

ORIGINAL RESEARCH ARTICLE

Alcohol consumption and intentional homicides among the female population in Mexico

DOI: 10.29063/ajrh2026/v30i11.10

Xin Wang^{1*}

*School of Law, Nanjing Normal University, Nanjing 210023, China

For Correspondence: Email: wangxincat@sina.cn

Abstract

This research examines the relationship between alcohol consumption and female intentional homicides in Mexico from 2000 to 2022. The study explores the interrelationships among female alcohol consumption, unemployment rates, secondary school enrollment, and urbanization in relation to intentional homicide. Data sources include the World Bank's World Development Indicators (WDI). Descriptive graphical trend analysis was used to assess long-term patterns and the concurrent movement of variables. The findings reveal a significant association between alcohol consumption, female unemployment, educational achievement, and urbanization, as well as fluctuations in female homicide rates over the study period. Specifically, alcohol consumption and unemployment appear to heighten vulnerability, whereas education serves as a protective factor. Urbanization carries both potential hazards and benefits, contingent on the presence of adequate social and institutional support systems. These findings highlight the strong relationship between female intentional homicide, alcohol consumption, and broader socioeconomic influences in Mexico. Consequently, reducing female intentional homicide in Mexico requires implementing comprehensive policies that encompass alcohol regulation, economic stability, educational progress, and inclusive urban development strategies. (*Afr J Reprod Health* 2026; 30 [11]: 111-118).

Keywords: Alcohol consumption, school enrolment, homicide, women, Mexico

Résumé

Cette recherche examine la relation entre la consommation d'alcool et les homicides volontaires de femmes au Mexique entre 2000 et 2022. L'étude explore les interrelations entre la consommation d'alcool chez les femmes, les taux de chômage, la scolarisation dans le secondaire et l'urbanisation, en lien avec les homicides volontaires. Les données proviennent des Indicateurs du développement dans le monde (IDM) de la Banque mondiale. Une analyse descriptive des tendances graphiques a été utilisée pour évaluer les tendances à long terme et l'évolution concomitante des variables. Les résultats révèlent une association significative entre la consommation d'alcool, le chômage féminin, le niveau d'instruction et l'urbanisation, ainsi que des fluctuations des taux d'homicides de femmes au cours de la période étudiée. Plus précisément, la consommation d'alcool et le chômage semblent accroître la vulnérabilité, tandis que l'éducation constitue un facteur protecteur. L'urbanisation comporte des risques et des avantages potentiels, sous réserve de la présence de systèmes de soutien social et institutionnel adéquats. Ces résultats soulignent le lien étroit entre les homicides volontaires de femmes, la consommation d'alcool et des facteurs socio-économiques plus larges au Mexique. Par conséquent, la réduction des homicides volontaires de femmes au Mexique nécessite la mise en œuvre de politiques globales englobant la réglementation de l'alcool, la stabilité économique, le progrès éducatif et des stratégies de développement urbain inclusif. Mots-clés : Consommation d'alcool, scolarisation, homicide, femmes, Mexique. (*Afr J Reprod Health* 2026; 30 [11]: 111-118).

Mots-clés: Consommation d'alcool, scolarisation, homicides, femmes, Mexique

Introduction

Alcohol consumption is a significant public health challenge and a major driver of interpersonal violence globally. Excessive alcohol use is linked to impaired decision-making, heightened aggression, a higher likelihood of violent interactions, and adverse effects on psychological and physical health.^{1,2}

Traditionally, men have had higher rates of substance use, dependence, mortality, and legal problems than women; however, the past few decades have seen a rise in substance use among women³. Violence, especially homicide, is often treated as a legal matter, yet women experience specific forms of lethal violence, often stemming from domestic, intimate partner, and gender-based

contexts. The World Health Organization (WHO) has recognized violence as a crucial public health concern with extensive repercussions for communities, societies, and nations. Given its broad implications, reducing violence is articulated in the Sustainable Development Agenda for 2030⁴⁻⁷

Mexico provides a crucial setting for examining the link between alcohol use and female homicide. Over the past twenty years, the percentage of women who reported drinking alcohol at least once increased from 53.6% in 2002 to 62.6% in 2011^{8, 9}. Additionally, the percentage of women who smoked increased from 3.8% in 2008 to 8.1% in 2011^{8, 10, 11}. Regarding drug use, 0.7% of women reported using any drug in the previous year, with marijuana being the most common^{8,9}

In 2008, the World Health Organization reported that men accounted for 70% of tobacco-related fatalities, 86.2% of alcohol-related deaths, and 78% of drug-related deaths; conversely, women accounted for 30%, 13.8%, and 21.6%, respectively¹². The United Nations Office on Drugs and Crime¹³ estimated that between 153 and 300 million people aged 15 to 64 had used an illicit substance at least once in the preceding year¹⁴. In Mexico, the incidence of alcoholic liver disease (K70) among women rose by 13% between 1970 and 1995⁸. Furthermore, the prevalence of alcohol consumption among females aged 12–17 remains significant¹⁵, suggesting a potential increase in adolescent consumption. Homicide rates have also surged, with the number of female victims rising by roughly 50% from 2013 to 2022.¹⁶

Alcohol consumption is often associated with domestic and intimate partner violence, which accounts for a considerable share of fatal violence against women. Nevertheless, there is a paucity of research rigorously examining enduring national trends linking alcohol consumption to female intentional homicides in Mexico.

This study seeks to address this gap by providing a descriptive analysis of the relationship between alcohol consumption and female intentional homicide in Mexico from 2000 to 2022. Through a visual assessment of temporal trends, this research contributes to the literature on gender-based violence and public health, thereby providing evidence to inform policy formulation and prevention initiatives.

Literature review

Revuelta-Herrera *et al.*¹⁷ conducted an epidemiological study of female drug users and drug-related mortality in Mexico from 2001 to 2015. The research used data from the Epidemiological Surveillance System for Addictions and the National Institute of Statistics and Geography. Using chi-square tests and logistic models, the analysis found an increase in the proportion of female drug users between 2001 and 2015. The findings also indicated that alcohol consumption posed a greater risk among older age cohorts, whereas marijuana use was more common among younger populations.

García-Torres *et al.*¹⁸ examined the mediating role of depression in the relationship between violence-related health effects and tobacco and alcohol use. The analysis used data from four nationally representative Mexican surveys conducted in 2000, 2006, 2012, and 2018, and applied econometric methods to evaluate these associations. The research found a link between violence-related health effects and increased tobacco and alcohol use among adults and teenagers. Depression was found to explain the relationship between violence-related health effects and tobacco use. However, the role of depression in alcohol use among adults was not clearly established.

Dávila-Cervantes and Pardo-Montaño¹⁹ examined changes in premature homicide deaths in Mexico from 1998 to 2020. They analyzed data for both men and women at the national and state levels. The study used vital statistics data to calculate age-adjusted homicide death rates and years of life lost (YLL), employing joinpoint regression analysis. In 2020, Mexico had 36,773 homicides, more than four times the number in 2007. Male populations consistently had higher Years of Life Lost (YLL) homicide rates across all age brackets, whereas premature homicide mortality among females was most pronounced among those aged 20 to 34. The investigation also uncovered substantial disparities in homicide mortality trends across the various states of Mexico. Such mortality studies are indispensable for elucidating the descriptive epidemiology of violence.

Despite substantial theoretical and empirical support for a link between alcohol consumption and violence, and despite acknowledging the gendered

aspects of homicide, there remains a paucity of research on the enduring relationship between alcohol consumption and intentional homicides among women in Mexico. This study endeavors to fill this void through a national-level, trend-based analysis

Methods

This study employed descriptive analysis to examine the relationship between alcohol consumption and intentional homicides involving women in Mexico. A descriptive trend approach is suitable for examining enduring patterns and associations when establishing causality is not the principal objective²⁰. The analysis covers the years 2000 to 2022, using secondary data from the World Development Indicators (WDI) database maintained by the World Bank²¹. The study evaluated the interrelationships among alcohol consumption, female unemployment rates, female school enrollment figures, urbanization levels, and the occurrence of intentional homicides among women in Mexico.

Data analysis

Graphical analysis was the primary analytical method used in this investigation. To visually assess their interrelationships, trends in alcohol consumption, female unemployment rates, female school enrollment, urbanization levels, and female intentional homicides were plotted over time. This methodology facilitated the interpretation of enduring patterns and the identification of intervals when fluctuations in these variables corresponded with changes in homicide outcomes affecting women. Meanwhile, following health economic studies, this method offers a comprehensive display alongside a visually informative analysis, making it easy to identify patterns, trends, and potential relationships among the variables throughout the study.²²⁻²⁵

Ethical considerations

This study exclusively used anonymized, aggregated statistical data from the World Development Indicators (WDI) to prevent the disclosure of identifiable information. No personal data was incorporated, and the analysis strictly complied with the data providers' stipulations regarding data use.

The methodology was executed with rigor, and the findings were presented objectively. Ethical approval was deemed unnecessary, as the study did not involve human or animal subjects.

Results

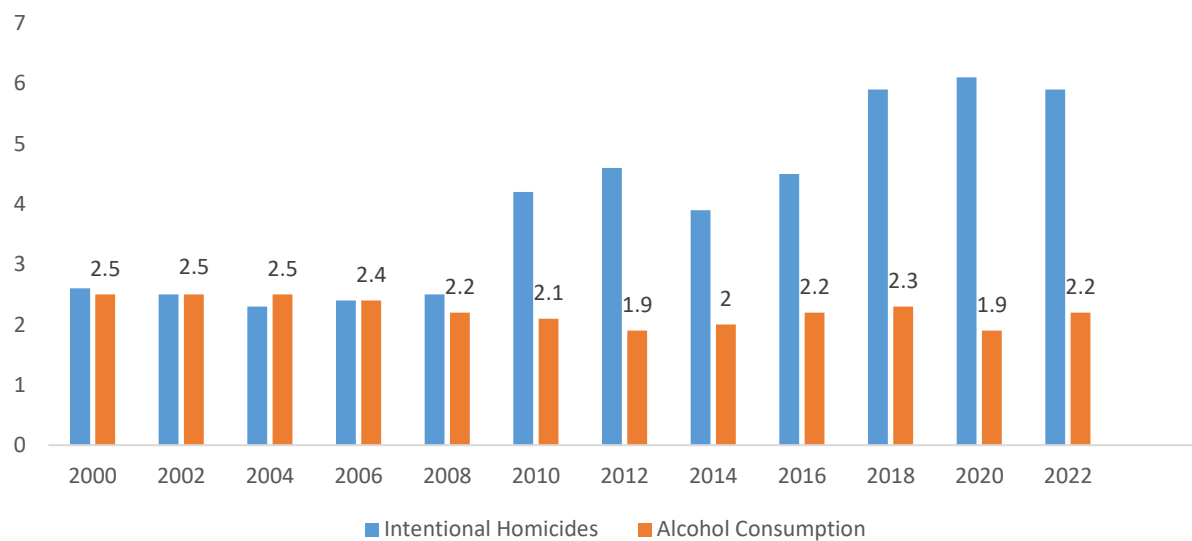
Figure 1 illustrates the enduring correlation between female intentional homicides (FHOM) and alcohol consumption (ALC) in Mexico from 2000 to 2022. The female deliberate homicide rate in 2000 was 2.6%, mirroring the 2.5% alcohol consumption rate among women. Alcohol consumption exhibited a gradual upward trend, indicating shifts in societal norms, increased accessibility, and changing lifestyle behaviors. Concurrently, female intentional homicide rates rose consistently, reaching 4.2%, especially between the late 2000s and the mid-2010s. The most pronounced escalation in female homicides coincided with periods of heightened alcohol consumption. By 2022, alcohol consumption had stabilized at 2.2%, and the increase in female homicide rates had moderated to 5.9%, potentially reflecting the influence of broader social or policy measures.

Figure 2 shows the correlation between female intentional homicides (FHOM) and female secondary school enrollment (EDU) in Mexico from 2000 to 2022. In 2000, the female homicide rate was 2.6%, while female secondary school enrollment stood at 74.8%. Over the course of the study, female secondary school enrollment increased substantially, suggesting improvements in educational accessibility and gender equity. This increase in educational attainment was associated with a deceleration and partial stabilization of female homicide rates, especially after the mid-2010s. Nevertheless, from 2014 to 2020, female secondary school enrollment declined to 73%, while the female intentional homicide rate increased to 5.9%.

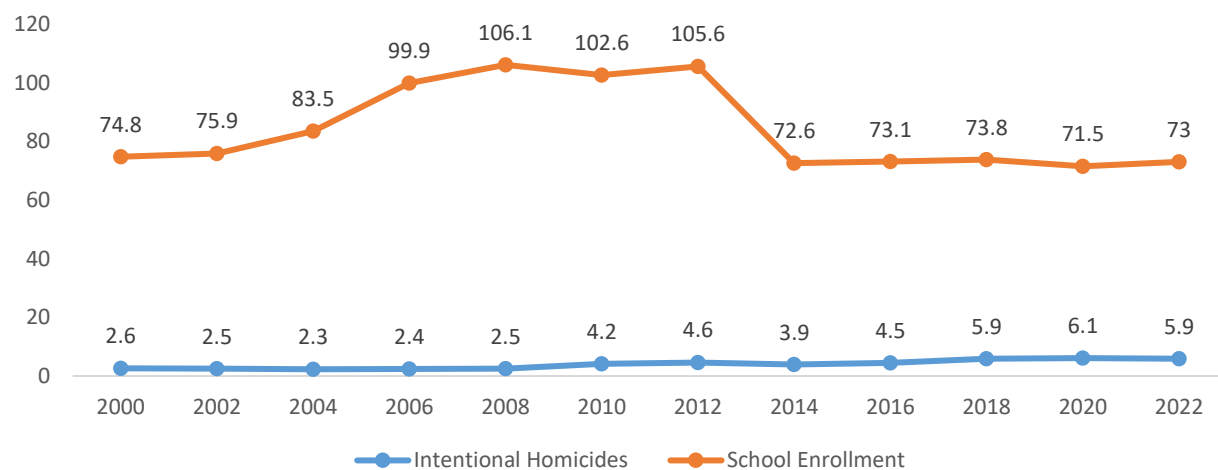
Figure 3 shows the correlation between female unemployment (UNEMP) and female intentional homicides (FHOM) in Mexico from 2000 to 2022. In 2000, the female unemployment rate was 3.4%, while the female homicide rate was 2.6%. From 2000 to 2010, female unemployment increased significantly while female homicide rate rose marginally within the same periods. Periods of rising female unemployment were linked to higher female homicide rates, especially during periods of

Table 1: Measurement of variables

Variable	Code	WDI Indicator Name	Measurement	Source
Female Intentional Homicide	FHOM	Intentional homicides, female	Death per 100,000 females	WDI
Alcohol Consumption	ALC	Alcohol consumption, female (% total)	Percentage	WDI
Education	EDU	School enrollment, secondary, female (% gross)	Percentage	WDI
Female Unemployment	UNEMP	Unemployment, female (% of female labor force)	Percentage	WDI
Urbanization	URB	Urban population growth (% annual)	Percentage	WDI

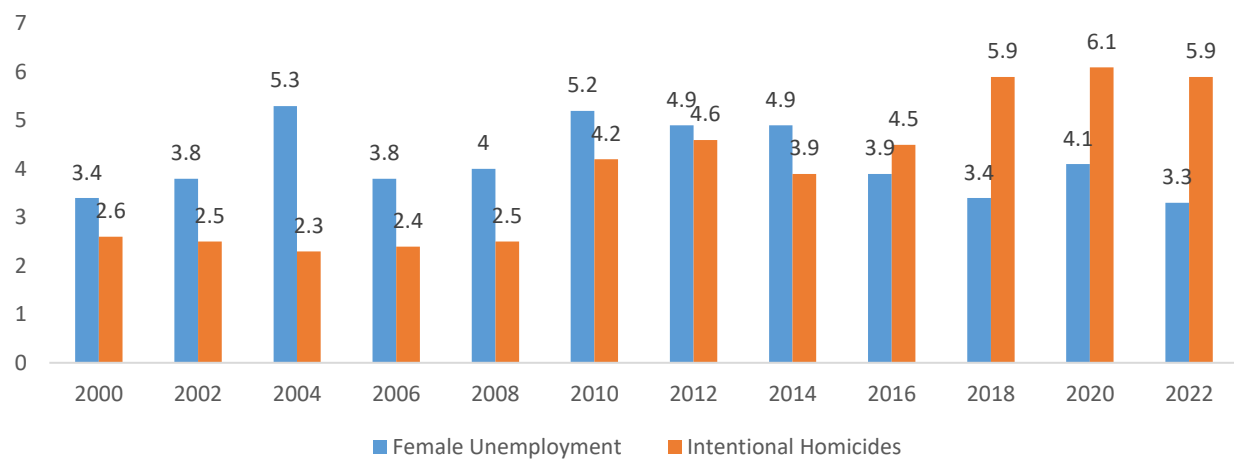
**Figure 1:** Female intentional homicides and alcohol consumption in Mexico

Source: Authors' computation

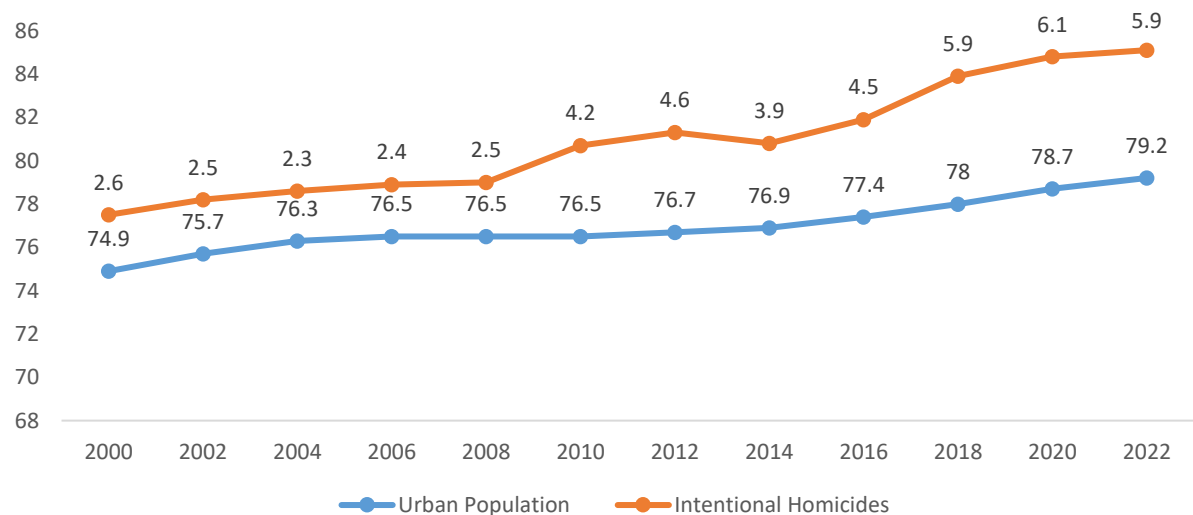
**Figure 2:** Female intentional homicides and school enrollment in Mexico

Source: Authors' computation

Female Unemployment and Intentional Homicides

**Figure 3:** Female unemployment and intentional homicides in Mexico

Source: Authors' computation

**Figure 4:** Female intentional homicides and urban population in Mexico

Source: Authors' computation

economic volatility. Conversely, periods of reductions or stabilization in female unemployment were associated with more gradual increases in homicide rates.

Figure 4 shows the correlation between urbanization (URB) and female intentional homicides (FHOM) over the study period. From 2000 to 2010, the urban population share expanded from 74.9% to 76.5%, while the female homicide rate rose from 2.5% to 4.2%. This pattern

underscores the challenges of rapid urbanization, including social instability, high population density, and limited access to essential services. As urbanization persisted and infrastructure improved, the female homicide rate decelerated, reaching 5.9% by 2022. These observations suggest that the early stages of urban expansion may heighten risk, whereas prolonged urban development, particularly when coupled with strong social and institutional support, can mitigate violence.

Discussion

The results of this investigation suggest a strong correlation between female intentional homicide in Mexico and socioeconomic variables, including alcohol consumption, employment circumstances, educational attainment, and urbanization. Firstly, the observed positive relationship between alcohol consumption and female homicide suggesting a potential link between alcohol use and increased susceptibility to lethal violence among women. This finding aligns with prior research, which has established alcohol as a key contributor to both interpersonal and domestic violence²⁶. Consequently, this finding implies that life skills prevention initiatives targeting Mexican youths, especially female folks should incorporate substance use education alongside violence prevention strategies, acknowledging the interconnectedness of these risk behaviors, which manifest differently for males and females. Mexican policymakers are advised to adopt preventive measures during adolescence to mitigate the correlation between substance abuse and violence. It is important to stress that alcohol consumption can diminish inhibitions, escalate aggression, and exacerbate conflicts, especially in private or intimate settings where women are more vulnerable to fatal violence. Conversely, the inverse correlation between female educational attainment and homicide rates highlights education's protective function. The contrasting trends between educational attainment and female homicide rates suggest that improved education may confer a protective effect, potentially by broadening women's economic prospects, fostering social empowerment, and heightening awareness of available support systems. In the same vein, greater access to secondary education fosters women's economic autonomy, social empowerment, and capacity to escape violent situations. Furthermore, education cultivates awareness of legal entitlements and available support systems, potentially mitigating prolonged involvement in abusive relationships. These observations are consistent with the broader gender and development scholarship, which recognizes education as a crucial factor in determining women's safety and overall well-being¹⁷.

Moreover, female unemployment exhibits a strong correlation with female homicide, highlighting economic instability as a fundamental catalyst of violence. These patterns suggest that

labor market instability could amplify women's susceptibility to violence by exacerbating economic pressures, fostering dependence, and increasing exposure to hazardous circumstances. Unemployment and volatile labor market dynamics can exacerbate psychological distress, economic reliance, and exposure to perilous circumstances. Consequently, restricted access to stable employment diminishes women's negotiating power within domestic settings and amplifies their susceptibility to abuse, which may culminate in fatal consequences.

Urbanization's impact on female homicide is multifaceted. Elevated homicide rates observed in the early stages of urban expansion likely result from social instability, the erosion of community bonds, and limited access to social and mental health resources for women who are migrants or from low-income backgrounds. As urban development progresses, these risks seem to diminish, presumably due to improvements in infrastructure, healthcare accessibility, and integration into the labor market. Consequently, these observations imply that urbanization is not intrinsically detrimental; instead, its consequences depend on institutions' ability to manage population growth effectively and provide sufficient social support.

In sum, the findings suggest that female intentional homicide in Mexico transcends the purview of criminal justice and is fundamentally intertwined with broader socioeconomic frameworks. Alcohol consumption, labor market dynamics, educational prospects, and urban transformation collectively influence women's vulnerability to lethal violence.

Strengths and limitations

This research adds to existing knowledge by offering a longitudinal descriptive examination of the relationship between alcohol consumption and female intentional homicides in Mexico, drawing on data from national and international sources. The application of graphical trend analysis effectively illustrates robust patterns, thereby enhancing the accessibility of the results for policymakers and lay audiences. Moreover, the gender-specific emphasis fills a notable void in homicide research, which often emphasizes male victimization.

Notwithstanding these contributions, the study is subject to certain limitations.

The use of aggregate data limits the ability to establish causal relationships or to elucidate individual-level behaviors, including drinking habits, relationship dynamics, and prior experiences with violence. Proxy variables may prove inadequate to fully capture the intricacies of alcohol-related harm or gender-based violence. Furthermore, pertinent factors such as drug-related violence, regional variations, cultural influences, and institutional efficacy are not directly considered. Future investigations employing causal methodologies and more detailed datasets could yield deeper understanding of the causal pathways linking alcohol consumption and female homicide.

Policy implications

The results of this research underscore the need for comprehensive policy interventions to reduce female intentional homicide in Mexico. Strengthening alcohol control measures by regulating availability, pricing, and marketing, alongside expanding access to treatment for alcohol use disorders, can reduce alcohol-related aggression and domestic violence, thereby lowering women's risk of lethal harm. Furthermore, promoting female employment and economic integration is crucial. Expanding job opportunities, enforcing labor protections, and supporting women's skill development can bolster economic independence and reduce susceptibility to violence. Prioritizing sustained investment in female education, especially at the secondary and tertiary levels, is a crucial long-term strategy for violence prevention. Education cultivates empowerment, resilience, and access to essential support networks. Urban development policies should integrate social services, mental health care, and gender-sensitive safety measures, particularly during periods of rapid urban expansion. Strengthening community-based support systems, alongside ensuring access to healthcare and legal protection, can effectively mitigate the risks associated with urbanization. A coordinated policy framework linking public health, labor market initiatives, educational programs, and urban planning interventions is essential for addressing the structural determinants of female homicide.

Conclusion

This study examined the relationship between alcohol consumption and female intentional homicides in Mexico, using graphical trend analysis from 2000 to 2022. The findings reveal a significant association between alcohol consumption, female unemployment, educational achievement, and urbanization, as well as fluctuations in female homicide rates over the study period. Specifically, alcohol consumption and unemployment appear to heighten vulnerability, whereas education serves as a protective factor. Urbanization carries both potential hazards and benefits, contingent on the presence of adequate social and institutional support systems. Consequently, reducing female intentional homicide in Mexico requires implementing comprehensive policies that encompass alcohol regulation, economic stability, educational progress, and inclusive urban development strategies.

Acknowledgement

The Postgraduate Research & Practice Innovation Program of Jiangsu Province “A Methodological Study of Max Weber’s Sociology of Law” (KYCX24_1681).

References

1. Centers for Disease Control and Prevention. The Public Health Approach to Violence Prevention|Violence Prevention|Injury Center|CDC. Available online: <https://www.cdc.gov/violenceprevention/about/publichealthapproach.html> (accessed on 26 March 2016).
2. WHO. Global status report on alcohol and health. *World Health Organization*, 2023.
3. Villatoro JA, Medina ME, Fleiz C, Téllez MM, Mendoza LR, Romero M and Guisa C. Reporte de drogas. Encuesta Nacional de Adicciones. *Instituto Nacional de Psiquiatría Ramón de la Fuente Muñiz. México*, 2011a. https://www.gob.mx/cms/uploads/attachment/file/239022/ENA_2011_Drogas.pdf
4. United Nations Peace, Justice and Strong Institutions. Available online: <https://www.un.org/sustainabledevelopment/peace-justice/> (accessed on 26 March 2024).
5. Centers for Disease Control and Prevention. The Public Health Approach to Violence Prevention|Violence Prevention|Injury Center|CDC. Available online:

- <https://www.cdc.gov/violenceprevention/about/publichealthapproach.html> (accessed on 26 March 2024).
6. American Public Health Association. Violence Is a Public Health Issue: Public Health Is Essential to Understanding and Treating Violence in the U.S. Available online: <https://www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2019/01/28/violence-is-a-public-health-issue> (accessed on 26 March 2024).
 7. Gebo E. Intersectoral Violence Prevention: The Potential of Public Health–Criminal Justice Partnerships. *Health Promot. Int.* 2022, 37, daac062. [CrossRef] [PubMed]
 8. Medina ME, Villatoro JA, Fleiz C, Téllez MM, Mendoza LR, Romero M and Guisa V. Reporte de alcohol. Encuesta Nacional de Adicciones. *Instituto Nacional de Psiquiatría Ramón de la Fuente Muñiz. México*, 2011. www.inprf.gob.mx
 9. Villatoro JA, Medina ME, Fleiz C, Téllez MM, Mendoza LR, Romero M. and Guisa V. Encuesta Nacional de Adicciones. *Instituto Nacional de Psiquiatría Ramón de la Fuente Muñiz. México*, 2011b. www.inprf.gob.mx
 10. Rodríguez C, Villatoro JA, Medina ME, Téllez MM, Díaz C and Mendoza L. Reporte de tabaco. Encuesta Nacional de Adicciones. *Consejo Nacional contra las Adicciones México*, 2008. http://www.dgepi.salud.gob.mx/sis/SISVEA%202008/sisvea_2008_index.html.
 11. Hernández M, Tena C, Alvear C, Medina ME, Rodríguez MH, Guisa VM and Villatoro JA. Reporte de tabaco. Encuesta Nacional de Adicciones. *Instituto Nacional de Psiquiatría Ramón de la Fuente Muñiz. México*, 2011. http://www.inprf.gob.mx/opencms/export/sites/INPRFM/psicosociales/archivos/ena/ena2011_tabaco.pdf
 12. Mathers C, Gretchen S and Mascarenhas M. Mortality and burden of disease attributable to selected major risks. Geneva, Switzerland: *World Health Organization*, 2009. http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf
 13. United Nations Office on Drugs and Crime. Global study on homicide 2013: Trends, contexts, data. Vienna, Austria: *United Nations publication*, 2014, (Sales No 14.IV.1).
 14. Fedotov Y. Informe Mundial sobre las Drogas. Oficina de las Naciones Unidas contra la Droga y el Delito. *Recuperado del sitio*, 2012. https://www.unodc.org/documents/data-and-analysis/WDR2012/WDR_2012_web_small.pdf
 15. Health Ministry. Encuesta Nacional de Adicciones 2011: Reporte de Alcohol. México, DF, México: Instituto Nacional de Psiquiatría Ramón de la Fuente Muñiz; Instituto Nacional de Salud Pública; Secretaría de Salud, 2012. Retrieved from www.inprf.gob.mx.
 16. INEGI. Estadísticas de defunciones Registradas. Comunicado de prensa 2023. Available online: <https://www.inegi.org.mx/contenidos/saladeprensa/buletines/2023/EDR/EDR2022.pdf> (accessed on 23 April 2024).
 17. Revuelta-Herrera A, Ruiz-Matus C, Jiménez-Corona ME, Rodríguez-González KG, Mendoza-Villavicencio I, Suarez-Garnica J and Salcedo-Ubilla M. Epidemiological overview of the consumption of drugs in women and its impact as immediate cause of death, Mexico 2001–2015. *Journal of Substance Use*, 2018, 23(5), 492–499. <https://doi.org/10.1080/14659891.2018.1489011>
 18. García-Torres M., Allen-Leigh B, Basto-Abreu AC, Escamilla-Núñez MC, Ayala-García JC, Cupul-Uicab LA and Hernández-Cadena L. The Association Between Violence Against Women and the Consumption of Addictive Substances in Mexico and the Role of Depression as a Mediator. *Journal of Interpersonal Violence*, 2025, 0(0). <https://doi.org/10.1177/08862605251365659>
 19. Dávila-Cervantes CA, Pardo-Montañón AM. An Unrelenting Epidemic of Violence: Trends of Homicide Mortality in Mexico, 1998–2020. *International Journal of Social Determinants of Health and Health Services*. 2022;53(2):195-205. doi:10.1177/27551938221141827
 20. UNODC. Global study on homicide. *United Nations Office on Drugs and Crime*, 2023.
 21. World Bank. World Development Indicators [Internet]. Washington (DC): World Bank; 2025. Available from: <https://databank.worldbank.org/source/world-development-indicators>
 22. Hao S, Yang H, Bi R, Akinbode SO, and Aderemi TA. Effects of remittances on life expectancy and under-five mortality in sub-Saharan Africa: Evidence using Generalized Method of Moments analysis. *African Journal of Reproductive Health*, 2023, October 2023, 27 (10), 87-98.
 23. Zhou D, Bassey RA, Yan M, and Aderemi TA. Do health expenditures affect under-five mortality and life expectancy in ECOWAS sub-Region. *African Journal of Reproductive Health*, 2023, 27(8), 105-113.
 24. Zheng Y, Gong Z, Ajayi E O, and Aderemi TA. Female labour participation and infant mortality in Nigeria: implication for the Sustainable Development Goal 3. *African Journal of Reproductive Health*, 2024, 28[3], 30-37.
 25. Jia H, Han X, Aderemi TA, Ifekwem NE, and Al-Faryan MA. Out-of pocket expenditure and human welfare in Nigeria: Evidence from a fully modified ordinary least squares regression. *African Journal of Reproductive Health*, 2025, 29(2), 151-157.
 26. Kulis SS, Marsiglia FF, Nuño-Gutiérrez BL. Reciprocal Effects of Alcohol Use and Violence Perpetration Among Early Adolescents in Mexico: A Gendered Analysis. *J Youth Adolescence* 2019;48, 1519–1531. <https://doi.org/10.1007/s10964-019-01014-1>