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ORIGINAL ARTICLE

Association between homicide and myocardial infarction mortality: a population-level analysis in Mexico from 2000 to 2019

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ABSTRACT

BACKGROUND

Globally, violent deaths represent a serious public health issue, and Mexico has shown an increase in homicides. Exposure to violence has been linked to adverse mental and physical health outcomes, including cardiovascular disease. However, population-level evidence linking homicide mortality to myocardial infarction (MI) mortality remains limited. This study assesses the association between homicides and mortality from myocardial infarction in Mexico from 2000 to 2019.

METHODS

This ecological time-series study used national mortality data from the Mexican National Institute of Statistics and Geography (INEGI). Adjusted annual mortality rates were calculated. Mortality trends were evaluated using Joinpoint software. The association between homicides and other causes of mortality was analyzed using Pearson correlation and univariate and multivariate regression analyses.

RESULTS

During the study period, the average adjusted mortality rates were 16.8/100,000 for homicides and 67.4/100,000 for myocardial infarction. Both homicide and MI mortality rates increased significantly over time. In simple linear regression, homicides only showed significant associations with myocardial infarction ($B = 0.55$, $p < 0.05$). In multivariate regression analyses, homicide mortality remained significantly associated with MI mortality after adjustment for unemployment, gross domestic product per capita (GDP-PC), and diabetes mortality, although the association was attenuated when suicide mortality was included in the model.

CONCLUSION

At the population level, from 2000 to 2019 both homicide and MI mortality rates increased significantly, while homicides were positively associated with myocardial infarction mortality in Mexico. Elevated homicide rates act as a population-level stressor that coincides with higher mortality from heart attacks.

Keywords: Violence exposure, homicides, myocardial infarction, suicides, Mexico

INTRODUCTION

Globally, violent deaths are a major public health concern. In 2021 alone, an estimated 458,000 people lost their lives due to homicide, with men accounting for the majority of cases (81%) compared to women (19%). Firearms were the primary means of committing homicide (40%), followed by sharp objects (22%).[1]

Additionally, since 2006, the Mexican government has implemented measures against organized crime groups, which has led to an increase in violent deaths, particularly those involving firearms.[2] In this context, a violent environment is known to affect various aspects of human life, including social, economic, and health dimensions.[3]

Previous studies have documented associations between individual-level exposure to violence and adverse cardiovascular outcomes, including hypertension, ischemic heart disease (IHD), and stroke.[4,5] Some longitudinal studies suggest that childhood exposure to interparental violence is associated with higher cardiovascular risk in adulthood, whereas evidence among adults exposed to community violence has been inconsistent.[5,6] A longitudinal study from 2000 to 2014, found that in Chicago a greater decrease in violent crime at the community area level was associated with a greater decrease in cardiovascular and coronary artery disease mortality rates.[7] A time-series methods from January 2000 to December 2012 found that elevated levels of homicides in Mexico serve as a population-level stressor that acutely increases the risk of IHD death.[8] The hypothesis pertains to IHD deaths among already vulnerable persons that may plausibly be triggered by heightened anxiety pertaining to safety and security. Additionally, future investigation might allow refined testing of IHD deaths precipitated by myocardial infarction.

The objective of this study was to assess any association between homicide deaths and mortality from myocardial infarction in Mexico from 2000 to 2019.

METHODS

Research design

This ecological, population-level time-series study analyzed national mortality data in Mexico from January 1, 2000, to December 31, 2019.

Research subjects

The study population comprised all registered deaths attributed to homicide, myocardial infarction, suicide, and diabetes mellitus. There were no individual-level inclusion or exclusion criteria, as the analysis was based on aggregated national mortality data.

Data source

Population data for the years 2000, 2005, 2010, 2015, and 2020 were obtained from Mexico's population censuses and surveys, which are available in the databases of the National Institute of Statistics and Geography (*Instituto Nacional de Estadistica y Geografía*, INEGI). For non-census years, population numbers were estimated using linear interpolation.

The total number of homicide-related deaths was extracted from INEGI's vital statistics, using codes from the International Classification of Diseases, 10th Revision (ICD-10): Homicides: X85-Y09 and Y87.1; Suicides: X60-X84 and Y87.0; Myocardial infarction: I21-I22; and Diabetes mellitus: E10-E14.

Outcome

The primary outcome was the age-adjusted annual mortality rate from myocardial infarction, per 100,000 inhabitants. Secondary outcomes included age-adjusted mortality rates from homicide, suicide, and diabetes mellitus, as well as regression B and β coefficients describing their association with myocardial infarction mortality

Statistical analysis

For each cause of death, annual mortality rates were calculated and adjusted using the direct method and the world standard population. Rates were expressed per 100,000 inhabitants. Trends and annual percentage changes (APC) in mortality rates over the study period were analyzed using the Joinpoint Program (v5.0.2).

To evaluate the association between homicides and myocardial infarction mortality, mortality rates and other variables were detrended using the first difference, followed by standardization. Using these standardized data, the association between homicides and myocardial infarction mortality was evaluated with simple and multiple linear regression analyses. For multiple regression, models were adjusted for

unemployment rates, Mexico's annual GDP per capita (GDP-PC), and other causes of death (suicide, diabetes). Statistical software NCSS 12 was used for the analysis.

Ethical approval

The study was approved by the Institutional Review Board (FARLIC-099604-OGS-24/01).

RESULTS

During the study period, there were a total of 387,167 homicide deaths, 104,148 suicides, 1,240,898 myocardial infarction deaths, and 1,580,893 deaths from diabetes. The average adjusted mortality rates were 16.8/100,000 for homicides, 4.8/100,000 for suicides, 67.4/100,000 for myocardial infarction, and 89/100,000 for diabetes (Table 1).

Mortality trends

All studied causes of death showed significant increases during the study period. Homicide rates rose from 12.3/100,000 inhabitants in 2000 to 26.6/100,000 inhabitants in 2019 (APC = 5%, $p<0.05$). Myocardial infarction mortality increased from 58.7/100,000 inhabitants to 67.4/100,000 inhabitants [Annual Percentage Change (APC) = 1.8%, $p<0.05$)]. Suicide rates rose from 3.9/100,000 inhabitants to 4.8/100,000 inhabitants (APC = 1.7%, $p<0.05$), while diabetes-related deaths increased from 77.7/100,000 inhabitants to 89/100,000 inhabitants (APC = 0.4%, $p<0.05$) (Table 1).

Associations

In the simple linear regression, homicides only showed significant associations with myocardial infarction (B = 0.55, $p<0.05$). After adjusting for unemployment and GDP per capita, the coefficient for myocardial infarction ($\beta = 0.52$, $p<0.05$) remained significant (Model 1) (Table 2). When suicides were included in the model, the association between homicides and myocardial infarction mortality was not significant (Model 2). When diabetes mortality was included (Model 3), the association between homicides and myocardial infarction mortality remained significant ($\beta1 = 0.53$, $p<0.05$) (Table 2).

Table 1. Trends of world-adjusted mortality rates in Mexico from 2000 to 2019 (per 100,000 inhabitants)

Cause of defunction	2000	2005	2010	2015	2019	Average	IC95%	APC
Homicides	12.3	10.3	22.8	16,2	27.8	16.8	13.9-19.7	5.0*
Suicides	3.9	4.5	4.6	5.3	5.7	4.8	4.6-5.0	1.7*
Infarcts	58.7	61.4	69.8	73.7	84.1	67.4	63.3-71.6	1.8*
Diabetes	77.7	93	94.7	92.1	84.4	89.0	86.8-91.2	0.4*

*Note : * $p<0.05$; APC= Annual Percentage Change

Table 2. Association of myocardial infarcts with homicides and other factors using univariate and multivariate linear regression

Variable	Univariate		Multivariate					
			Model 1		Model 2		Model 3	
	B (95% CI)	p value	β (95% CI)	p value	β (95% CI)	p value	β (95% CI)	p value
Homicides	0.55 (0.12-0.97)	0.021	0.52 (0.06-0.98)	0.030	0.42 (-0.05-0.90)	0.071	0.53 (0.04-1.0)	0.041
Unemployment	0.09 (-0.42-0.60)	0.7122	-0.13 (-0.76-0.49)	0.651	-0.23 (-0.85-0.40)	0.440	-0.19 (-0.81-0.43)	0.512
Gross domestic product per capita	-0.24 (-0.74-0.26)	0.321	0.23 (-0.86-0.41)	0.452	-0.52 (-1.28-0.24)	0.163	-0.32 (-1.13-0.49)	0.412
Suicides	-0.20 (-0.70-0.31)	0.422			-0.38 (-0.95-0.19)	0.182	-0.16 (-0.82-0.51)	0.623
Diabetes	0.32 (-0.16-0.80)	0.181					0.32 (-0.20-0.85)	0.202

*Note: Model 1: after adjusting for unemployment and GDP per capita; Model 2: after adjusting for unemployment, GDP per capita and suicides; Model 3 : after adjusting for unemployment, GDP per capita, suicides

and diabetes mortality; p<0.05. B (beta): unstandardized coefficient of regression; β: standardized beta; CI : confidence interval

DISCUSSION

This study analyzes the association between homicides and mortality from myocardial infarction in Mexico. Mexico's homicide mortality rates rank among the highest globally and rank second-highest in Central America. In 2021, Mexico's estimated homicide rate was 28.2/100,000 inhabitants, which significantly exceeded the global average of 5.8/100,000 inhabitants.[1] Our study found an adjusted rate of 27.8/100,000 in 2019, closely aligning with 2021 UNODC data.[1] This minimal discrepancy suggests that violence in Mexico persisted during the COVID-19 pandemic.[9] Both homicide and myocardial infarction mortality exhibited sustained and significant increases over the study period.

The analyzed mortality outcomes all exhibited significant increases over the study period. For homicides, this rise has been observed previously and appears primarily linked to territorial disputes among organized crime groups across Mexican states, exacerbated by systemic corruption and social fragmentation.[2,3] Regarding suicides, increasing rates may reflect both the growing burden of mental illness and substance use disorder.[10,11] Finally, the observed growth in myocardial infarction deaths and diabetes mortality may relate to Mexico's escalating obesity and dyslipidemia epidemics, themselves driven by poor nutritional habits and physical inactivity [12,13]

Our results provide empirical support for the view that violence constitutes a public health issue with measurable impacts on population health, because homicide mortality showed a significant positive association with deaths from myocardial infarction.[14] This association remained significant in most models, even after adjustment for key socioeconomic indicators and other major causes of death, including GDP per capita, unemployment, suicide, and diabetes mortality. Although association does not necessarily imply causation, the association persisted even after adjusting the linear model for GDP per capita, unemployment, diabetes mortality, and suicide mortality. Previous studies using other approaches have also found a link between violence and cardiovascular diseases. For example, it has been reported that children exposed to abuse develop cardiovascular issues in adulthood, such as hypertension, angina, and stroke.[5] However, adults exposed to violence show a contradictory association.[6,8,15] Systematic reviews and cohort studies have reported associations between violence exposure and hypertension, ischemic heart disease, stroke, and overall cardiovascular mortality.[4-6] However, evidence has been mixed, particularly among adult populations exposed to community-level violence, with some studies reporting weak or inconsistent associations.[5,8] Unlike most previous research, which focused on individual or neighborhood-level exposure, the present study examined national homicide mortality as a proxy for population-level violence exposure, thereby extending existing knowledge to a broader ecological context.

The possible mechanisms that could explain the association found in this study include increased stress levels due to violent environments, which trigger the release of catecholamines, followed by cortisol.[7,16] These neuroendocrine responses promote endothelial dysfunction, inflammation, platelet activation, and a hypercoagulable state, increasing the risk of myocardial infarction and other cardiovascular events.[7,16-19] Additionally, stress-related behavioral responses such as smoking, alcohol consumption, poor diet, and physical inactivity further elevate cardiovascular risk. [12,16]

Efforts to reduce mortality from violent causes would not only yield social benefits but could also positively impact other mortality outcomes, particularly myocardial infarction and, to a lesser extent, suicide mortality in Mexico. Such interventions could collectively increase life expectancy, which has stagnated in recent years.[9] Integrating violence prevention with chronic disease prevention strategies may therefore offer synergistic public health benefits.[20]

This study has several limitations. First, its ecological design precludes causal inference and does not allow for individual-level assessment of exposure or outcomes. Second, potential misclassification or underreporting of causes of death in mortality records may have affected rate estimates. Third, unmeasured confounding factors, such as regional healthcare access, urbanization, and behavioral risk factors, were not included in the models. Finally, the use of national-level data may mask important regional

heterogeneity in both violence exposure and cardiovascular risk.

Despite these limitations, the findings highlight violence as a potential population-level determinant of cardiovascular health. Clinicians and policymakers should consider the broader health consequences of violence exposure and incorporate violence prevention into comprehensive cardiovascular disease prevention strategies. Future research should use individual-level longitudinal data, assess regional and subpopulation differences, and evaluate the impact of violence-reduction interventions on cardiovascular outcomes.

CONCLUSION

During the study period, at the population level, the homicide mortality rate was positively associated with myocardial infarction mortality in Mexico.

Acknowledgement

None

Conflict of Interest

The author declares that he has no conflict of interest.

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Data Availability Statement

All data used in this study are publicly available from the National Institute of Statistics and Geography (INEGI) databases.

Declaration of AI Usage in Scientific Writing

Grammarly IA software was used for English review.

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