Geographic distribution of risk of death due to homicide in Puerto Rico, 2001–2010

Diego E. Zavala-Zegarra,[1] *Magdalena López-Charneco,*[2]
Enid J. Garcia-Rivera,[3] *Alberto Concha-Eastman,*[4]
José F. Rodriguez,[5] *and María Conte-Miller*[6]

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ABSTRACT

Objective. *To raise awareness of the impact of homicides in Puerto Rico based on the findings of the spatial and temporal distribution of homicides and the use of firearms, by age and gender, using reports of interpersonal violent deaths from the Institute of Forensic Science (IFS) headquartered in San Juan, Puerto Rico.*

Methods. *This was a descriptive study of all homicide incidents in Puerto Rico reported by the IFS for the period 2001–2010. For each of the 8 542 cases, data analyzed included age, sex, municipality of incident, date of death, and mechanism. Crude sex- and age-specific mortality rates for Puerto Rico and for each municipality per year and for the 10-year period were calculated. Cumulative rate and cumulative risks were estimated and defined as lifetime risk. The relative distribution of cumulative rates for each municipality was categorized into quartiles of highest to lowest risk and displayed as a map.*

Results. *The risk of homicide death among males is 13 times greater than among females. The highest rates were observed among males 20–24 years of age (198.4 homicides per 100 000). In any given year, firearms were used in at least 80% of homicides. The average lifetime risk of homicide death for males is 1 in 34.*

Conclusions. *Young adult males with access to firearms are at greatest risk of homicide in Puerto Rico. Also, highly urbanized municipalities are at highest risk; however, certain non-urban municipalities along the coast also have a very high homicide risk. Top priorities should be applying the WHO "ecological model" for violent injury prevention and establishing a surveillance system that will assist in identifying the role that socioeconomics, illegal firearms trade, and drug trafficking are playing.*

Key words Homicide; firearms; violence; premature mortality; Puerto Rico.

[1] Ponce School of Medicine and Health Sciences, Ponce, Puerto Rico. Send correspondence to Diego E. Zavala-Zegarra, dzavala@psm.edu
[2] University of North Carolina School of Public Health, Chapel Hill, North Carolina, United States of America.
[3] Puerto Rico Department of Health, San Juan, Puerto Rico.
[4] Former Senior Advisor, Pan American Health Organization, Washington, D.C., United States of America.
[5] Department of Biochemistry, School of Medicine, University of Puerto Rico, San Juan, Puerto Rico.
[6] Institute of Forensic Sciences, Department of Health, San Juan, Puerto Rico.

In Latin America and the Caribbean (LAC), injuries rank ahead of infectious and chronic diseases as the leading causes of disease burden (1); and among injuries, interpersonal violent injuries are the area's greatest concern. In low- and middle-income LAC countries, deaths due to homicide are the leading cause of death among males 15–59 years of age, representing 57% of adult mortality (2).

Possession and use of a small firearm constitutes a common risk factor for interpersonal violence worldwide, but is of grave concern in LAC. A comparative study of firearms-related mortality rates among youths (15–24 years of age) for a single year reported in 2002–2006 in 83 countries showed that 9 of the 10 countries with the highest rates (> 15.0 per 100 000 population) were in LAC (3).

In the Caribbean, Puerto Rico has the highest rate of firearms-related mortality among youths, and is in fourth place overall (47.1), surpassed only by Colombia (80.5), El Salvador (78.1), and Venezuela (104.7) (3).

According to a detailed report by the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF, Washington, DC, United States) on firearms commerce, approximately 4.3 million new firearms were sold in the United States in 1999; an additional estimated 2 million were sold by unlicensed sellers (4). The number of firearms in civilian possession is difficult to estimate because of the illicit arms trade worldwide. Based on data for regulated firearms sales, the United States has the largest civilian population in possession of firearms in the world; approximately 9 out of 10 individuals possess at least one firearm (5).

The status of gun ownership in the United States is mirrored by Puerto Rico. As a United States territory, Puerto Rico enforces United States federal laws, including customs regulations; therefore, possession of firearms by the civilian population is restricted by certain purchasing procedures. However, there is a thriving, illegal interstate flow of firearms between mainland United States and Puerto Rico, partially documented by the ATF in its annual firearms tracing reports. In 2009, there were 1 727 firearms confiscated by police that were sent to ATF for tracing. Approximately 35%, or 604, of these weapons were not successfully traced to their original sale. Of the remaining 1 123 firearms, 66% were legally sold first in Puerto Rico; the other 34%, from a gun retailer on the United States mainland, 20.8% of which came from the state of Florida alone (6).

Further evidence for the impact of small firearms on health in the United States is documented by the National Violent Death Reporting System (NVDRS, Centers for Disease Control and Prevention [CDC], Atlanta, Georgia, United States) and *Crime in the United States*, an annual report published by the Federal Bureau of Investigation (FBI) (7, 8). A recent NVDRS report stated that of the 4 563 homicides/legal-intervention deaths reported in 2007 by 16 states, firearms were used in 2 of 3 cases (66.1%) (7). The FBI annual report on crime stated that of the 14 180 homicides committed in the United States as a whole in 2007, half of the victims (48.8%) were young males (13–29 years of age), and firearms were used in two-thirds (66.9%) of the homicides (8). Although the FBI report does not include Puerto Rico, comparable statistics were calculated by the authors using 2008 death certificate data obtained from the CDC National Center for Health Statistics. These show that of the 720 homicides reported for Puerto Rico, more than half (56.9%) of the victims were young males (13–29 years of age) and firearms were used in 85.7% of the homicides (9).

The most reliable data on violent deaths in Puerto Rico is provided by the Institute of Forensic Sciences (IFS), headquartered in San Juan, Puerto Rico. According to the laws of Puerto Rico, the IFS must investigate, document, and report all homicides. The forensic findings are provided to the Vital Statistics Office, located in Puerto Rico's Health Department, for recording and coding of the appropriate cause(s) on the death certificate.

The study objectives were to raise awareness of the impact of homicides in Puerto Rico based on the findings of the spatial and temporal distribution of homicides and firearms usage, by age and gender, using IFS reports.

MATERIALS AND METHODS

This was a descriptive study of all homicide incidents among residents of Puerto Rico reported by the IFS for the period 2001–2010. Homicide, as defined by the IFS, included all intentional and non-intentional fatal injuries inflicted by one person or persons to other(s). Non-intentional homicides (negligent homicide) and legal-intervention homicides, of which there were fewer than 5 cases per year, were excluded.

Data collection

For each case of homicide, information was obtained on the age and sex of the victim, place of the incident (municipality), the mechanism of injury, and the date of death. Although the IFS also records the type of weapon used and conducts criminal laboratory analysis related to the context of the homicide, e.g., ballistic analysis and detection of blood alcohol and drugs levels in the deceased, this information was unfortunately not available for study.

Population estimates for Puerto Rico and its 78 municipalities, by year, sex, and age group, were obtained from the United States Census Bureau (Washington DC, United States). However, due to the low number of cases in some municipalities, 10-year age group intervals were used to calculate cumulative rates and cumulative risks (i.e., < 5 years of age; 5–14 years, 15–24, 25–34, 35–44. . .75–84, 85+). These age group intervals are the same as those used by the United States National Center for Health Statistics (10).

Data analysis

The *Z* test statistic for the difference between rates was used to compare male and female homicide rates. The joinpoint regression method (11) was used to test for significant changes in (linear) trend of homicide rates over the 10-year period for Puerto Rico overall, and for each municipality, utilizing the joinpoint regression model, as well as the average annual percent change (AAPC) as suggested by Clegg (12). The AAPC is a useful summary statistic of the annual percent change (APC) over the 10-year period. The calculated AAPC is valid even when significant changes in rates are observed within the period. This test was also applied to age-specific rates for the male population in Puerto Rico.

Stata® version 8.2 (StataCorp LP, College Station, Texas, United States) and a customized Microsoft Excel™ (Microsoft Corp., Redmond, Washington, United States) spreadsheet were utilized to calculate crude and sex- and age-specific mortality rates for Puerto Rico as a whole and for each municipality, per year, as well as an average for the 10-year period. Cumulative rate and cumulative risks were estimated. The cumulative rate is the sum of age-specific rates up to a certain age group; in this analysis, it was up to and including the age group 70–74 years. The cumulative risk is an approximation based on the cumulative rate and can be defined as "lifetime risk" when calculated up to certain age (e.g., 74 years old), assuming that other causes of death remain constant (13). This statistic procedure assumes a Poisson distribution model of, in this case, homicide incidents in the population. Since a small number of homicide cases yields an unreliable estimate of rate, the

cumulative rate and risk were not calculated for municipalities with less than 20 homicide cases in the 10-year period. The magnitude of the cumulative risk is expressed as 1 in a number of persons that die of homicide.

Finally, the relative distribution of all the calculated cumulative risks were categorized into quartiles, with the top quartile reported as highest risk of homicide death and illustrated on a map of Puerto Rico.

RESULTS

The IFS documented a total of 8 542 homicide deaths for the period 2001–2010, an average of 854 homicides per year. The average homicide rate for the 10-year period was 22.0 per 100 000 population, with a significant difference between males (42.5) and females (3.0) ($P < 0.001$). Table 1 provides detailed information on the distribution of these deaths by gender, age-group, incident year, AAPC in rates, and the mechanism of the injury. The AAPC in the annual homicide rate for the 10-year period was +2.8% ($P < 0.05$), +3.1% for males ($P < 0.05$) and –1.5% for females. A similar analysis using age-adjusted rates yielded similar results (data not shown).

Homicide rate trends

Figure 1 shows the homicide rates overall and by gender. There was a distinct change in homicide rates, which was mostly driven by changes in the male population. In this population, a rather stable trend of annual homicide rates was observed in 2001–2007, at approximately 40.0 per 100 000, with a non-significant APC of -0.8%. However, the trend in 2007–2010 showed a marked increased (APC +11.1%, $P < 0.05$). The trend of homicide rates among the female population remained below 4.0 per 100 000 throughout the 10-year period, with a non-significant APC of -1.4%. Similar APC analysis for homicides rates with firearms yielded similar results.

The rates in Figure 1 show large differences by gender throughout the 10-year period of analysis. The male to female ratio (MFR) in 2006 and 2009 indicated the greatest difference between the genders (17.8 and 17.6, respectively), and was even greater for firearms homicides (28.9 and 30.3, respectively).

Male gender and age-specific rates

Since most of the changes in the homicide rate over the 10-year period were observed in the male population, further trend analysis focused on this gender. For most of the age-specific homicide rate trends, there were no significant changes over time except for among those 20–44 years of age. Figure 2 shows the trend in homicide rates for these

TABLE 1. Homicide deaths counts and rates by sex and age group, incident year, and mechanism, Puerto Rico, 2001–2010

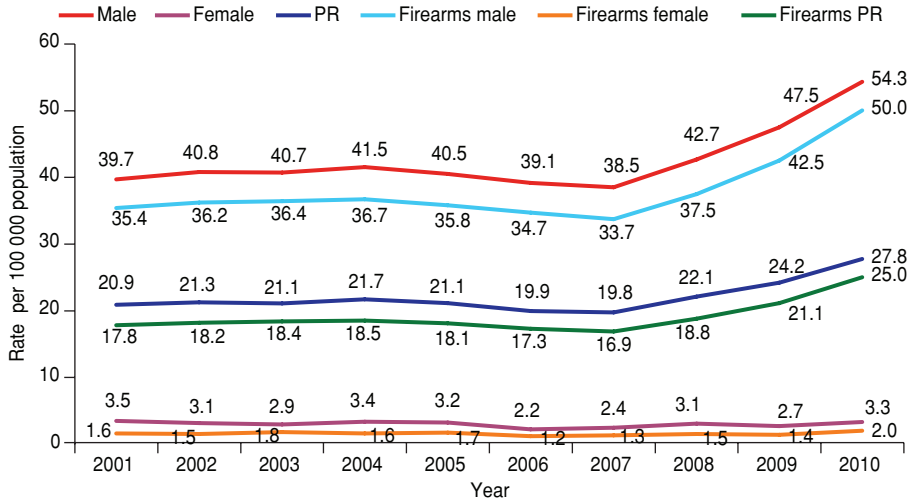
	2001			2002			2003			2004			2005			2006		
	No.	%	Rate	No.	%	Rate	No.	%	Rate	No.	%	Rate	No.	%	Rate	No.	%	Rate
Gender																		
Male	733	91.4	39.7	757	92.3	40.8	759	92.8	40.7	777	92.0	41.5	761	92.0	40.5	738	94.3	39.1
Female	69	8.6	3.5	63	7.7	3.1	59	7.2	2.9	68	8.0	3.4	66	8.0	3.2	45	5.7	2.2
Total	802	100	20.9	820	100	21.3	818	100	21.1	845	100	21.7	827	100	21.1	783	100	19.9
Age group (years)																		
< 5	12	1.5	4.2	7	0.9	2.5	9	1.1	3.3	6	0.7	2.3	7	0.8	2.7	8	1.0	3.2
5–9	4	0.5	1.3	0	0.0	0.0	1	0.1	0.3	0	0.0	0.0	4	0.5	1.4	1	0.1	0.4
10–14	5	0.6	1.6	4	0.5	1.3	1	0.1	0.3	8	0.9	2.6	4	0.5	1.3	2	0.3	0.7
15–19	111	13.8	36.4	86	10.5	28.7	95	11.6	32.2	103	12.2	35.0	79	9.6	26.6	75	9.6	25.2
20–24	213	26.6	70.1	218	26.6	71.6	207	25.3	68.4	237	28.0	79.5	208	25.2	71.4	211	26.9	73.9
25–29	182	22.7	67.2	163	19.9	59.7	190	23.2	68.6	179	21.2	63.7	180	21.8	63.2	192	24.5	67.0
30–34	85	10.6	32.3	104	12.7	39.4	99	12.1	37.3	116	13.7	43.7	113	13.7	42.6	92	11.7	34.7
35–39	48	6.0	17.9	68	8.3	25.4	70	8.6	26.4	67	7.9	25.5	72	8.7	27.5	64	8.2	24.4
40–44	39	4.9	15.3	44	5.4	17.2	46	5.6	17.8	44	5.2	16.8	44	5.3	16.6	40	5.1	15.0
45–49	29	3.6	12.2	37	4.5	15.3	27	3.3	11.0	25	3.0	10.0	33	4.0	13.1	32	4.1	12.5
50–54	25	3.1	10.8	27	3.3	11.7	22	2.7	9.6	23	2.7	9.9	20	2.4	8.5	18	2.3	7.6
55–59	15	1.9	7.5	20	2.4	9.5	14	1.7	6.5	8	0.9	3.6	15	1.8	6.6	8	1.0	3.5
60–64	11	1.4	6.7	6	0.7	3.5	5	0.6	2.8	6	0.7	3.3	16	1.9	8.5	12	1.5	6.0
65–69	4	0.5	2.9	12	1.5	8.4	7	0.9	4.8	5	0.6	3.3	7	0.8	4.5	6	0.8	3.8
70–74	4	0.5	3.6	6	0.7	5.3	7	0.9	6.1	4	0.5	3.4	8	1.0	6.5	9	1.1	7.1
75–79	4	0.5	4.7	4	0.5	4.6	4	0.5	4.5	5	0.6	5.5	5	0.6	5.5	3	0.4	3.2
80–84	4	0.5	7.1	4	0.5	6.8	0	0.0	0.0	2	0.2	3.2	5	0.6	7.7	2	0.3	3.0
≥ 85	1	0.1	2.0	2	0.2	3.9	5	0.6	9.4	0	0.0	0.0	1	0.1	1.7	1	0.1	1.7
Unknown	6	0.7		8	1.0		9	1.1		7	0.8		6	0.7		7	0.9	
All ages	802	100	20.9	820	100	21.3	818	100	21.1	845	100	21.7	827	100	21.1	783	100	19.9
Mechanism																		
Firearm	685	85.4		702	85.6		715	87.4		719	85.1		707	85.5		679	86.7	
Sharp instrument	41	5.1		60	7.3		55	6.7		62	7.3		50	6.0		58	7.4	
Other	76	9.2		56	6.8		48	5.9		63	7.5		70	8.5		46	5.9	
Unknown	0	0.0		2	0.2		0	0.0		1	0.1		0	0.0		0	30.0	
Total	802	100		820	100		818	100		845	100		827	100		783	100	

TABLE 1. (Continued)

	2007			2008			2009			2010			AAPC[a]	2001–2010		
	No.	%	Rate	No.	%	Rate	No.	%	Rate	No.	%	Rate	%	No.	%	Rate
Gender																
Male	729	93.6	38.5	810	92.7	42.7	904	94.2	47.4	970	93.80	54.3	3.4[b]	7 937	92.9	42.5
Female	50	6.4	2.4	64	7.3	3.1	56	5.8	2.7	64	6.20	3.3	–1.4	603	7.1	3.0
Total	779	100	19.8	874	100	22.1	960	100	24.2	1034	100	27.8	3.1[b]	8 540	100	22.0
Age (years)																
< 5	5	0.6	2.0	9	1.0	3.8	8	0.8	3.4	6	0.6	2.7	–1.1	77	0.9	3.0
5–9	0	0.0	0.0	3	0.3	1.1	1	0.1	0.4	1	0.1	0.4	–5.6	15	0.2	0.5
10–14	4	0.5	1.3	3	0.3	1.0	6	0.6	2.1	6	0.6	2.2	2.7	43	0.5	1.4
15–19	85	10.9	28.5	91	10.4	30.5	97	10.1	32.6	92	8.9	32.4	–0.8	914	10.7	30.8
20–24	186	23.9	66.5	194	22.2	70.3	222	23.1	80.6	268	25.9	102.7	2.9	2 164	25.3	75.2
25–29	169	21.7	58.9	200	22.9	70.1	215	22.4	76.4	234	22.6	95.8	3.8[b]	1 904	22.3	68.7
30–34	113	14.5	42.3	117	13.4	43.2	155	16.2	56.3	161	15.6	64.9	6.2[b]	1 155	13.5	43.6
35–39	73	9.4	27.7	81	9.3	30.6	92	9.6	34.7	88	8.5	36.5	5.7[b]	723	8.5	27.6
40–44	43	5.5	16.1	57	6.5	21.5	50	5.2	19.0	55	5.3	22.7	7.7[b]	462	5.4	17.8
45–49	22	2.8	8.6	29	3.3	11.1	36	3.8	13.6	31	3.0	12.5	–0.6	301	3.5	12.0
50–54	23	3.0	9.5	23	2.6	9.3	25	2.6	10.0	23	2.2	9.6	–1.7	229	2.7	9.6
55–59	18	2.3	7.9	17	2.0	7.4	14	1.5	6.1	24	2.3	10.7	1.7	153	1.8	6.9
60–64	9	1.2	4.3	11	1.3	5.1	8	0.8	3.6	14	1.4	6.4	0.5	98	1.2	5.1
65–69	8	1.0	4.9	13	1.5	7.7	7	0.7	4.0	8	0.8	4.6	–0.7	77	0.9	4.9
70–74	6	0.8	4.6	5	0.6	3.7	7	0.7	5.0	10	1.0	7.3	2.8	66	0.8	5.3
75–79	8	1.0	8.3	2	0.2	2.0	5	0.5	4.9	6	0.6	6.0	2.0	46	0.5	4.9
80–84	0	0.0	0.0	8	0.9	2.0	2	0.2	2.8	2	0.2	3.0	–11.2[b]	29	0.3	4.5
≥ 85	1	0.1	1.6	4	0.5	6.0	5	0.5	7.1	0	0.0	0.0	0.7	20	0.2	3.4
Unknown	6	0.8		7	0.8		5	0.5		5	0.5			66	0.8	
All ages	779	100	19.8	874	100	22.1	960	100	24.2	1 034	100	27.75		8 542	100	22.0
Mechanism																
Firearm	665	85.4		743	85.0		839	87.4		932	90.1			7 386	86.5	
Sharp instrument	53	6.8		68	7.8		63	6.6		51	4.9			561	6.6	
Other	61	7.8		63	7.2		58	6.0		51	4.9			592	6.9	
Unknown	0	0.0		0	0.0		0	0.0		0	0.0			3	0.04	
Total	779	100		874	100		960	100		1 034	100			8 542	100	

[a] Average Annual Percent Change.
[b] Statistically different from zero ($P < 0.05$).

FIGURE 1. Annual homicide rates overall and by firearms and gender, Puerto Rico (PR), 2001–2010



specific age groups among males, and Table 2 summarizes the estimated APC and AAPC for different segments in the 10-year period. The APC in homicide rates in the 20–24 year and 25–29 year age groups showed significant increase from 2007 onwards and the rates in these age groups remained above 100 per 100 000 throughout the 10-year period. The AAPC showed significant increases across all five age groups, ranging from 3.9% in the 40–44 year age group to 7.3% in the 30–34 age group ($P < 0.05$). The greatest APC change of +20.7% was recorded in the 20–24 year age group in

FIGURE 2. Annual homicide rates among males by selected age groups, Puerto Rico, 2001–2010

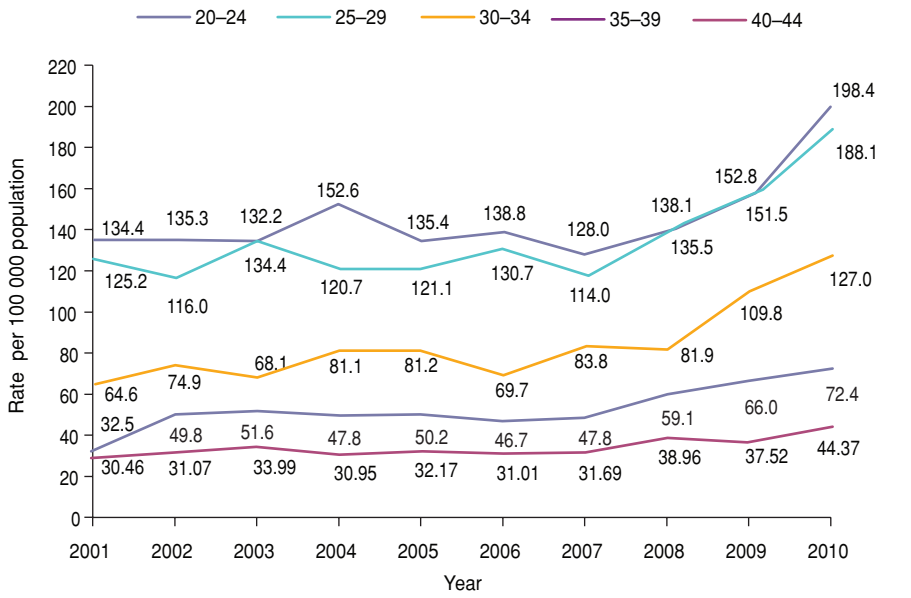


TABLE 2. Annual Percent Change (APC) and Average Annual Percent Change (AAPC) in male homicide rates, Puerto Rico, 2001–2010

Males	APC						AAPC[a] 2001–2010
	Segment 1		Segment 2		Segment 3		
Age group (years)	%	Period	%	Period	%	Period	%
20–24	–0.2	2001–2008	+20.7[a]	2008–2010	—	—	+4.1
25–29	–0.8	2001–2007	+15.1[a]	2007–2010	—	—	+4.2
30–34	+3.0	2001–2008	+24.0	2008–2010	—	—	+7.3
35–39	+5.9[a]	2001–2010	—	—	—	—	+5.9
40–44	+0.7	2001–2007	+10.6[a]	2007–2010	—	—	+3.9
All ages	+1.3	2001–2004	–2.8	2004–2007	+12.2[a]	2007–2010	+3.4

[a] $P < 0.05$.

2008–2010 (P <0.05). The highest homicide rate in the 10-year period (198.4 per 100 000) was recorded among this age group in 2010.

Figure 3 shows the age-specific average-annual homicide rates by gender for the 10-year period. The high homicide rates seen among young adults (20–39 years of age) were consistent throughout the period. The contrast between the male and female mortality experience is clearly noted. The highest average homicide rate was observed among males 20–24 years of age (144.0 homicides per 100 000).

Firearm usage

Figure 4 shows the proportion of homicides perpetrated using firearms compared to other methods, by gender, for the 10-year period. Firearms are used in approximately 9 out of 10 homicides among males (88.6%) compared to 5 out of 10 homicides among females (52.6%). For any given year, the proportion of homicides using firearms among males is at least 87%.

Seasonality

There was no suggestion of seasonality in the relative distribution of homicide deaths by month in the 10-year period. The monthly average proportion of deaths was distributed evenly through any given year, fluctuating between 8% and 9%.

FIGURE 3. Average annual age-specific homicide rates by gender, Puerto Rico (PR), 2001–2010

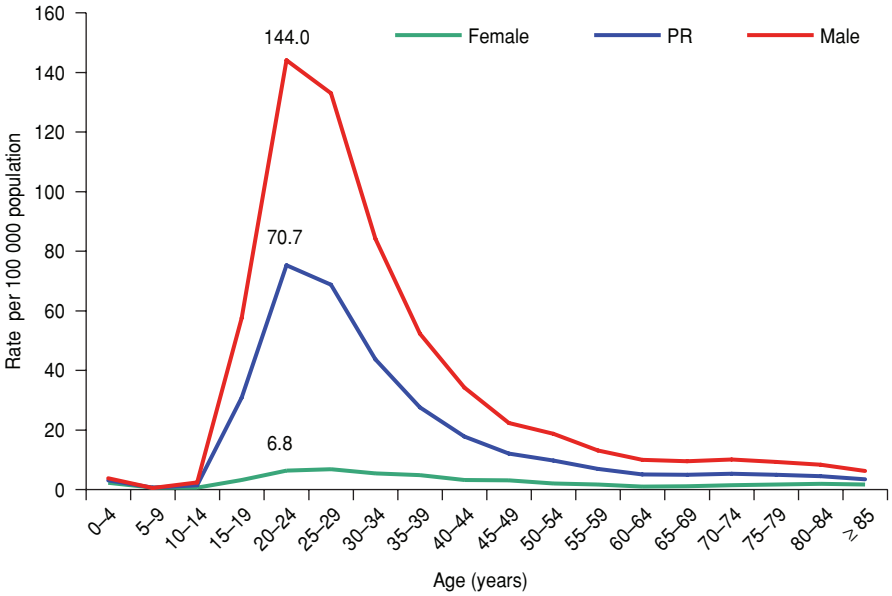
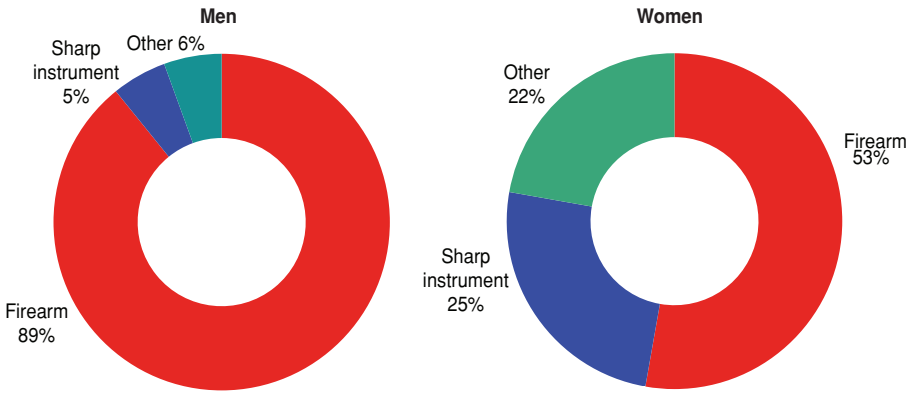


FIGURE 4. Mechanism of homicide death by gender, Puerto Rico, 2001–2010



Geographic distribution and risk

Figure 5 shows the geographical distribution of the average, lifetime, cumulative risk of homicide death for the 10-year period in four categories of risk. The cumulative risk calculation was based on the 10-year period experience in each municipality and did not take into account annual variations within the study period. Of the 78 municipalities, 20 reported less than 20 cases of homicide (25.6%). These municipalities represented 2.3% or 193 homicide incidents in the 10-year period; no cumulative rate or risk was calculated as shown in Figure 5.

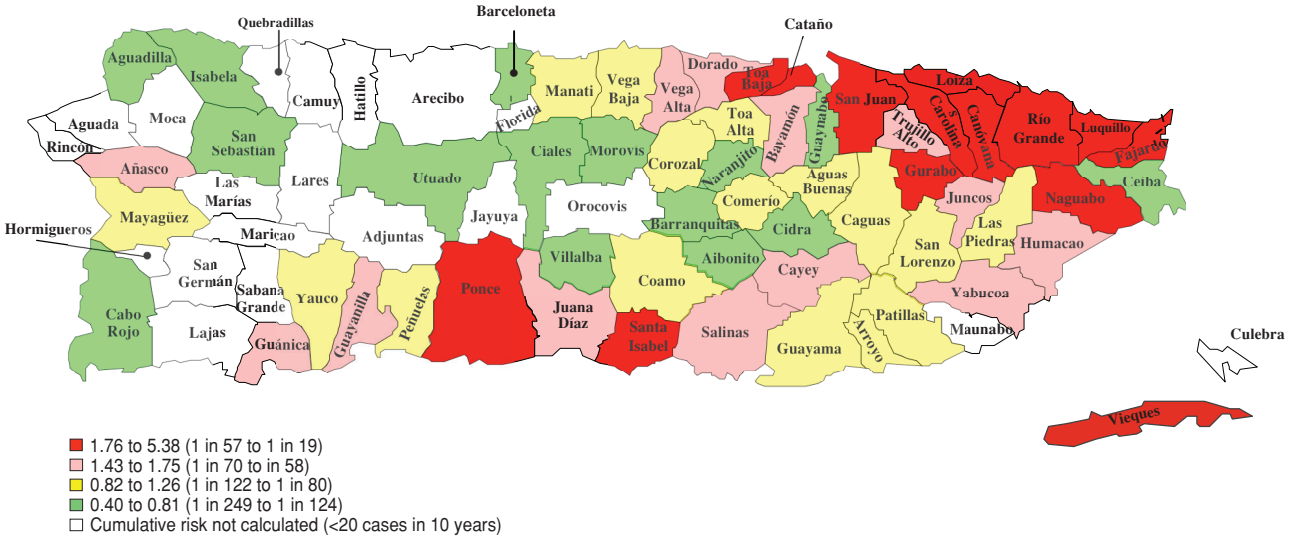
The 15 municipalities in the highest quartile (shown in red) account for 60.2% of all homicides reported. Twelve of these (Canovanas, Carolina, Cataño, Dorado, Fajardo, Gurabo, Loiza, Luquillo, Naguabo, Rio Grande, San Juan, and Toa Baja) are in northeastern Puerto Rico where metropolitan San Juan is located. The lifetime risk of homicide death in these municipalities varied from 1 in 19 to 1 in 57 residents.

Seven of the 17 municipalities in the second highest category of homicide risk are also located in northeast and eastern Puerto Rico (Bayamon, Caguas, Humacao, Juncos, San Lorenzo, Trujillo Alto, and Yabucoa). These have an estimated life time risk of homicide death variability of 1 in 58–70 residents.

Another area of concern is in and near the southern city of Ponce, where two municipalities (Ponce and Santa Isabel) were in the highest category of homicide risk and five (Guanica, Guayanilla, Juana Diaz, Salinas, and Yauco) were in the second highest category. Figure 5 suggests that the coastal area along the northeast, east, and southern parts of Puerto Rico experienced the greatest burden of homicidal deaths.

The estimated lifetime risk of homicide death during this 10-year period among males in Puerto Rico was about 1 in 34, versus 1 in 459 for females.

FIGURE 5. Average lifetime cumulative risk of homicide death per residents by municipality, Puerto Rico, 2001–2010



Municipalities with the lowest risk of homicides are scattered throughout the island. The west and northwestern municipalities were the least affected by homicide deaths, except for the municipality of Añasco, which is in the top category. Municipalities with less than 20 homicide cases are located in the central mountain and northwestern areas, as well as, on the smaller island of Culebra. Vieques, Puerto Rico's other island, reported 20 homicides in the 10-year period.

DISCUSSION

In Puerto Rico, the average homicide rate in 2001–2010 was 22.0 per 100 000 population, with an average lifetime risk of homicide death of 1 in 64 residents, 1 in 34 male residents, and 1 in 459 female residents. Approximately 9 out of 10 of the homicides among males were committed using a firearm. The population at greatest risk of homicide deaths in Puerto Rico is the youth and young adult males 15–44 years of age.

Higher rates have been reported by other LAC countries, such as Honduras, 60.9 in 2008; Jamaica, 59.5 in 2008; Venezuela, 52.0 in 2008; El Salvador, 51.8 in 2008; Guatemala, 45.2 in 2006; Colombia, 38.8 in 2007; and finally, Brazil with 22.0 in 2008 and the Dominican Republic with 21.5 in 2007 have rates similar to that of Puerto Rico (14). A prior study conducted in Puerto Rico for the period 1999–2003 indicated that homicide was the first cause of death among males 15–29 years of age (15). Similar findings have been reported by several of the LAC countries listed above that have high homicide rates (3).

The municipality of San Juan, a densely populated urban area, showed a marked increase in homicide rates during the last three years of the 10-year study period. Moreover, San Juan's neighboring municipalities (e.g., Dorado, Humacao, Juncos, and Vega Alta) were in the second highest risk category. These changes suggest that firearms violence is spreading beyond the main metropolitan center to the suburban areas of Puerto Rico.

The U.S. Drug Enforcement Agency (Washington, DC, United States), classifies Puerto Rico as a "high-intensity drug-trafficking area" because it is an established route for illicit drugs produced in South America (16). The amount of cocaine seized by authorities in Puerto Rico and the U.S. Virgin Islands has increased annually, from 1 544 kg in 2006, to 4 414 kg in 2007, to 17 113 kg in 2008 (16). Additionally, a recent DEA report described the use of newly indiscriminate violence and intimidation among retail-level drug distributors in Puerto Rico that stems from increased efforts by criminal gangs seeking to dominate the market (17). The link between drug trafficking and the demand and widespread use of firearms is difficult to overlook. The socioeconomic incentives of partaking in the drug trade may be stronger for young males living in marginalized communities than for others. Any of the roles suited to a young male in the drug trade—drug distributor, facilitator, enforcer, runner, site operator, supplier, among others—would require brandishing small arms or light weapons.

The ease of access to firearms in Puerto Rico is evidenced by the present study's findings that 87% of all homicides involve a firearm. According to official United States government export statistics, a total of 182 316 small arms and light weapons were exported from the United States to Puerto Rico in 2001–2010 (18). The implications of both legal and illegal access to firearms in the United States translate into a continuous flow of these weapons to Puerto Rico. There are no official estimates, however the ATF and public media report that firearms smuggled onto the island constitute a significant security problem (19, 20). It has been shown that small arms and light weapons move from states with weaker gun control laws to states with stricter laws (21). While Puerto Rico has strict laws regulating the possession and use of firearms, neighboring states, such as Florida, do not restrict multiple firearms purchases. The accessibility of firearms in Florida thereby extends to Puerto Rico, as reported by the 2009 ATF firearms tracing system (6). It is estimated that less than 5% of shipping containers arriving at the seaports of Puerto Rico are inspected (16); therefore, control of illegal firearms imports is severely lacking.

Study limitations

One of the study's limitations was the significant changes in homicide rates during the 10-year study period. While homicide rates did not change significantly in 2001–2007, there were significant increases in 2007–2010. These changes in homicide risk over time were not reflected in the computation of the average homicide rates and risks presented in Figure 5. Another limitation was that the study data did not included information on the context in which firearms-related homicides occurred. Though context is recorded by the IFS, it is available only on paper, and time constraints did not permit for the review of more than 10 000 of these files.

Conclusions

Clearly, the illegal, small firearms traffic in Puerto Rico needs to be rigorously addressed, however, it would be futile to continue to respond to high homicide rates with law enforcement campaigns alone. Crime and violence must be seen as a socioeconomic and development issue. The possession of illegal firearms is a risk factor for homicides on the island, and therefore, it is both a health and security issue that must be targeted by both the United States and Puerto Rican authorities. Concrete steps must be taken to reduce the flow of illegal firearms to Puerto Rico. To begin with, the stricter firearms-purchasing regulations in place along the U.S.-Mexico border, which make multiple purchases of firearms and large-caliber weapons reportable, should be applied with the same sense of urgency to states from which illegal firearms are entering Puerto Rico (22).

The World Health Organization (WHO) has recommended applying an "ecological model" for violent injury prevention (23), an approach that if applied in Puerto Rico could lead to a better understanding of the context in which violence prevails on the island. Identifying risk and protective factors beyond the individual, such as those at the community and society level, could explain current conditions that make illegal drug trafficking an opportunity for getting out of poverty, especially for the young men involved in this dangerous trade. Media reports of young male homicide victims with multiple gunshot wounds from assault weapons suggest involvement in the highly competitive and violent illicit drug market. This phe-

nomenon is reflected in the high risk of an early death, as demonstrated by the extremely high homicide rates among males in the 20–24 year age group.

To date, the application of the WHO ecological model in Puerto Rico has been impeded by the lack of a systematic approach to collecting, analyzing, and disseminating comparable sources of injury data. Currently, Puerto Rico does not have a surveillance system like those that have been successfully implemented in Colombia and the United States to track the incidence and characteristics of violent deaths (7, 24). A well-establish observatory of violence could provide the needed support for the development of evidence-based prevention strategies. Public institutions, such as the police department, the IFS, the vital statistics department, and other relevant institutions need to work together in a sustained effort to consolidate the information on violent deaths systematically. Digitalization of key information on homicides in Puerto Rico, such as the type of weapons used and specific geographic information (e.g., zip code or street coordinates) would permit more detailed geospatial analysis of violence.

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RESUMEN

Distribución geográfica del riesgo de muerte por homicidio en Puerto Rico, 2001–2010

Objetivo. Concientizar sobre la repercusión de los homicidios en Puerto Rico con base en los resultados de la distribución espacial y temporal de los homicidios y el uso de las armas de fuego, según la edad y el sexo, a partir de los informes del Instituto de Ciencias Forenses (ICF), con sede en San Juan, Puerto Rico, sobre defunciones por violencia interpersonal.

Métodos. Estudio descriptivo de todos los incidentes de homicidio ocurridos en Puerto Rico informados por el ICF durante el período del 2001 al 2010. La edad, el sexo, el municipio del incidente, la fecha de muerte y el mecanismo fueron los datos analizados en cada uno de los 8 542 casos. Se calcularon las tasas brutas de mortalidad específicas de cada sexo y edad en Puerto Rico y en cada municipio, por año y durante el período de 10 años. Se calcularon también las tasas y los riesgos acumulados y se definieron como riesgo durante toda la vida. La distribución relativa de las tasas acumuladas para cada municipio se clasificó en cuartiles, del riesgo más alto al más bajo, y se ilustró en un mapa.

Resultados. El riesgo de muerte por homicidio en varones es 13 veces mayor que en mujeres. Las tasas más elevadas se observaron en hombres de 20 a 24 años de edad (198,4 homicidios por 100 000). Cualquiera que fuera el año escogido, en al menos 80% de los homicidios se utilizaron armas de fuego. En varones, el riesgo promedio de morir por homicidio durante toda la vida es de 1/34.

Conclusiones. Los jóvenes varones adultos con acceso a las armas de fuego están sometidos a un mayor riesgo de homicidio en Puerto Rico. Además, en los municipios muy urbanizados el riesgo es más alto; sin embargo, en ciertos municipios no urbanos de la costa también hay un riesgo de homicidio muy alto. Las máximas prioridades deben ser aplicar el "modelo ecológico" de la OMS para prevenir las lesiones violentas y establecer un sistema de vigilancia que ayude a determinar la función que desempeñan las condiciones socioeconómicas, el comercio ilegal de armas de fuego y el tráfico de drogas.

Palabras clave Homicidio; armas de fuego; violencia; mortalidad prematura; Puerto Rico.