Calculating Years of Life Lost to estimate premature mortality due to firearms in Ecuador 1998-2018

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Abbreviations

UN. United Nations.
GHP. Global Health problems.
USA. United States of America.
LA. Latin America.
EAJC. Ecuadorian Army Joint Command.
ICD-10. International Classification of Disease.
INEC. Instituto Nacional de Estadísticas y Censos. (Ecuadorian Institute for Census and Statistics)
SIPRI. Stockholm International Peace Research Institute.
GDP. Gross Domestic Product.
UNODOC. United Nations Office on Drugs and Crime.
PH. Public Health.
YLL. Years of life lost
YLD. Years lived with disability.
DALY. Disability adjusted life years.
GBD. Global Burden of Disease.

Abstract

Introduction

Violence and death resulting from firearms has been a ubiquitous problem for Latin American nations. Ecuador has dealt with this problem and its repercussions to varying degrees in the last 20 years.

In order to tackle this violence, a different point of view may be needed. We aim to provide a Public Health perspective to aid in the development of good policy and to monitor the result of interventions by defining the role of firearm violence on premature mortality and estimating its toll on the community.

Methods

Certificates for all recorded deaths attributed to firearms in the period between 1998 and 2018 were obtained from the Ecuadorian data banks. These records were organized in age groups and according to ICD-10 categories.

Years of life lost were calculated for all groups and intentionality. In order to establish a comparison, all causes of death during the last five years were ranked by the total number YLL calculated.

Results

During the studied years, a total of 27.146 fatalities were recorded; 25.355 (93,40%) were males, and 1.791 (6,6%) females. The average death rate for the 21 years is 9,46 per 100.000.

A total of 670,384 years lost were computed, males lost 624,954 years, and females 45,430, the most enormous amount of YLL was found among persons between 20-40 years of age.

For males during, the last five years of the series, deaths from firearm injuries are, consistently among the 5 leading causes of premature mortality.

Conclusions

While being preventable, firearm violence is a leading cause of premature mortality in Ecuador, heavily affecting the younger population and special young males. For this demographic, firearms generate more loss of life than any other cause excluding, Vehicular accidents and Suicide.

It is true even when the overall rates of firearm deaths are lower now than in the previous decade. There is a pressing need for firearms to be considered from a Public Health perspective, and for policy and intervention to be guided by data and studies like it can be used to monitor and aid policymakers.

Chapter I: Introduction

1.1 Firearms violence in the global context

The availability and production of firearms is a global problem, endangering the lives of thousands of people worldwide and becoming a massive obstacle in reaching global development.
In the words of UN's ex-secretary general Koffi Annan, *"The death toll from small arms dwarfs that of all other weapons systems — and in most years greatly exceeds the toll of the atomic bombs that devastated Hiroshima and Nagasaki. In terms of the carnage they cause, small arms, indeed, could well be described as 'weapons of mass destruction [1].".*

According to the latest trade report by Small Arms Survey at the end of 2017, there were an estimated 1 billion firearms in current circulation worldwide.

An approximated 85% are currently in civilian possession (875 million), distributed within 230 countries and autonomous territories. Of those, 13% are located and under control of military armories or stockpiled for military use, and the remaining 2% are in use by police and law enforcement agencies [2][3].

Shifting trends in significant world conflict, stagnation of ongoing armed clashes, and the sudden but steady presence of new manufacturers and providers have made an ideal environment for accelerating production and export of firearms.

Worldwide, the most prominent manufacturers are: the USA, the Russian Federation, France, Germany, and China. With an estimated production rate of 130 rounds per minute [4].

SIPRI (Stockholm International Peace Research Institute) calculated the military spending for the year 2017 toppling at 1.7bn. [5]. This industry with an estimated revenue of 2.2% of the world's GDP [6], has enormous, economic and political leverage.

Firearms themselves constitute a significant cultural, social, demographic and economic determinant, both at global, and domestic scales. Small arms, identified as firearms designed to be readily carried and used by a single individual, make up the bulk of world firearm production, with 700.000-900.000 units fabricated each year [7].

Over 80% of them are produced in 15 countries, with Brazil being the only industry producer in Latin America. The great majority of firearms will end up in the hands of the civilian population, thus, becoming the means of everyday violence, either in homicides, aggression, suicide, or accidental death.

Available data backs this reality, in 2006 it was estimated by the Declaration on Armed Violence that nine out of every ten violent deaths takes place in non-conflict scenarios [8].

Firearm violence is a primary driver for social instability, which becomes a determinant of poor health outcomes rippling across the communities, countries, and eventually reaching a global scale.

It is not surprising then that in 2015, the Millennium Development Goals' revision process, crystalized the long-awaited inclusion in the international development framework for a specific goal, in peace and security (included as peace and justice) [9].

To develop a more detailed understanding of the problem, a careful look at firearms and their impact on society is needed.

1.2 Firearm violence as a public health issue

There is an undeniably strong link between firearm violence and health. The overall pattern of violence is congruent with the shift in disease burden during the last 25 years. The risk of being a victim of a violent death resulting from intentional homicide is declining, in a growing global population.

According to the last Global Study on Homicide conducted by UNODC (United Nations Office on Drugs and Crime), the number of deaths due to homicide in 1993 was 7.4 per 100.000 global population, and by 2017 it had declined to 6.1 [10].

The world population has increased substantially during these last years. Since these measures are computed as proportional to the population, it can be deduced that this decrease may be a result of the overall population gain.

The highest homicide rate in 2017, was recorded in the Americas: 17,2 per 100.000 in a region with a population of 1 billion, compared to Africa with a rate of 13,0 per 100.000 and populated by an estimated 1,2 billion, the Asian continent in contrast recorded only 2,3 per 100.000, while containing 4,5 billion of the total world population [10].

Suicide also implies in the global the global scale; its intimate relation with firearms requires an even more delicate study. Given the already stablished and well-researched status of suicide as a preventable cause of death and its growing role in public health.

Firearms are center-featured as one of the three leading methods of suicide for both males and females globally when they are readily available [11]. The unanimous conclusion seems to point at one fact [12]: restricting the availability of firearms is the most technically feasible and cost-effective measure.

1.3 Statement of the problem

The amount of deaths attributed to firearms globally poses great concern to professionals and academics in Public health. In some countries in which public policies are not yet in tune with the current situation or have not been adequately benchmarked for their effectiveness, availability of data is of primordial importance.

To understand the need for this study, a description of the particularities related to firearms in Ecuador's health research is needed. There is a necessity for Ecuador as a developing nation, to monitor its most pressing public health issues.

To prioritize the available resources for data collection and research to continuously measure the spread, burden, and overall status of communicable diseases and their non-communicable counterparts.

This broader spectrum of Public Health concerns limits the time and resources available to conduct studies for other less apparent public health problems, such as the ones related to violence and safety, and its influence on the public's wellbeing and quality of life. There is also a matter of jurisdiction; at first glance, firearm violence's ill consequences would be up to the health professionals to handle.

Historically, firearm-related injuries have been the subject of various assessments and guidelines, from analysis of hospital admission, pharmaceutical management, treatment protocols [22,23], to epidemiological and societal interventions.

The practical medical implications are plain to see. However, there is another component to the analysis of firearm violence that gets further complicated due to the delicate string of intervening factors and institutions.

Firearms are, in essence, a means for perpetrating violence and causing injury, and as such, their use and circulation are to be regulated. In Ecuador, it is the EAJC, in charge of regulating training, imports, domestic sell, and permits [24], for firearms, explosives, and ammunition.

The practical control and vigilance of violence generated by firearms falls in law enforcement agencies such as local police departments. The vast majority of firearms entering the country (by legal means) are regulated by Ecuadorian Customs. In contrast, a sizeable amount enters due to arms trafficking and smuggling from neighboring countries [25]. This adds the involvement of law-makers and legislators responsible for setting up control structures.

The amount of government agencies involved in the regulation, control, and vigilance process makes the study of firearms as a Public Health concern a very complicated one, akin only to illicit drugs [26]. In a different tone from drugs, though, the higher level of governmental effort necessary for the prevention does not feature as heavily in the issue of firearms.

There are no public campaigns warning from the dangers of firearms for the community's more vulnerable, there is no commitment from education authorities, with the of sharing to youths the same facts and counseling as are provided for drug prevention.

All of this shows how firearm violence is an ongoing issue in Ecuadorian society, with implications that can be felt throughout the country. Policies are in place intended to control the issue, but they have not been adequately benchmarked, and what is more, some questions relating to the problem remain.

How do firearms affect the population in the country? What kind of violence is caused by firearms? What if any type of firearm is responsible for the violence? Or, what is the magnitude of firearm mortality? Answering these questions would help with understanding how much of a Public Health problem firearm are.

As with any other significant health concern, the readily evident magnitude is not as significant as the potential for positive intervention. The primary directive continues to be to promote and protect the health of the population and the communities in which they live and interact.

To achieve this, we have to develop a comprehensive grasp of the issue to measure its influence and importance in the context of time and policy. In doing so, we will be able to fulfill a critical step towards understanding firearm violence and hopefully influence the policies and approaches to be taken in the future.

By calculating expected years of life lost (YLL) for the collected records, taking into account: the intention, as registered in death certificates (suicidal, aggression, accidental or other), type of firearm, sex, and age group. The present study aims to measure the burden of premature mortality firearms are responsible for the last 20 years in Ecuador.

The choice of using expected years of life lost *YLL* as the metric tool in this study spawns from the validity and reliability of the measurement initially developed in the GBD Study [27].
YLL is part of the broader indicator: Disability-adjusted life years DALY, the other being years lived with disability (YLD). However (YLD), this component is not considered in the present work due to the prohibitive nature and lack of data available for life with a disability after firearm injuries

1.4 The situation in Ecuador

In Latin America, the problem of firearm mortality is readily palpable; of the 6 countries amounting up to 50,5% of deaths due to firearm-related injuries, only one (USA) is not in LA [13].

The problem spawns from internal conflict and instability, either as a long-time problem (such as the armed conflict between regular and paramilitary forces in Colombia [14]) or as of recent development (political unrest in Venezuela and Honduras).

Simultaneously, the availability of vital registration and statistical data (a determinant factor of public health monitoring) ranges from irregular in some areas of the region to unreliable or even inexistent.

Ecuador has strict laws restricting the carrying of firearms and the purchase and stashing of ammunition; in 2007 the country started with a voluntary return program. By 2011, the government outlawed the domestic production of firearms [15]. The open carrying of weapons ban was ratified in 2018.

Local regulation, however, still allows permits for firearms (up to a number of 2) per geographical location. These permits are issued only if the firearm and its ballistic characteristics, being registered in a country-wide electronic database.

Despite this, Ecuador has enjoyed, during the last decade, one of the lowest homicide rates in Latin America, standing at 5,80 per 100,000, only above that of Chile [16].

It may not continue to be the case, firearms are continuously dumped into the Ecuadorian market with the intent of being smuggled into Colombia, and Ecuador continues to be part of drug trafficking routes; these factors have helped the number of homicides to grow.

According to internal data, there were 1,056 homicides in 2019 (JAN-NOV), compared with 912 during the same period the previous year. The number of femicides also rose from 55 in 2018 to 60 in 2019 [17]. At the end of last year, Ecuadorian President Lenin Moreno expressed his concern about the growing number of firearm purchases recorded during October 2019 protests.

Ecuador has the second-highest number of suicides in South America, with the rate of suicide in 2015 being for the first time higher than the rate for homicide [18]. Suicide was identified as a major problem in adolescents during the last two decades leading up to 2016, with some correlation, towards family instability due to emigration [21].

Previous studies have shown that firearms are among the leading methods of suicide in Ecuador, ranking third after hanging, and poisoning [19]. In Ecuador, firearms have further connotations to be considered in regional differences and disparities.

The bulk of firearm violence due to homicide or injuries due to gunshot wounds is concentrated in urban areas and in the population's fraction without complete mandatory education [20]. Aside from the established and somewhat tracked issues, there is also the problem of societal and economic burden [53], inherently difficult to measure, and public perception of the problem directly affecting the trust in government entities and health systems.

In the next section, summary-measures, for the collected data are displayed in order to provide a contextual frame to better understand the problem, these measures are derived from the sourced data, and have been calculated to show its overall status.

1.5 Data for Firearm mortality in Ecuador

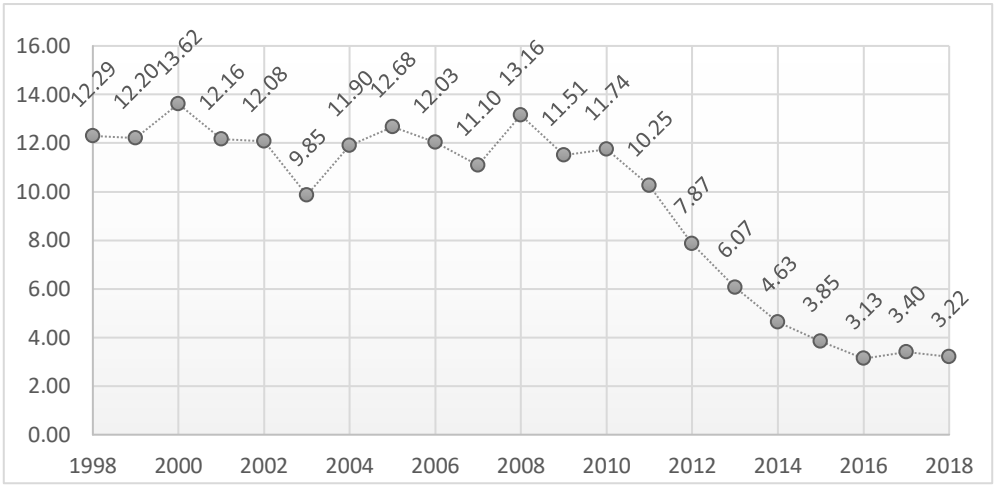
1.5.1 General mortality overview.

Between 1998 and 2018, a total of 27,146 deaths attributed to firearms were registered countrywide, averaging at 3.3 deaths per day at the time of writing; the total number for males is 25,355 (93.40%) and for females 1,791 (6.6%). From the analyzed period the lowest number of deaths was recorded in the year 2016 for both males and females, with 524 deaths total, 494 males and 30 females.

The highest total number belongs to the year 2008 with 1,847 records. For males, the same year coincides with the highest number at 1,747 deaths, but for females is the year prior 2007, the one with the most deaths recorded with 118. Age-adjusted death rates average out at 9.46 deaths per 100.000 population, for the 21 years studied, are displayed in Table 1.

For the first decade, the values center between the upper 10 points with 1998 (12.29) and 1999 (12.20) maintaining relative stability, the all-time high corresponds to the year 2000 (13.62). Rates start declining from 2009 (11.51) to 2013 with (6.07) and finally its lowest point in 2016 (3.22), Fig1.

Figure 1. Age adjusted rates by year (rates per 100.000), 1998-2018

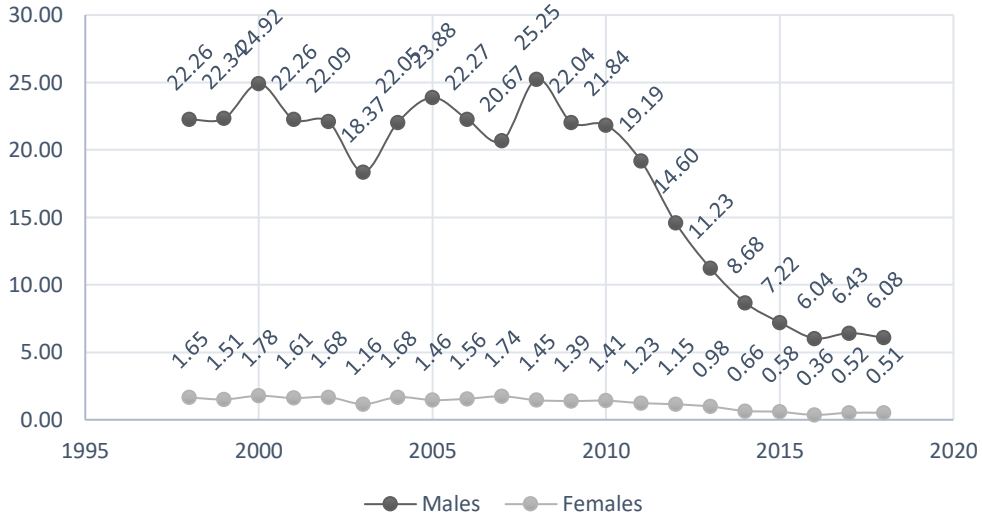


1.5.2 Mortality By sex

Specific rates by sex for every year were calculated to show differences between males and females and how both rates advance through time. Both rates show the same trend compared to their specific populations, Table 2, with a clear difference in magnitude. For females, the highest rate is in the year 2000 (1.78), and for males (25.25) in 2008.

Fig 2 shows two different graphs for comparison; during the first decade for each female death, there are 14 amongst males, and during the last 8 years, male mortality continues to define the trend.

Figure 2. Superior, shows rates per 10.000 for men and women, inferior shows only the female rates for comparison, 1998-2018



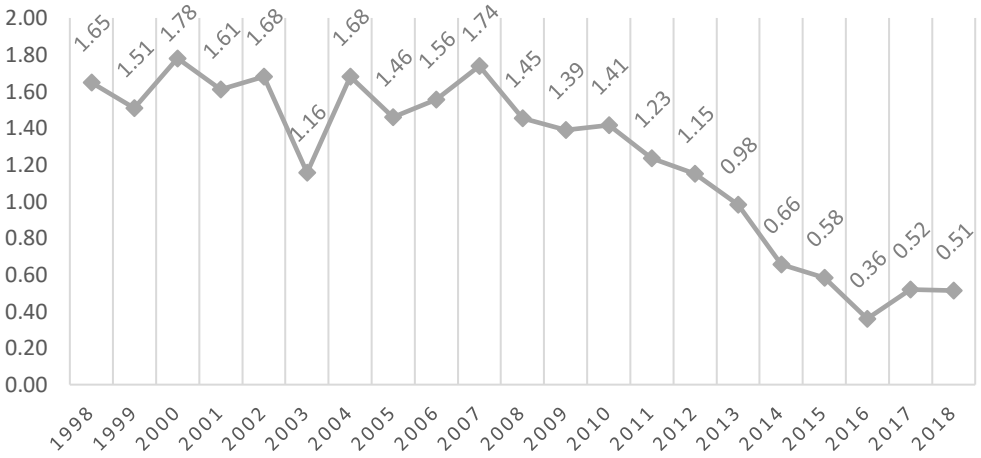


Table 1. Crude and age adjusted death rates attributed to firearms, per year, Ecuador 1998-2018

Year	Crude rate	Adjusted rate	Confidence interval (95.0%)	
1998	12.00	12.29	11.66	12.93
1999	11.97	12.20	11.58	12.85
2000	13.40	13.62	12.97	14.27
2001	11.98	12.16	11.54	12.82
2002	11.93	12.08	11.46	12.72
2003	9.80	9.85	9.32	10.39
2004	11.90	11.90	11.30	12.51
2005	12.71	12.68	12.09	13.30
2006	12.10	12.03	11.44	12.62
2007	11.23	11.10	10.54	11.67
2008	13.38	13.16	12.55	13.80
2009	11.74	11.51	10.95	12.09
2010	11.54	11.74	11.19	12.32
2011	10.13	10.25	9.74	10.77
2012	7.82	7.87	7.45	8.35
2013	6.06	6.07	5.71	6.47
2014	4.63	4.63	4.27	4.99
2015	3.87	3.85	3.54	4.14
2016	3.17	3.13	2.86	3.41
2017	3.45	3.40	3.14	3.71
2018	3.27	3.22	2.93	3.50

Table 2. Sex specific death rates attributed to firearms by sex, per year, Ecuador 1998-2018

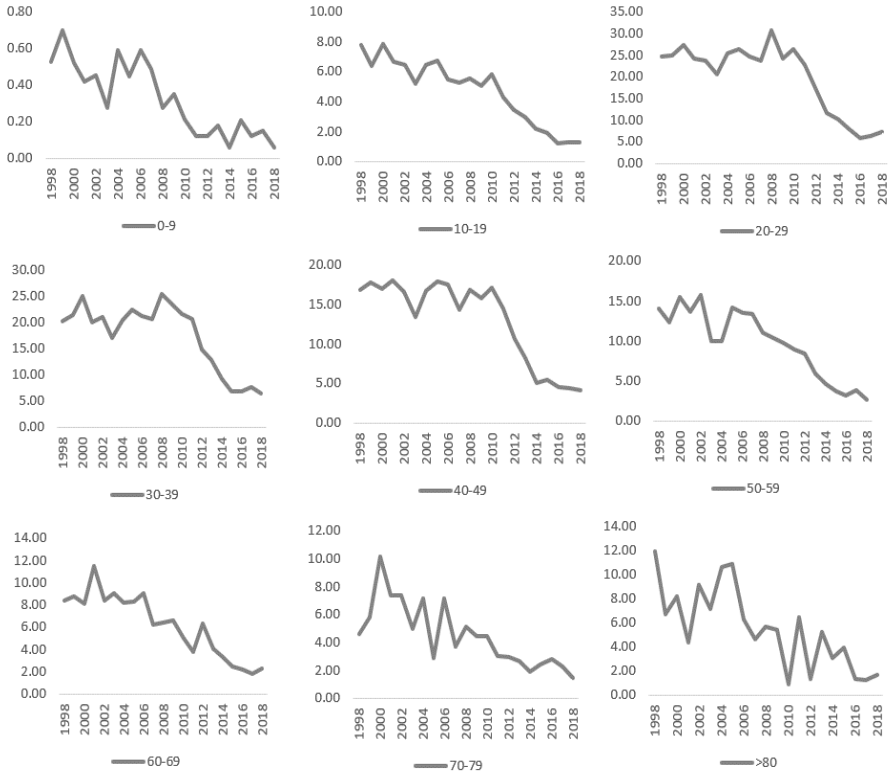
Year	Rates per 100,000	
	Males	Females
1998	22.26	1.65
1999	22.34	1.51
2000	24.92	1.78
2001	22.26	1.61
2002	22.09	1.68
2003	18.37	1.16
2004	22.05	1.68
2005	23.88	1.46
2006	22.27	1.56
2007	20.67	1.74
2008	25.25	1.45
2009	22.04	1.39
2010	21.84	1.41
2011	19.19	1.23
2012	14.6	1.15
2013	11.23	0.98
2014	8.68	0.66
2015	7.22	0.58
2016	6.04	0.36
2017	6.43	0.52
2018	6.08	0.51

1.5.3 Mortality by age groups

Age-specific mortality rates, calculated for 9 age buckets, with population projections for each included year. The majority of deaths were recorded amongst individuals between 20-29 years, followed closely by those 30-39, with 9,880 and 6,993 total records, respectively.

If the persons within 20 to 49 years were combined in the same group, deaths among them would amount to 20,819, 6% of total deaths. During the first decade, the most considerable amount of records was recorded for all age groups. Figure 3 displays the rates for each age group during the time series.

Figure 3. Age specific mortality rates attributed to firearms, by age group, per 100,000, Ecuador 1998-2018



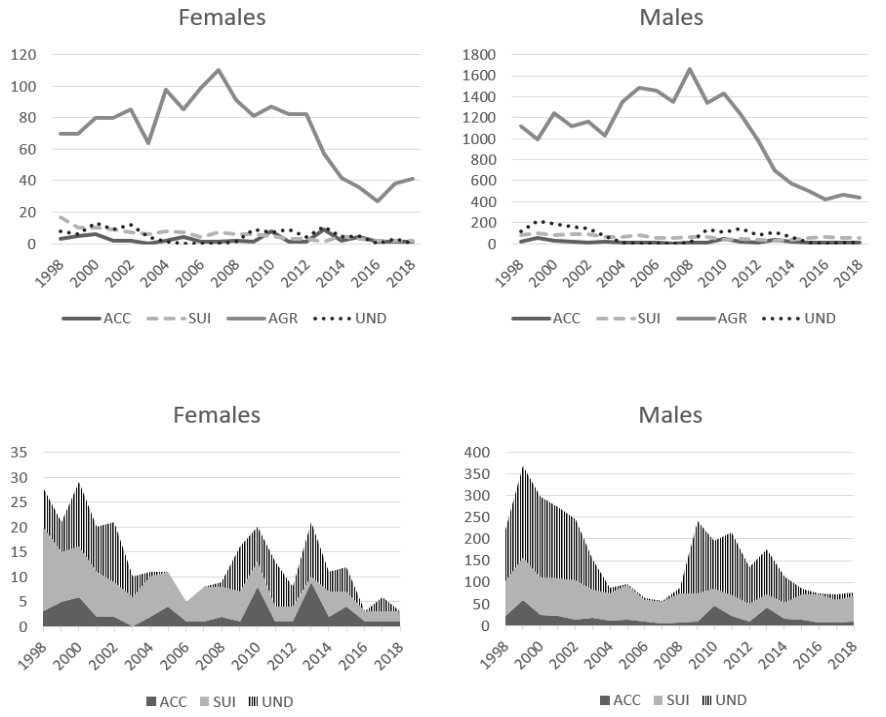
1.5.4 Mortality by intentionality

The category of Assaults (homicide) contains for males and females, 22,048, and 1,505 records, respectively. For females, Intentional self-harm (suicide) holds second place with, 123 records, and lastly, by undetermined intentionality deaths with 106.

For males the second-highest number is found as undetermined intentionality with 1,609, followed by suicide with 1,310. For both sexes, the lowest records are in the accidental category with 57 for females and 388 for males, Table 3, shows the total number of deaths for each category.

Data for both males and females can be compared in the two separate charts displayed in Figure 4.

Figure 4. Number of deaths attributed to firearms by intentionality and sex, Ecuador 1998-2018. For comparison inferior chart does not include homicide



1.5.5 Deaths by type of firearm

Of the total 27,146, we can see as a prevailing trend in all groups favoring unspecified type of firearm, as the category with the highest number of records in the included period containing 25,719 of the registered deaths.

Deaths involving pistols, revolvers, and one-handed weapons amount to 804, and finally, those adjudicated to rifles and shotguns include 623 (Figure 5).

Figure 5. Percentage of total deaths attributed to firearms by type of firearm, Ecuador 1998-2018

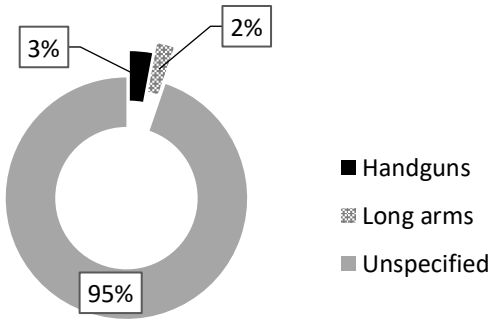


Table 3. Number of deaths attributed to firearms by intentionality and sex per year, Ecuador 1998-2018

Year		Sex	Accidental	Suicide	Aggression	Undetermined
1998	Total		25	97	1184	128
		Female	3	17	70	8
		Male	22	80	1114	120
1999	Total		63	109	1062	217
		Female	5	10	70	6
		Male	58	99	992	211
2000	Total		31	95	1321	201
		Female	6	10	80	13
		Male	25	85	1241	188
2001	Total		25	95	1202	173
		Female	2	9	80	9
		Male	23	86	1122	164
2002	Total		16	97	1244	153
		Female	2	7	85	12
		Male	14	90	1159	141
2003	Total		17	72	1093	76
		Female	0	6	64	4
		Male	17	66	1029	72
2004	Total		13	72	1451	14
		Female	2	8	98	1
		Male	11	64	1353	13
2005	Total		18	87	1572	2
		Female	4	7	85	0
		Male	14	80	1487	2
2006	Total		11	54	1554	4
		Female	1	4	99	0
		Male	10	50	1455	4
2007	Total		6	57	1463	2
		Female	1	7	110	0
		Male	5	50	1353	2
2008	Total		10	72	1750	15
		Female	2	6	91	1
		Male	8	66	1659	14

Year		Sex	Accidental	Suicide	Aggression	Undetermined
2009	Total		10	72	1418	144
		Female	1	6	81	9
		Male	9	66	1337	165
2010	Total		53	46	1518	116
		Female	8	5	87	7
		Male	45	41	1431	109
2011	Total		24	49	1320	154
		Female	1	3	82	9
		Male	23	46	1238	145
2012	Total		11	44	1070	88
		Female	1	3	82	4
		Male	10	41	988	84
2013	Total		50	31	759	116
		Female	9	1	57	11
		Male	41	30	702	105
2014	Total		17	42	617	66
		Female	2	5	42	4
		Male	15	37	575	62
2015	Total		18	61	534	17
		Female	4	3	36	5
		Male	14	58	498	12
2016	Total		9	67	444	4
		Female	1	2	27	0
		Male	8	65	417	1
2017	Total		7	55	501	15
		Female	1	2	38	3
		Male	6	53	463	12
2018	Total		11	59	476	10
		Female	1	2	41	0
		Male	10	57	435	10
Total			445	1433	23553	1715

1.6 Objectives

This study has prioritized its objectives as follows:

- Define the impact of firearms on premature mortality during the past two decades in Ecuador.
- Calculate years of life lost to call attention to premature mortality due to firearms.
- Identify the use of YLL as a measurement tool for tracking premature mortality.

1.7 Scope

This study will only focus on data collected from 1998 and up to 2018, given the unreliable and non-uniform nature of data for the previous years.
Data for the year 2019 is not yet available in the national archives to the time of writing and could not be included.

Although ICD-10 includes firearm injuries into the broader category of *External Causes*, the present study will not include any other of the diagnostic subcategories, such as deaths caused by self-propelled explosives (including tear gas) and propelled projectiles (arrows, bolts, or pellets). Even if in some jurisdictions, those may fall in the same group as firearms.

Firearm deaths occurring as a consequence of legal intervention (ICD-Y35), and war operations will not be included since their intentionality is a matter of debate. The available data is limited and subject to different jurisdictions in the country.

1.8 Limitations

This study is based on data collected from the death certificates issued by the different jurisdictions in the country. At the same time, most of them are filled and supervised by medical professionals, the veracity of them cannot be guaranteed.

Data for the earlier years may contain errors in codification, including codes for broad categories, which are not to be included in death certificates due to their nonspecific nature.

Due to the categorization of codes and their description in Spanish, they are containing the same wording such as W32 (*Disparo de arma corta, escopeta y arma larga*) lit. discharge from small arm, shotgun, long weapon, and W33 (*Disparo de rifle, escopeta y arma larga*) lit. discharge from rifle, shotgun, long weapon. Some of the records may include wrongly coded data.

In the same fashion, the subcategory other and unspecified firearms include conventional firearms and other projectile weapons, such as flare guns and spring guns. Records included in this category are assumed to be attributed to other types of conventional firearms.

The study does not aggregate results by race due to inconsistent race categories in source data during the recording period.

Given their expensive nature, unpractical condition, and the overall lack of data regarding people surviving firearm injuries, is impossible for the present study to cover the calculation for YLDs. Thus, adequately constructing DALYs for this particular problem is not possible.

Chapter II: Methods

2.1 Methodology

During the years 1998-2019, registered deaths attributed to firearms were obtained from the yearly records on vital statistics from the Ecuadorian Institute for Statistics and Census [28]. This registry holds records from all death certificates generated country-wide after the statistical information has been processed and indexed.

Data were stratified by year, sex, age group (in buckets of 10 years), intentionality, and type of weapon recorded.

Classification based on intentionality was derived from the subcategories included in ICD-10, considering the 4 major diagnostic categories, attached to external causes related to firearms[a], (accidents, assaults (homicide), self-inflicted (suicide) and events of undetermined intent), W32-34, X93-X95, X72-X74, Y22-Y24.

Classification by type of weapon follows ICD-10 subcategories separated by type of weapon used for all categories described before, and are consistent between categories[b]. Years of life lost were computed for all records included with these criteria, a number of deaths times life expectancy at the age of death, for the average age of death in each specific age group.

$$number\ of\ deaths * life\ expectancy\ at\ death$$

Records were organized in age groups with buckets of 10 for each year and sex, the total number of deaths from each group served as the number of deaths variable. From each age group, the average age at death was also calculated; this value was used to compute the remaining life expectancy at death.

Using the Coale and Demeny [29], model life-table West, level 26 and 25, with a life expectancy at birth of 80 years for males and 82.5 years for females. The remaining life expectancy was calculated using linear interpolation[c], by looking for the life expectancy at each group's average age value.

All years of life lost were calculated without age weighting and including a 3%-time discount.

To provide a comparison between the leading causes of premature mortality. The same process was used with all causes of death for the last 5 years of the series; this was done in to rank them by the amount of YLL generated for each sex and age group.

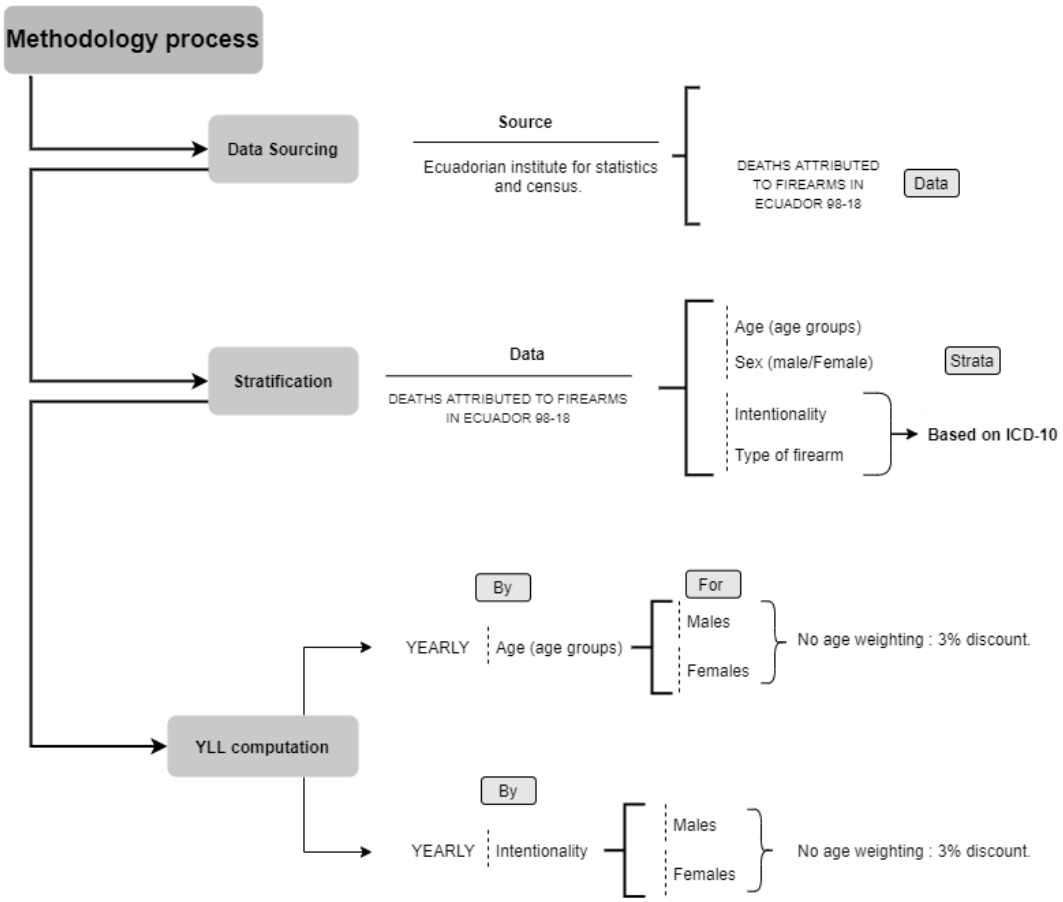
Finally, to calculate YLL by intentionality, a different grouping was necessary, even though the same process was used. This changed the estimated life expectancy remaining due to differences in average age at death rounding. The result differs in about 2% from the initial calculation[d].

When displayed, for comparison purposes, the overall mortality rates were adjusted using the direct method with the averaged population from all study periods as standard. All YLL calculations were done using the "yll" computation package, developed for R software [30].

For the statistical analysis of the data and linear interpolation models, the programs: Excel 2016, Epidat 4.2 [31], and R 3.6 were used; references were managed by Zotero 5.0, charts and tables were constructed using Microsoft Excel 2016, Word 2016, and Draw.io 13.7.3.

Diagram 1, details the methods as described in this section.

Diagram 1. Methodology Process: from top to botton this diagram shows, data sourcing from the Ecuadorian Insitute for Statistics; stratification for analysis according to: age, sex, intentionality and type of weapon used as registered according to ICD-10; and YLL computation



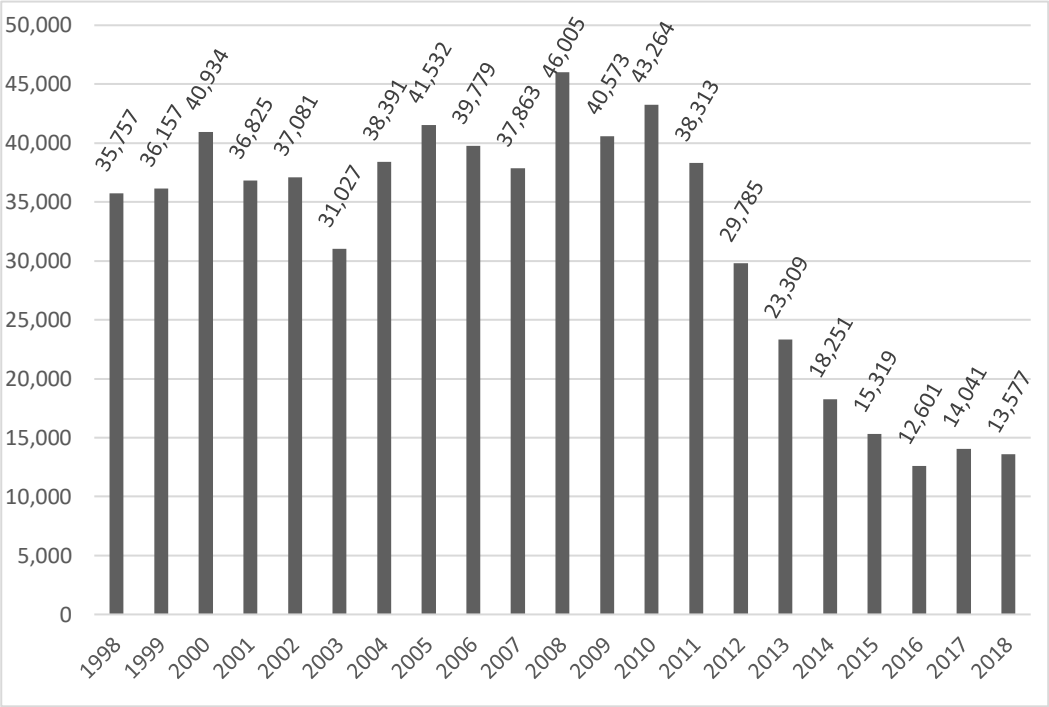
2.2 Results

2.2.1 Computation of Years of life lost

During the time series, 25,355 deaths were recorded for men, with 624,954 years of life lost, and for women, 1,791 deaths, generated 45,430 years of life lost. The cumulative number of Years of life lost, 670,384, is displayed by year (Figure 6); during the first decade, YLL are over 30,000 for all years and start declining from 2011.

During the last years of the series, the overall number of years of life lost reach their lowest point in 2016, and in the next two years, the number rises slightly but stays below the 15, 000 years of life lost.

Figure 6. Cumulative number of expected YLL due to firearms, by year, Ecuador 1998-2018



The YLL, number of deaths and YLL mean, is stratified by sex and age buckets of 10 years, displayed in Table 4. Although the frequency by age buckets is similar between men and women (Figure 7), the number of YLL is remarkably higher.

Furthermore, in both sexes, the most enormous amount of YLL is found among the younger population (20-29 years), despite the overall lower number of YLL.

Table 4. Years of life lost and number of deaths due to firearms, by sex and age, Ecuador 1998-2018

Sex	Age	YLL	Deaths	YLL mean [+]
Female				
	0-9	2,436.4	81	27.2
	10-19	8,459.6	293	28.8
	20-29	14,527.8	526	27.6
	30-39	9,374.8	365	25.7
	40-49	6,349.6	274	23.2
	50-59	3,004.7	150	20.1
	60-69	825.7	52	13.6
	70-79	376.1	35	9.3
	80-89	62.5	10	2.1
	90-100	12.8	5	0.5
	Total	45,430.1	1,791	17.8
Male				
	0-9	3,636.5	122	29.8
	10-19	70,586.9	2,491	28.3
	20-29	253,721.6	9,354	27.1
	30-39	166,225.9	6,628	25.1
	40-49	81,734.0	3,672	22.3
	50-59	34,778.2	1,862	18.7
	60-69	10,737.5	760	14.2
	70-79	2,900.6	307	9.5
	80-89	529.1	97	5.5
	90-100	103.7	62	1.6
	Total	624,954.0	25,355	18.2

[+]YLL mean= YLL/ Deaths

Years of life lost were calculated for all recorded causes of death in the last 5 years of the time series, which have overall lower YLL for firearm violence. These results were stratified by sex, age group, and year.

For females, firearm-related diagnostic did not rank in the leading 5 causes of death for any specific year; various other causes of death and their respective YLL are displayed in Table 5.

Calculations exclude the age buckets at the extremes of life; the leading causes of death corresponding to external causes for women are Suicide by hanging and Vehicular accidents.

This result is congruent with the rates calculated previously and indicates the burden of preventable death in females. It is interesting to note that the Record for “Unknown cause of death” ranks among the five leading causes in all but one age group.

Figure 7. Number of expected YLL due to firearms for females, by age, Ecuador 1998-2018

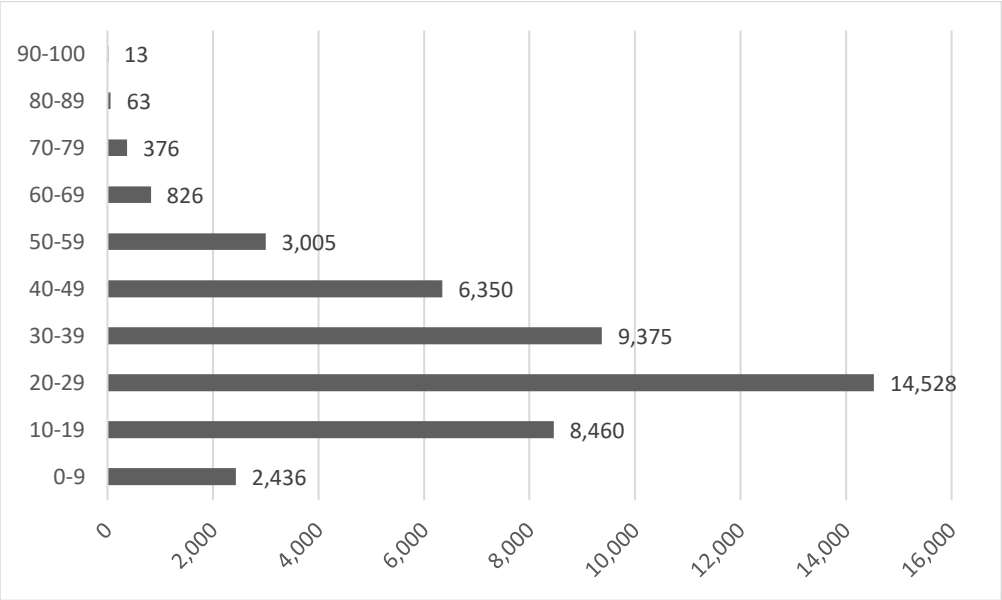


Figure 8. Number of expected YLL due to firearms for males, by age, Ecuador 1998-2018

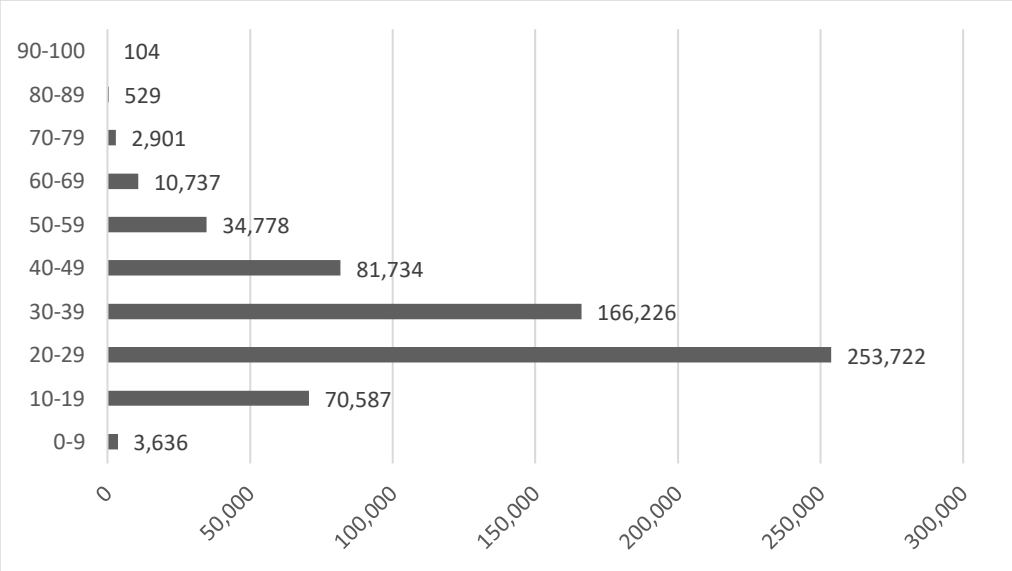


Table 5. Leading causes of death for females by age, ranked by computed years of life lost. Ecuador 2013-2018

Age	Rank	Cause	YLL
10-19			
	1º	Suicide/Hanging	10,334.5
	2º	Vehicular accident	5,991.3
	3º	Unknown	5,729.5
	4º	Respiratory Distress	4,563.2
	5º	Bronchopneumonia	4,491.7
20-29			
	1º	Vehicular accident	9,505.7
	2º	Suicide/Hanging	5,558.9
	3º	HIV complications	5,380.8
	4º	Unknown	4,753.7
	5º	Bronchopneumonia	3,171.0
30-39			
	1º	HIV complications	7,039.7
	2º	Vehicular accident	6,986.0
	3º	Cervix Neoplasm	6,389.9
	4º	Unknown	6,334.9
	5º	Breast Neoplasm	6,155.3
40-49			
	1º	Breast Neoplasm	14,071.5
	2º	Myocardial infarction	10,445.4
	3º	Cervix Neoplasm	10,071.7
	4º	Stomach Cancer	8,416.0
	5º	Unknown	7,989.3
50-59			
	1º	Myocardial infarction	18,099.5
	2º	Adrenal hyperplasia	17,385.1
	3º	Breast Neoplasm	16,579.4
	4º	Diabetes Complications	16,249.8
	5º	Biliary cirrhosis	11,729.3

For males, the code for assault by other and unspecified firearm discharge (X95) frequently features among the leading causes of death in all years of the series for at least one age group.

Between 10 and 19 years, young males recorded deaths by this code as the 3rd and 4th leading causes in 2013 and 2014, respectively. And with the rest of the years, dominated by Vehicular accidents and Suicide by hanging.
Tables 6 and 7 display the leading causes of death for males, by year and age group and ranked by the total amount of YLL computed.

For the age group 30 to 39 years, firearms rank among the five leading causes of death in all years but one (2015), and the total number of YLL computed rank second in all of those years except for 2018 in which is the 5th cause.

The most interesting result is found among males within the 20 to 29 age group, for all the years almost all of the 5 leading causes of death are among external causes. Assault by other unspecified firearm discharge (X95) consistently ranks second or third in this age group.

Furthermore, the computed YLL for this cause shows an increase during the last three years, in contrast with all other age groups for which the amount of YLL has decreased somewhat continuously

Table 6. Leading causes of death for males by year, ranked by computed years of life lost, age groups 10-19years, 20-29years. Ecuador 2013-2018

		10-19 years		20-29 years	
	Rank	Cause	Total Yll	Cause	Total Yll
2013					
	1º	Vehicular	3,943.2	Vehicular	11,952.9
	2º	Suicide/Hanging	2,372.2	Assault/firearm	6,258.9
	3º	Assault/firearm	1,867.8	HIV complications	2,753.9
	4º	Transport	1,428.6	Motorcycle accident	2,609.1
	5º	Unknown	1,146.6	Suicide/Hanging	2,589.4
2014					
	1º	Vehicular	3,409.5	Vehicular	10,110.4
	2º	Unknown	2,509.6	Assault/firearm	5,397.1
	3º	Suicide/Hanging	2,200.2	Unknown	3,217.3
	4º	Assault/firearm	1,500.4	Suicide/Hanging	3,155.5
	5º	Unspecified	1,023.9	HIV complications	3,141.7
2015					
	1º	Vehicular	3,908.8	Vehicular	10,458.0
	2º	Suicide/Hanging	3,422.5	Suicide/Hanging	4,810.9
	3º	Leukemia	1,438.8	Assault/handgun	2,983.7
	4º	Motorcycle accident	1,186.3	HIV complications	2,653.0
	5º	Unknown	1,175.0	Motorcycle accident	2,583.7
2016					
	1º	Suicide/Hanging	3,905.5	Vehicular	9,996.2
	2º	Vehicular	3,038.4	Suicide/Hanging	5,637.0
	3º	Leukemia	1,145.8	Assault/firearm	3,555.3
	4º	Respiratory distress	893.2	HIV complications	2,558.7
	5º	Drowning	884.1	Motorcycle accident	2,017.2
2017					
	1º	Suicide/Hanging	3,797.3	Vehicular	10,565.2
	2º	Vehicular	3,474.4	Suicide/Hanging	6,021.7
	3º	Respiratory distress	1,326.0	Assault/firearm	3,935.0
	4º	Leukemia	1,261.4	HIV complications	2,655.5
	5º	Bronchopneumonia	978.5	Motorcycle accident	1,933.2
2018					
	1º	Vehicular	4,058.1	Vehicular	12,758.2
	2º	Suicide/Hanging	3,945.9	Suicide/Hanging	5,301.9
	3º	Respiratory distress	1,121.7	Assault/firearm	4,172.6
	4º	Leukemia	1,119.1	Assault/stabbing	2,619.8
	5º	Bronchopneumonia	947.3	HIV complications	2,420.7

Table 7. Leading causes of death for males by year, ranked by computed years of life lost, age groups 30-39years, 40-49years. Ecuador 2013-2018

		30-39 years		40-49 years	
	Rank	Cause	Total Yll	Cause	Total Yll
2013					
	1º	Vehicular	6,991.3	Vehicular	3,810.8
	2º	Assault/firearm	5,219.1	Myocardial infarction	2,238.4
	3º	HIV complications	3,210.5	Assault/firearm	2,228.5
	4º	Accident/other	1,992.5	HIV complications	1,996.0
	5º	Transport	1,847.0	Biliary cirrhosis	1,558.9
2014					
	1º	Vehicular	6,423.6	Vehicular	3,305.1
	2º	Assault/firearm	4,145.9	Unknown	3,280.5
	3º	Unknown	3,668.4	Myocardial infarction	3,263.5
	4º	HIV complications	3,167.7	HIV complications	1,967.0
	5º	Myocardial infarction	2,099.2	Biliary cirrhosis	1,790.8
2015					
	1º	Vehicular	6,613.2	Vehicular	3,816.0
	2º	HIV complications	3,731.0	Myocardial infarction	3,572.6
	3º	Suicide/Hanging	2,498.8	Biliary cirrhosis	1,968.0
	4º	Myocardial infarction	2,062.0	HIV complications	1,817.3
	5º	Unknown	1,889.5	Unknown	1,758.9
2016					
	1º	Vehicular	6,558.0	Myocardial infarction	4,400.0
	2º	HIV complications	3,571.8	Vehicular	4,170.2
	3º	Assault/firearm	3,327.7	Biliary cirrhosis	1,891.1
	4º	Myocardial infarction	2,910.3	HIV complications	1,876.1
	5º	Suicide/Hanging	2,904.1	Stomach Cancer	1,613.3
2017					
	1º	Vehicular	6,571.5	Myocardial infarction	4,595.8
	2º	Assault/firearm	3,998.8	Vehicular	3,531.7
	3º	HIV complications	3,867.6	Biliary cirrhosis	2,130.7
	4º	Suicide/Hanging	2,930.8	HIV complications	1,722.1
	5º	Myocardial infarction	2,793.5	Unknown	1,641.7
2018					
	1º	Vehicular	7,119.8	Myocardial infarction	5,251.3
	2º	HIV complications	3,218.2	Vehicular	4,197.5
	3º	Myocardial infarction	3,050.7	HIV complications	2,242.7
	4º	Suicide/Hanging	3,038.5	Biliary cirrhosis	1,893.7
	5º	Assault/firearm	2,888.3	Suicide/Hanging	1,882.9

2.2.2 Computation by intentionality

Years of life lost computed by intentionality have a slight difference in result due to the average ages estimated by summed intentionality groups being different from those estimated by age group. Table 8 shows the amount of YLL computed; Assault (homicide) ranks first, with more than 80% of the total amount calculated for both males with 557,554 females and 39,140 YLL.

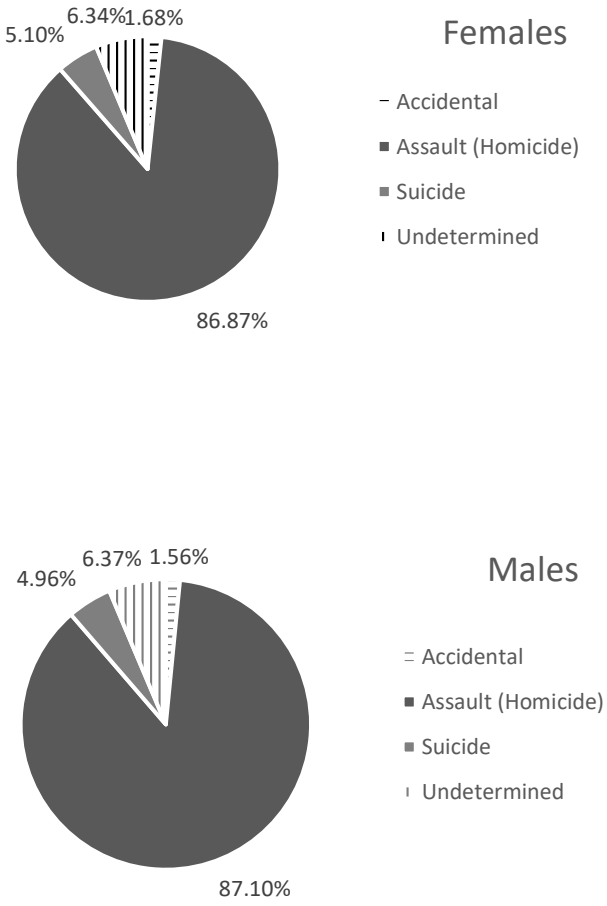
Undetermined intent 40,778.3, YLL for males and 2,774, for females, describes those records for which the specific intentionality (Assault, Suicide, or Accidental) could not be identified, the implications of this are discussed in the next section. This category holds 2nd and 3rd place for males and females respectively.

Finally, Accidental deaths generated the lowest amount of YLL in the series for both sexes. Figure 8 shows a comparison between the two sexes for all categories.

Table 8. Years of life lost by intentionality (descending) for females and males, Ecuador 1998-2018

	Category	%	YLL
Females			
	Assault (Homicide)	83.69%	39,140.1
	Suicide	7.02%	3,285.6
	Undetermined	5.93%	2,774.1
	Accidental	3.36%	1,570.6
Males			
	Assault (Homicide)	87.10%	557,554.0
	Undetermined	6.37%	40,778.3
	Suicide	4.96%	31,776.2
	Accidental	1.56%	9,999.8

Figure 9. Percentage of YLL by intentionality for females and males, Ecuador 1998-2018



Chapter III: Discussion

3.1 General implications

The main calculation of years of life lost during the two decades gives some perspective regarding the magnitude of premature mortality that firearms have been responsible for in Ecuador.

To begin, we can observe a distinct division in the amount of expected YLL; the first decade holds the highest amount for both sexes, followed by a 7-year decline. At the end of this decline, the lowest amount is registered with the last two years (2017, 2018) showing a discrete climb.

Second, total YLL has a variation between sexes, with the number of deaths being higher among males (93,40%) consistent with several studies, showing the same result [35-36]. Overall, YLL for males is 13 times greater than for females. Furthermore, the YLL mean has a slightly greater value for males, suggesting that deaths occurred in younger males than females.

Third, when comparing the total YLL by age groups, the highest percentage of deaths for both sexes is found among persons between 20 and 29 years, followed, again in both groups by those between 30 and 39 years. Finally, the third group varies with females between 10-19 having the most YLL, compared to males between 40-49.

A sizeable amount of YLL was calculated for teenagers and a group that can be exposed to firearm violence directly as victims or perpetrators or indirectly due to community exposure [38]. The regional implication of firearm violence among youths has been partially assessed before,[39]; however, need for substantial evidence remains high.

Records for infants (0-9) show 6,072.9 years of life lost, while senior citizens (> 60) have a cumulative amount of 15,5548 YLL. The infant age group represents the highest potential for premature mortality, and their feature as victims of firearm violence demand serious attention on the part of policymakers.

If we observe the last five years of the series, in which the overall rates show the sharpest decline, a comparison can be made for the share of premature mortality among the other leading causes of death.

In the last 5 years leading up to 2018, we can observe the most common causes of death for both males and females in Ecuador being of preventable nature. For females, causes such as: vehicular accidents, Suicide, HIV complications, or Cancer were among the top for almost all age groups.

As described before, the overall number of years of life lost, went down with death rates. However, the results for males show firearm violence as a leading cause of death in all 5 years, in 2016 with the lowest number of deaths recorded, firearms were still the third cause of death by YLL for males between 20 and 39 years of age.

Four causes of death are ahead of firearm violence, ranking in different places (Tables 6, 7); two are external causes: Suicide and Vehicular accidents, while the other is pathologies: Myocardial infarction and Death resulting from HIV complications. This result is consistent with previous studies [29,40], showing the burden of suicide in the Ecuadorian Public Health landscape and the Epidemiological profile of vehicular accidents [32].

Although the number of registered deaths from firearms is lower in the last five years compared to the rest of the time series, for young males, YLL generated by firearms remains the third average cause of premature death. Violence and death resulting from firearms are a preventable cause of death, affecting a sizeable portion of the male population almost every year; thus, the need to focus on firearms from a Public Health point of view has an extreme connotation.

3.2 Intentionality

Fatal outcomes resulting from firearms are categorized in ICD-10, based on their intentionality. In this work, aside from assault (homicide), suicide, and undefined intent, deaths resulting from accidental discharges are included.

Because of considering the common occurrence of accidental gun injuries in homes and other private dwellings [42] as part of the firearm violence problem and the relation between the availability of firearms and unintentional firearm deaths [43]. When calculating YLL by intentionality, most massive amount is generated by Assault (homicide) in both genders.

The recent spike in recorded deaths since 2016 is due to a higher number of homicides. In 2016, 2017, and 2018, there were 67, 55, and 59 suicides through firearms respectively, compared to 444, 501, and 476 homicides. The second-largest amount varies between the two sexes, with Undetermined intent being second for males and Suicide for females.

Undetermined intent merits more discussion; from the total YLL by intentionality. This category generated 43,552.5 years of life lost for both males and females; among males, the number makes this the second-largest amount of years lost. This implicates that 40,778.3 years of life lost for males in the last 20 years are unaccounted for.

For females, undetermined intent makes up the third-largest YLL amount, which proves particular importance for pressing issues relating to gender equality. Femicides have been demonstrated to often go unrecognized [44] due to poor records and statistical performance in developing countries. Furthermore, the availability and validity of vital records are critical for tackling those problems [45].

3.3 Assessing the burden

UNODOC's Global Study on Homicide suggests that the reaching of peace and justice as a development goal might not be possible if the current trends on armed violence persist [10], and the Global estimation for firearm mortality in 2016 was for 251.000 deaths [48].

Despite Ecuador not ranking in the higher positions for firearm violence in Latin America and the number of years of life lost due to firearms having lowered considerably, there is a demonstrable Public Health implication to the problem.

The demographic profile is evident in the present estimation; the only comparable cause of YLL for males not found among external causes is death resulting from HIV complications. Among the remaining external causes, firearms are the leading sources of preventable loss of life for every year in the series and have risen in the last two.

The economic implications are also important; the vast majority of these years lost can be found in the active economic population, taking from the available pool of labor. This premature loss of life stops the inclusion of young people in the economy and hinders development, creating a higher chance for communities to fall into poverty, which has been proven to be a predictor for high homicide rates [49].

At the local level, premature mortality in young males is an aggravating factor for Ecuadorian society, still facing problems with income inequality, poverty, and social mobility, factors that have been related to firearm violence in other countries [46,47]. Further research assessing the societal and family implication of the premature loss of life is necessary.

3.4 Firearms, a point of public discussion

The exact relation between gun control policies and the effects on violence is a subject of debate. In Latin America, research about the subject has been conducted; in 2007, De Souza et al. [50] demonstrated a positive relation for gun control policies adopted in 2003 at effectively reducing firearm mortality in Brazil.

There have also been studies conducted in the US [51], suggesting that the effect (if any) of gun control policies is not yet known. Ecuadorian law allows any citizen to apply for a firearm permit and bans carrying guns; it also requires all firearms, including those in control of military and police personnel, to be registered.

However, most Ecuadorian citizens do not own any firearms and thus, gun control discussion is not as prevalent in Ecuadorian society. The main point of public concern and discussion is centered on the perception of safety, victimization, and crime.

Calls for action aiming to lower insecurity, and more efficient judicial systems dominate the conversation.

3.5 Conclusions

In the present study, we have used a simple and reliable measure of premature mortality (YLL); said measure can be computed used readily available data from death records; thus, all available records for firearm deaths and firearms types identified in them during the two decades were included.

Years of life are a good measure to use to identify the leading causes of death and focus the attention into those causes of premature mortality of preventable nature.
External causes are observed to be among the highest generators of premature mortality in the country. The top spots during the last five years are occupied by various external causes such as Vehicular accidents and Suicide.

On this study, this is the first study to assess the burden of firearm mortality in Ecuador; data shows that firearms are responsible for an essential portion of premature mortality in the country. Although mortality rates have gone down in recent years, premature and preventable mortality due to firearms continues to be a critical concern.

When compared with all others, the amount of YLL generated by firearms are consistently among the highest ones, the population between 20 and 40 years, particularly among males, seems to be the most affected.

The overall share of premature mortality due to firearms for males has not had any necessary changes during the series, even with the lower general numbers. The deaths found in this group (at no prejudice to other demographic groups), seem to define the Public health implication for preventable mortality.

The prevalent intentionality is shown to be assault, or homicidal intent, which generated the most immense amount of YLL overall. It keeps defining the leading role of firearms in premature mortality even during the recent decline.

There are signals to the existence of a broader array of socioeconomic and behavioral factors, calling for further research and policy development. Nevertheless, the detailed stratification of violence by intentionality seems to be hindered, by the low quality of records, as shown by a sizeable amount of them being included as having undetermined intent.

YLL, generated by undetermined intent the burden of firearm mortality on a gray area, would prove to be a problem for constructing sound policy and monitoring its results. It is also possible that some of those deaths could carry a more important significance for gender equality and vulnerabilities since they could mask acts of aggression towards women.

Finally, the study shows the importance of firearms in the Public Health context, as the preventable cause of a yearly death toll, for the country's young population. This amount of premature mortality requires attention on a vertical scale, with the involvement of the health and policy institution's different elements, aimed at mitigating the problem.

The measure used in this study makes the results capable of being compared by a similar analysis in the future, to guide and inform policymakers, to monitor the changes and shifts in the country's problem with firearms, and to serve as an evaluation tool.

There is a pressing need to obtain this kind of data in Latin America, a region that consistently ranks among the highest in firearm violence and does not have plentiful research on the topic.

We hope this research, adding to the existing body of work, serves as a useful reference for all the different focus groups, individuals and institutions, and the Latin American research community.

3.6 Conflict of interest

There is no conflicting interest to be declared from the author of this work.

3.7 Funding

The author produced this work while being beneficiary of a Master's Degree Scholarship sponsored by KOICA.

3.8 Recommendations

Recommendations are drawn from the data and different situations observed during the production of this work.

As a first point, we will like to recommend INEC to publish the different variable tables, including causes of death on their site, to make the information accessible to researchers and the public.
Furthermore, we believe a combined database of available material for all years should be published to avoid contacting the central offices.

There is also a need to train medical officers filling death certificates, deaths attributed to unspecified firearms pose a considerable lack of data. As a result, most firearm deaths are not attributable to any particular firearm type.

In the same fashion, a significant portion of deaths recorded by intentionality was identified as undetermined, lacking proper classification as homicides or suicides.
This could result in a considerable lack of measure for public action and policy development; we will like to recommend taking a more proactive approach towards the registration of these records.

We would also like to recommend further research on the links between firearms and economic stability in Ecuadorian society.

Finally, we will like to recommend the Latin American research community study further control policies and their impact in premature mortality. Our region's need to develop effective strategies and strong policies depends on having useful data to back them up.

Final notes

a. ICD-10 codes are included in external causes of death (V00-Y99); different code blocs are included according to intentionality. For this study (W32, W33, W34) referring to accidental firearm discharges or malfunctions, (X72, X73, X74) Intentional self-harm with firearms, (X93, X94, X95) Assault or aggression with firearms and (Y22, Y23, Y24) firearm discharge, undetermined intent, are considered, ICD provides further conditioning, however only principal codes are specified in the collected records.

b. Each subclassification: i.e. (Y22, Y23 Y24), is categorized by means of injury, three categories by means including firearms, and are consistent through every group; they are respectively: handgun discharge, rifle, shotgun and broader firearm discharge, and unspecified firearm and gun discharge.

c. YLL computation calls for the use of the remaining life expectancy at an average age of death. Since average values do not align with set intervals on life expectancy tables, specific values were interpolated from the Coale and Demeny model life-table West, using a linear interpolation function.

d. The calculation is dependent on average age values; all observations used for both calculations are equal. However, group values can vary; when ages are grouped in a different way, this variation is magnified by rounding the averages, and the remaining life expectancy extrapolated values, will result in a slight variation between the two calculations.

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