potential years of life was lost by males due to excessive mortality by aggression at young ages.

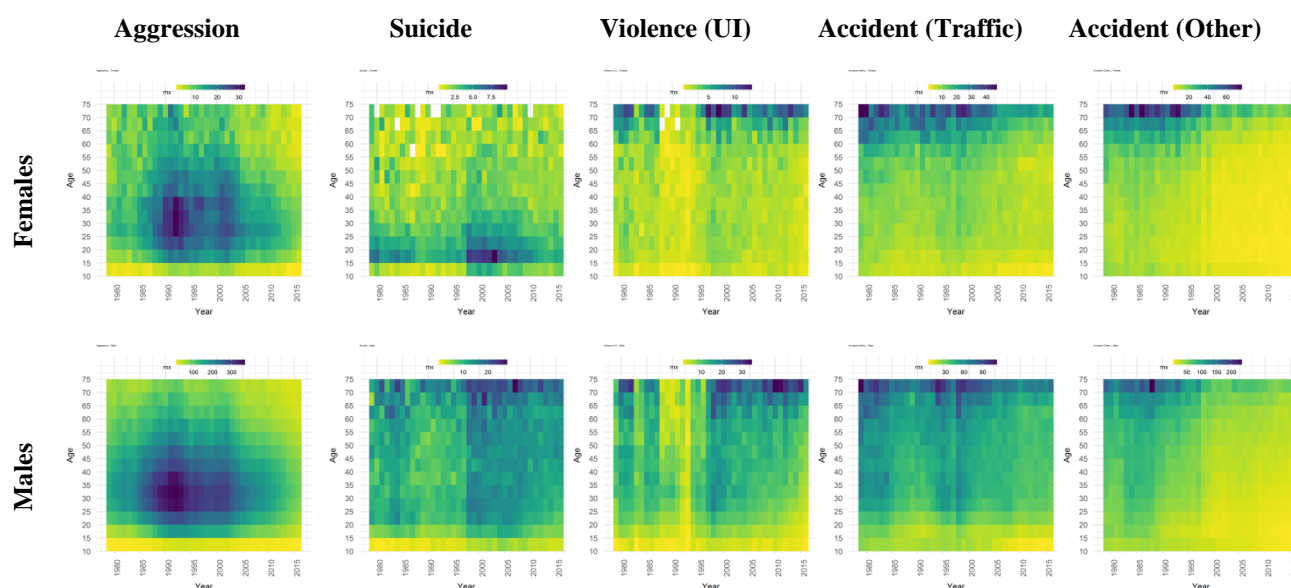


Figure 5. Annual age-specific death rates¹ by external cause of death and sex, 1979- 2016

¹Only shown are the results for ages 10-14 to 70-74. Age in vertical axis. Calendar year in horizontal axis.

The high mortality levels by aggression among young adults is also visible in the detailed lexis maps showing age-group specific death rates for each external cause of death (see Fig. 5). Without surprise, the highest death rates corresponded to aggressions during the years of extreme violence (from about the late 1980s until the early 2000s). For both sexes, that cause of death had the highest rates in ages 15 through 54, but during the periods of extreme violence, rates for ages 20 to 39 were considerably exacerbated. Although these results indicate unusually high mortality

levels by aggression among adolescents and young adults of both sexes during the periods of extreme violence, the levels experienced by males far exceeded those experienced by females, as the large male disadvantage in e_0 caused by aggression was concentrated at young ages (Fig. 2). In all four phases, but especially during the periods of extreme violence, the negative contribution of aggression for males increased rapidly until the ages 25-29, where it reached a maximum, and then decreased fast.

Table 3. Average age at death by external cause during each phase of analysis

Phase	Period	Sex	Aggression	Suicide	Violence (UI)	Accident (traffic)	Accident (Other)
1	[1981, 1985)	Female	33.2	27.6	33.7	33.9	31.4
2	[1991, 1995)	Female	31.1	28.6	33.3	36.7	40.6
3	[2001, 2005)	Female	32.0	27.2	42.3	38.5	36.0
4	[2011, 2015)	Female	32.8	31.7	51.5	42.0	47.2
1	[1981, 1985)	Male	33.9	35.8	35.6	34.1	32.3
2	[1991, 1995)	Male	31.3	34.9	34.3	36.2	36.3
3	[2001, 2005)	Male	32.3	36.1	38.1	38.2	35.6
4	[2011, 2015)	Male	32.5	38.2	45.6	40.4	42.4

NOTE: Phases of extreme violence are highlighted in grey.

The concentration of mortality by aggression at young ages is also reflected in the average age at death due to that cause: when entering periods of extreme violence, that age decreased considerably for both sexes (e.g. by 2.6 and 2.1 years for males and females respectively, see Table 3). Such a decrease is not surprising, since young age-groups are disproportionately affected by violent deaths. Thus, the average age at death by aggression is expected to be inversely correlated with violence intensity. However, considering the changes in aggression-ASCDR between the two extremely violent phases (Table 2), a slight decrease of 17.8% for women and 22.3% for men produced a full one-year increase in the average at death by aggression for both sexes, whereas a 55% decrease after the EV phases only increased the average age at death by 0.2 years and 0.8 years for males and females, respectively.

The increase in the average age at death by aggressions between the two phases of extreme violence was not only due to a decrease in mortality by intentional violence; it was also the result of a larger impact suffered by the civilian population during the second phase of EV, which included more persons in older age-groups than the first phase of EV. This finding is supported by the fact that, while death rates by aggression decreased considerably among young adults

(below the age of 40) between the two phases of extreme violence, those for middle-aged adults (40-64 years) remained at similar levels (Fig. 5). This suggests that during the second EV phase, aggressions were less concentrated in young ages and shifted toward wider segments of the population.

A final finding of interest revealed by our analyses by sex is that, despite experiencing lower mortality levels due to aggression in comparison with males, females experienced larger variations in that regard. For example, the aggression-ASCDR for females more than tripled between 1979 and 1992, and then decreased of 77% from 1992 to 2016. For males, the corresponding changes were an increase by a factor of 2.6 followed by a similar decrease of 78%. Estimates of ASCDR by periods of analysis also indicate a larger increase for females between pre-EV and cartel-related-EV periods (see Table 2).

6.2. *Suicides*

Compared to aggressions, suicides had a small impact on general mortality in Colombia during our study period. For example, the contribution of this cause to changes in e_0 is barely visible in figures 2 and 3. Nevertheless, our analyses revealed differences in suicide mortality between periods of analysis, as well as distinctive patterns by sex and age.

Suicides rates stabilized (among males) or even decreased slightly (among females) during the 1980s and the 1990s (see Fig. A5). This was followed by a sharp increase towards the end of the 1990s. Among our four periods of analysis, that highest suicide-ASCDR occurred during the early 2000s, i.e. during the second period of extreme violence (see Table 2). Part of that increase could be related to changes in the codification of causes of death, as ICD-9 codes were replaced by the ICD-10 version in the year 1997. However, even after that year, suicide rates continued to rise until the first half of the 2000s, with a slight decreasing trend afterwards.

The lowest suicide rates occurred around the years 1991-94, i.e. precisely during the first phase of extreme violence. This coincidence could be the result of selection in aggression-related mortality, as an important proportion of individuals with high susceptibility to die by suicide may have died by violent causes instead (e.g. because of their enrollment in violent activities, increasing their likelihood of becoming victims of homicides or war/legal operations). However, this explanation does not work for the second phase of extreme violence, when the highest suicide rates were registered. One possible explanation for this difference is that, instead of

reducing the odds of suicide by reducing the number of potential victims, indiscriminate violence against the civilian population—which was characteristic during the second phase of extreme violence—triggered desperate actions among victims who went through traumatic experiences, such as forced displacement, physical abuse, and the loss of close family members.

Males experienced higher mortality rates by suicide than females (see Table 2). The male-disadvantage in this cause of death is also illustrated by the results of the decomposition analyses (see Fig. 2 and Fig. A8a). As most other causes of death, suicides contributed to that disadvantage in all periods of analysis. The largest negative contributions for males were at young adult ages (around the 20s and the 30s); then they declined slowly with age (in contrast with Aggressions, where the negative contributions by age peaked around ages 25-29 and then declined fast with age). As for the comparisons between periods of analysis (see Fig. A8b and Table A2), these indicate that reductions in suicides produced small positive contributions to the differences in e_0 between the two earliest and the two latest periods. On the contrary, between the two periods of extreme violence, 1991-94 and 2001-04, suicide was one of only two causes of death with total negative contributions to the differences in e_0 for both sexes. The other cause was Violence with undetermined intent. Thus, although suicides contributed relatively little to the differences in e_0 , the results of the decompositions indicate an unusual increase in suicide mortality during the period 2001-04. Although (young) males were, on the whole, more affected, the results for women aged 15-19 are outstanding. Diverging age-patterns for males and females in the category of suicides (see Fig. 5) show indeed that, while males experienced relatively high rates within a wider age-range, the highest suicide rates in females were concentrated at very young ages (15-24). In 2003, 15.8% of all female deaths between the ages 15 and 19 occurred by suicide. For the entire period 1979-2016, that is the highest proportion of deaths by suicide for both sexes within any age-group. It more than doubles the maximum proportion of deaths by suicide among males (7.8% for ages 15-19 in 2016). The next highest proportions were observed in the two preceding years (2002 and 2001) also among females aged 15 to 19 years.

One possible explanation for the impressive increase in suicide mortality among young women during the early 2000s could be associated with the systematic expansion of forms of violence other than homicides against the civilian population during the second phase of extreme violence. During that phase, women were frequently victims of sexual abuse by different armed groups. According to data from CNMH (2018a), 48.2% (6573) of all registered sexual crimes

against women related to the armed conflict between 1979 and 2016 occurred during the short period 2000-05.

6.3. Other external causes of death

For the other categories of external causes of death, the results of our analyses did not reveal particular characteristics that could be related to the sociohistorical context of each period. As in the case of aggressions and suicides, males experienced a disadvantage in survival by those other causes of death: on average, the ASCDR for traffic accidents, other accidents, and violence with undetermined intent were respectively 3.7, 3.4, and 3.9 times higher among males than females during the entire period 1979-2016 (see Table 2). For those three categories, mortality rates increased with age (see Fig. 5).

In the case of violent deaths with undetermined intent, the corresponding ASCDR decreased by 13.7% and 23.1% between 1979 and 2016 for females and males, respectively (see Fig. A5). Regarding traffic accidents, important increases were observed during the decade of the 1990s, followed by a marked decrease afterwards. Sudden and irregular changes were identified in 1997 and 1998, when a drop of 15% and an increase of 35% occurred respectively during only those years. Those sharp, short-term variations could possibly be due to changes in the codification of causes of death (change of ICD version in 1997) or to inconsistencies in the vital statistics system (e.g. a transfer of some traffic-related deaths occurring in 1997 to 1998). In 2016, the lowest mortality rates related to traffic accidents were registered (5.3 and 23 deaths per 100,000, for females and males respectively). Finally, the mortality rate from other accidents (not related to traffic) decreased considerably during the study period (by 80.6% and 75.4% for females and males respectively). However, most of that decrease occurred between 1983 and 2002, after which it stagnated.

7. Discussion and Conclusion

The aim of this study was to identify whether different historical phases of violence in Colombia have distinctive characteristics in terms of external mortality. In order to do that, we defined four periods of analysis—representing four different sociohistorical contexts—and applied various demographic methods. Results from different types of analyses suggest that this was the case, but only for some external causes of death: while accidental mortality and deaths with undetermined

intent did not seem to be related to the historical context, mortality by aggressions and suicides differed during each period. The observed differences for aggressions and suicides seem to be rooted in the significant changes in the forms and intensity of violence that dominated during each phase. For instance, our results showed that age-standardized rates for aggressions increased the most between 1981-84 and 1991-94 (increases of 236% for females and 195% for males). Given that drug cartels (whose activities dominated the first phase of extreme violence) and armed groups were disproportionately composed by men, the higher relative increase for women is somewhat surprising. However, this could in part reflect the fact that increasing relative risks is easier when the initial number of cases is low (e.g. an increase of 1 homicide per 100,000 in 1979 represents a 14.9% increase in homicide rates among females, but only 1.1% increase for males). The appalling results related to aggressions showed that intentional violence had a large negative impact on survival in Colombia (especially among young males during the phases of extreme violence). However, our results for the most recent periods and years of analysis are relatively optimistic, as important reductions in aggression-related mortality between 2001-04 and 2011-14 contributed enormously to gains in male survival (47% of the total gains, vs. 6.8% for females, see Fig. 3). Moreover, mortality due to aggressions had the lowest ASCDR in 2016, and the trend suggests that it will continue to decrease during the next years.

In the case of suicides, the maximum deterioration occurred between 1991-94 and 2001-04 (increase of 58% for females and 28% for males). As mentioned in the results section, that increase may reflect the fact that forms of violence other than homicides were acting indirectly on mortality, through traumatic- and stress-related mechanisms. Indeed, the experience of violence can leave deep psychological sequels in a population, as shown in the study by Richards et al. (2011), where a large proportion of a sample of internally displaced Colombians suffered from mental distress, including symptoms of PTSD (88%) anxiety (59%) and depression (41%). This relationship between extreme forms of violence and suicides is not exclusive to the Colombian context. In Mexico, large increases in mental distress among the young population have been identified since the upsurge of the war on drugs in 2005 (O'Connor et al. 2014; Villar et al. 2017; Saucedo et al. 2017).

According to various reports about the armed conflict in Colombia (CNMH 2011, 2018b), women could suffer greater psychological distress than males when exposed to contexts of extreme violence, and this for two main reasons. First, even after living traumatic experiences,

women are expected to continue taking care of and giving emotional support to their family. In case of widowhood, as often happens in violent contexts due to excess male mortality, women also have to provide economic sustain for the whole family. Second, women are more likely to become victims of sexual abuse, which can have profound consequences in their life projects, in their self-perception, and in their relationships with family and community. During the armed conflict in Colombia, sexual violence, especially against women, was practiced systematically by armed groups as a means to ensure the control of territories and the subjugation of the population (CNMH 2018b)⁷. Despite the mental distress faced by victims of sexual abuse (especially when those crimes occur during infancy), the vast majority of them did not receive any form of psychological help, worsening their condition even more (CNMH 2011). Although the data and methods used in this study do not allow us to establish unambiguous causal relationships between sexual crimes against women and suicides, the synchronicity of the sharp increases in both events during the early 2000s is quite suggestive. Thus, we consider that further investigation is urgent and necessary in order to better understand the mechanisms linking forms of violence, mental distress and suicide in the Colombian context, and how does this relationship vary by sex.

The above discussion highlights the fact that the consideration of the sociohistorical context in the analysis of mortality by external causes in Colombia has important implications, since it adds conceptual meaning to the differences identified between periods of analysis: this sociohistorical delimitation provided meaningful cues for interpretation, suggesting possible mechanisms behind the changes analyzed. The definition of periods of analysis is indeed one of the innovative features of this study in comparison with others, where the evolution of mortality due to external causes in Colombia is analyzed without considering the important influence of the historical, sociopolitical context. Here we showed that taking that context into account is very important, not only for the identification of characteristics associated to each phase, but also for the definition of relevant categories of causes of death. Indeed, we identified that without any adjustment, aggression-related mortality could be underestimated by about 5%. This magnitude may seem small when expressed in percentage, but it represents at least 40,053 deaths, which

⁷ Sexual violence is rarely registered, as under-registration for those crimes is estimated to be around 95% to 98% (CNMH 2011; Semana 2012). Stigmatization that the legal complaints bring to the victim account for this low level of registration. According to the First Survey about Sexual Violence Prevalence in the context of the Colombian Armed Conflict (Casa de la Mujer 2011), during the period 2001-2009, 94,565 women declared to be raped and 7,754 declared to be forced to prostitution in 407 municipalities within the context of the armed conflict.

would be left unaccounted for in the absence of any adjustment. That figure exceeds the total number of fatal victims left by the worst Latin-American dictatorships of the 1970s, such as the Chilean (3,000 deaths) and the Argentinian (30,000 deaths).

Finally, it is worth keeping in mind that, even after adjustments and imputations, deaths by homicides remain underestimated, as numerous cases may be missing from the vital registration system. For instance, it has been estimated that during our same period of analysis, there were more than 60,000 forced disappearances related to the armed conflict (CNMH 2016). Nevertheless, according to some authors, homicides and the other external causes of death have lower levels of under-registration in comparison with other non-external causes. This is because, on the one hand, all deaths by external causes should follow strict protocols such as compulsory autopsy. On the other hand, external causes of death are easier to identify than other causes, and should be declared by competent medical authorities, reducing the risk of intrinsic miss-recording problems (Urdinola et al. 2017).

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Appendix Figures and Tables



Figure A1. Number of victims by lethal (a) and non-lethal (b) forms of violence related to the armed conflict in Colombia during the period 1979-2018
Data from the *Observatorio de Memoria y Conflicto*

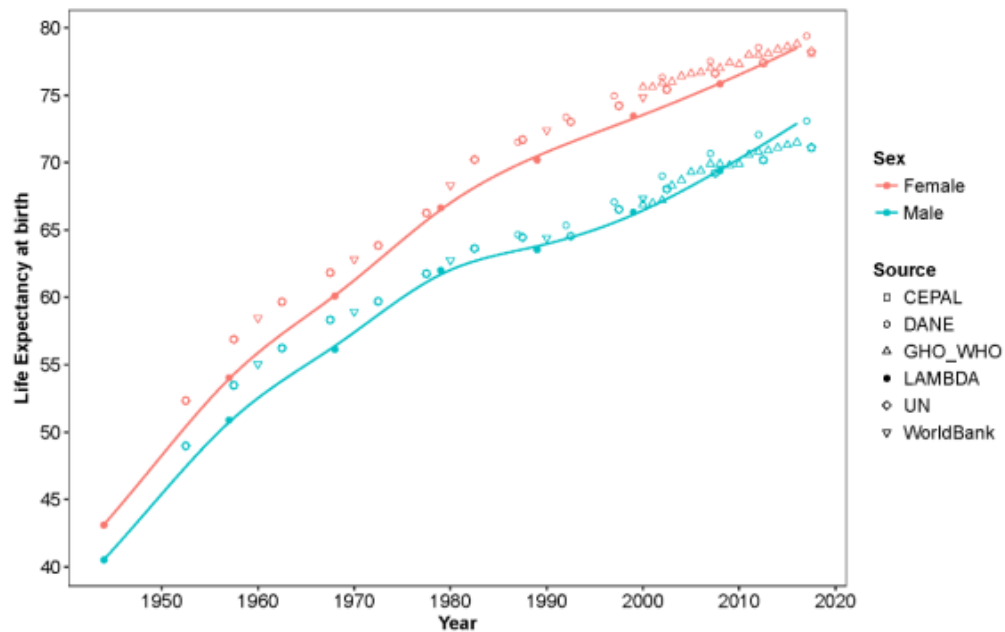


Figure A2. Estimates of life expectancy at birth (e_0) by sex, Colombia, 1944-2014

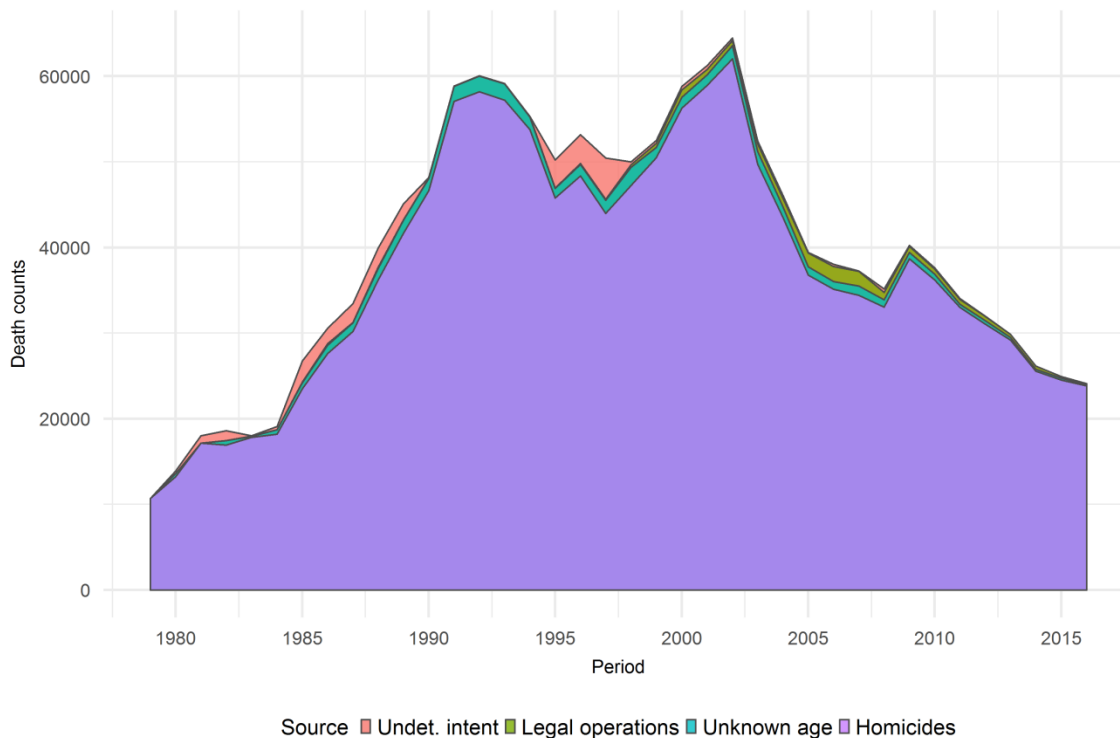


Figure A3. Annual death counts by aggression, according to the source¹.

¹Registered as homicides (in purple), registered as deaths from war and legal operations (in green), imputed from registers with unknown age at death (in blue), and imputed from violent deaths with undetermined intention (in red).

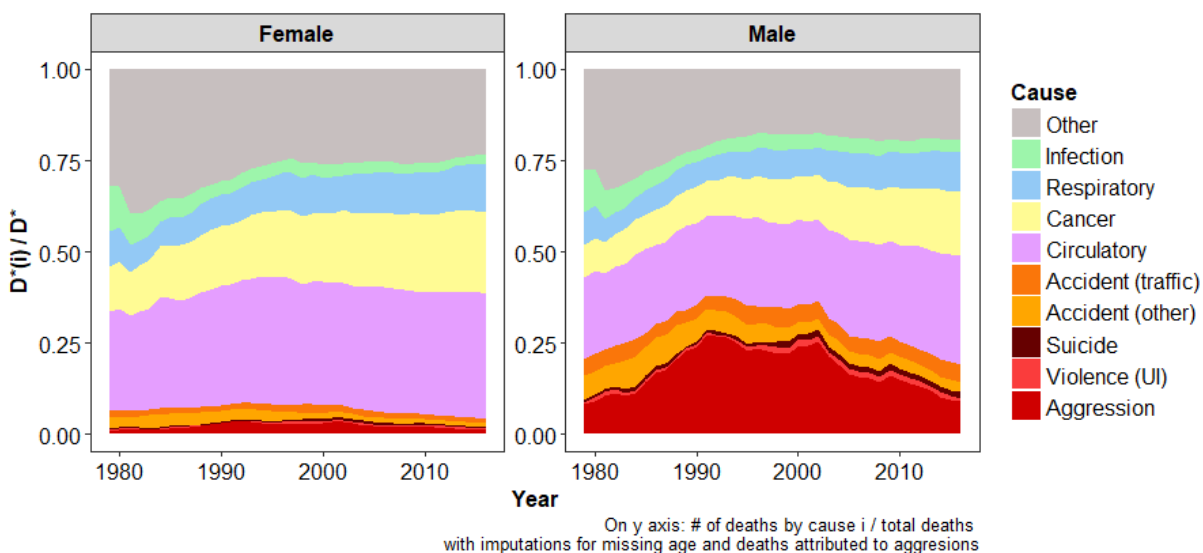


Figure A4. Proportion of total annual deaths by cause, Colombia 1979-2016

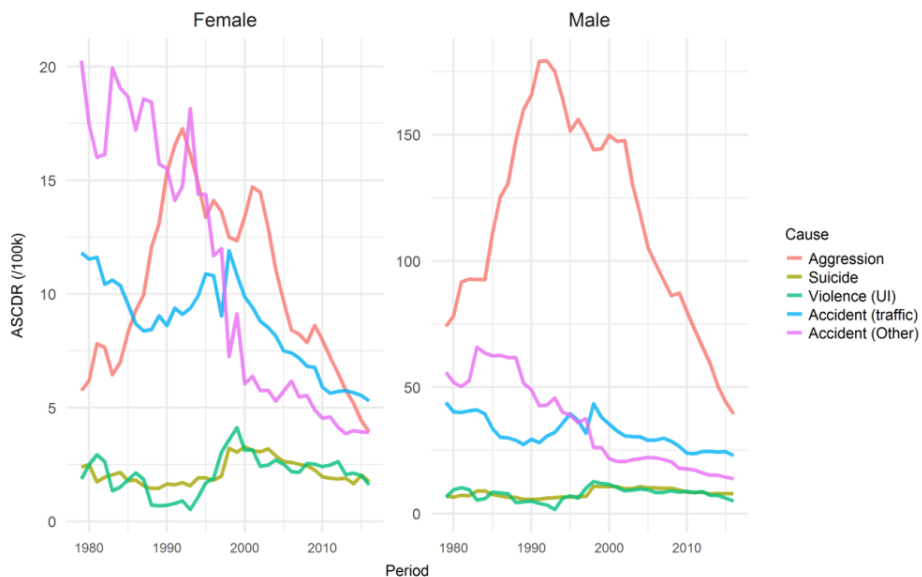


Figure A5. Age-standardized¹ crude death rates (ASCDR, per 100,000) by external cause
¹. Age structure of Colombian population in 2005 used as reference for standardization.

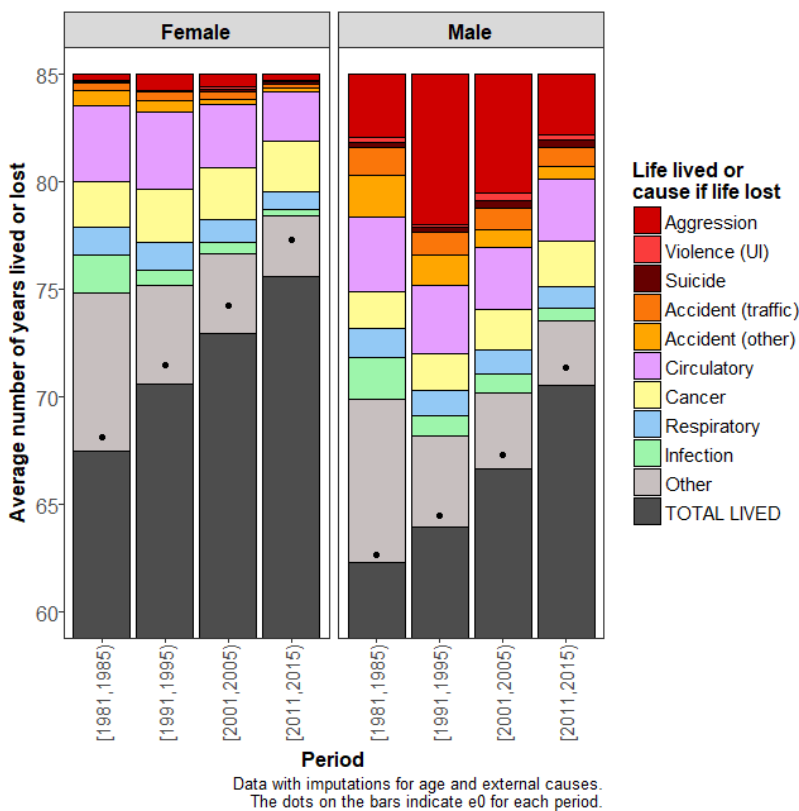


Figure A6. Average life lived and lost (by cause of death) up to age 85¹, by period of analysis
¹. Sum by ages of the results presented in Figure 7 in the main text

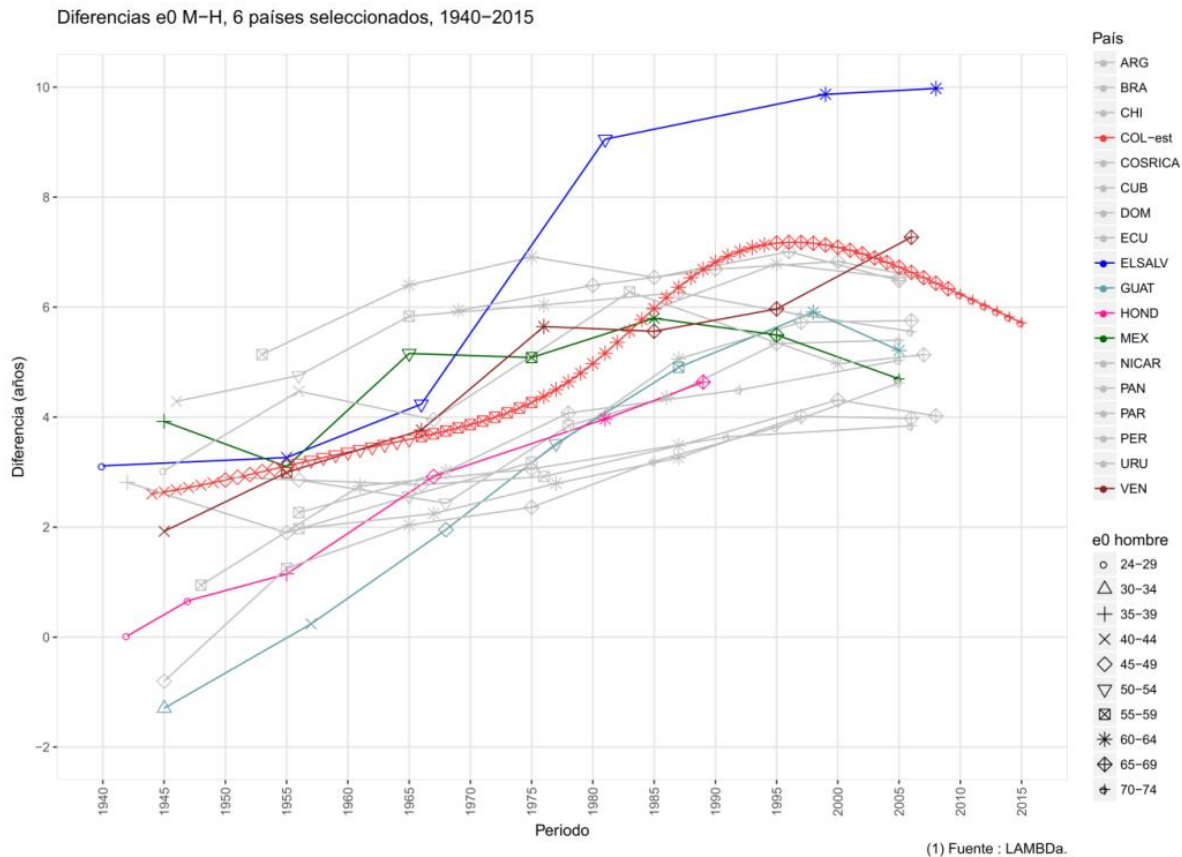


Figure A7. Sex-gap in life expectancy at birth (e_0 Females - e_0 Males) for selected Latin American countries¹, since the 1940s.

¹The trajectories of selected countries are highlighted in colors. The dots show male e_0 (in age-classes) at each moment available, so that female e_0 can be obtained by adding the sex-gap to the male e_0 . The annual estimates for Colombia show clearly that the sex-gap in e_0 increased rapidly during the years of extreme violence.

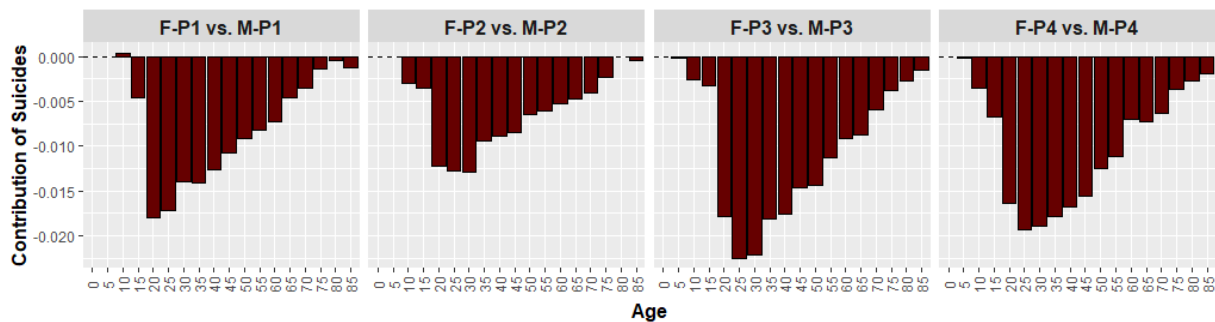


Figure A8a. Detail of age-specific suicide mortality contribution to the differences in e_0 between males and females, by period of analysis: complement to figure 5

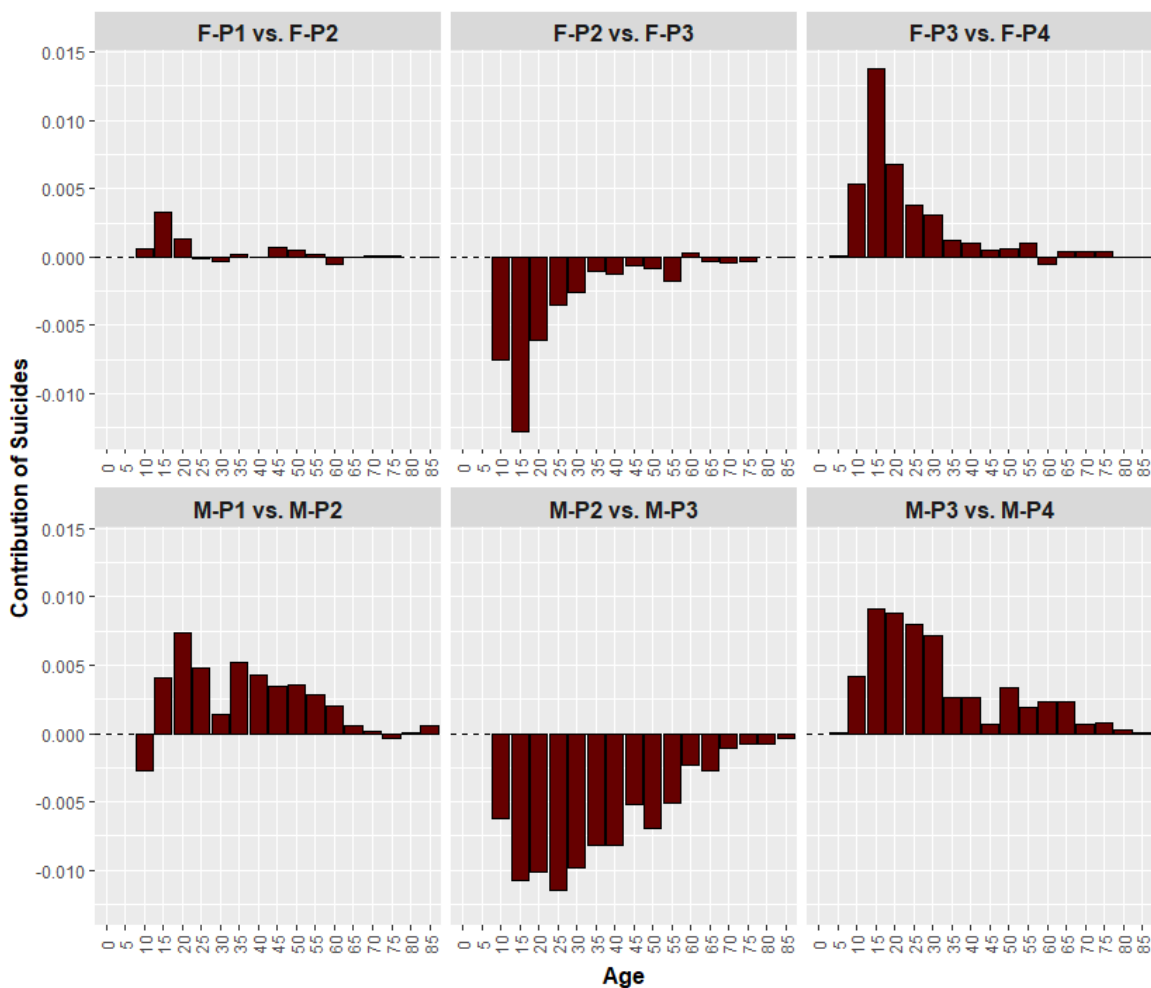


Figure A8b. Detail of age-specific suicide mortality contribution to the differences in e_0 between two consecutive periods of analysis, by sex: complement to figure 6

Table A1. Total number of deaths registered in Colombia from 1979 to 2016, by major causes of death, with and without imputations

Cause	Deaths (registered)	Deaths (adjusted)	Difference (%)
External			
Aggression	706869	746922	5.36%
Violence (undetermined intent)	68316	56375	-21.18%
Suicide	60720	61262	0.88%
Traffic accidents	216515	218704	1.00%
Other accidents	237730	234983	-1.17%
Circulatory	1834479	1850397	0.86%
Cancer	990956	997117	0.62%
Infection	275412	277936	0.91%
Respiratory	592528	596659	0.69%
Other	1563595	1579751	1.02%

NOTE: the differences for the non-external causes are due to imputations of age only; the differences for the external causes include imputations of age and transfer of some cases between sub-categories (e.g. from Violence (U.I), war, and legal operations to Aggression)

Table A2. Total contribution (in years) by cause of death to the difference in e_0 between two selected populations

Sex	Phase	Cause of death										Total
		Aggress.	Violence (U.I.)	Suicide	Accident (traffic)	Accident (other)	Infect.	Respira.	Cancer	Circula.	Other	
<i>Comparisons between males and females</i>												
Female vs. Male	Phase 1 (1981-84)	-1,876	-0,121	-0,127	-0,648	-0,911	-0,234	-0,194	0,052	-0,651	-0,752	-5,463
Female vs. Male	Phase 2 (1991-94)	-3,798	-0,069	-0,100	-0,519	-0,688	-0,263	-0,315	0,049	-0,706	-0,629	-7,039
Female vs. Male	Phase 3 (2001-04)	-3,152	-0,179	-0,176	-0,560	-0,416	-0,360	-0,411	-0,162	-0,957	-0,557	-6,928
Female vs. Male	Phase 4 (2011-14)	-1,545	-0,154	-0,168	-0,507	-0,341	-0,302	-0,486	-0,413	-1,314	-0,747	-5,977
<i>Comparisons between periods of analysis</i>												
Female	1 vs. 2	-0,239	0,029	0,006	0,033	0,113	0,570	-0,005	0,070	0,557	2,230	3,365
Female	2 vs. 3	0,081	-0,041	-0,039	0,021	0,214	0,111	0,121	0,190	1,074	1,017	2,750
Female	3 vs. 4	0,212	0,013	0,038	0,091	0,069	0,179	0,213	0,425	1,131	0,712	3,081
Male	1 vs. 2	-1,872	0,079	0,037	0,190	0,358	0,521	-0,041	0,089	0,478	1,949	1,788
Male	2 vs. 3	0,904	-0,120	-0,090	0,022	0,460	0,018	0,095	0,014	0,671	0,887	2,860
Male	3 vs. 4	1,898	0,053	0,055	0,169	0,162	0,224	0,174	0,158	0,641	0,500	4,032