Psychiatry Research 333 (2024) 115729

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Analyzing 14-years of suicide rates in Chile: Impact of alcohol policy, domestic violence, and a suicide prevention program

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ARTICLE INFO

Keywords:
Suicide preventive policies
Latin America
Domestic violence
Global health

ABSTRACT

Suicide is a major public health problem worldwide with far-reaching effects on families, communities, and societies. Influencing factors range from macro-level interventions like alcohol control policies and suicide prevention programs to individual contributors such as alcohol abuse and domestic violence. This study aimed to examine the relationship between Chile's suicide rate changes from 2002 to 2015 and the Alcohol Act of 2004, a national suicide prevention program implemented in 2007, alcohol abuse, and domestic violence. Assembling a unique longitudinal dataset from Chilean public institutions, the study employed an instrumental variable time-series cross-regional design. Results indicated that the Alcohol Act was not associated with suicide rates, domestic violence exhibited a significant association with increased suicide rates, and the national suicide prevention program was linked to reductions in suicide rates, especially among males. These findings align with research from neighbouring countries, showcasing the efficacy of suicide prevention programs in decreasing suicide rates in Chile. Results highlight the importance of integrating protocols to early-detect domestic violence in suicide prevention programs, as well as the need to further improving alcohol control policies to complement suicide prevention programs.

1. Introduction

Suicide is a major public health problem worldwide with effects on families, communities, and society. Globally, there are 703,000 annual deaths by suicide (World Health Organization, 2021). The global age-standardized suicide rate in males (12.6 per 100,000) is more than double that in females (5.4 per 100,000) (World Health Organization, 2021). Suicide prevention is a priority for the WHO and is included as an indicator in the United Nations Sustainable Development Goals (World Health Organization, 2021).

Alcohol use is a substantive risk factor for both deaths by suicide and suicide attempts (Amiri and Behnezhad, 2020; Isaacs et al., 2022; Perez et al., 2022). Furthermore, acute high-dose alcohol use increases the risk of suicide (Borges et al., 2017; Conner and Bagge, 2019; Razvodovsky, 2009) and contributes to the adoption of more violent suicide means (Choi et al., 2018; Yeskendir et al., 2022). Studies have consistently found that alcohol abuse and intoxication are prevalent in suicidal behavior (Norström and Rossow, 2016). Hence, strategies to control alcohol abuse and intoxication could impact suicides attributable to alcohol use (Anderson et al., 2009; Babor et al., 2010; Ilhan and Yapar, 2020).

There is a worldwide interest in identifying alcohol policies that can significantly reduce the adverse effects of alcohol consumption on health outcomes (Chisholm et al., 2018; Son and Topyan, 2011). Alcohol policies can include measures such as control of physical availability, alcohol taxes, regulation on publicity, or drink-driving countermeasures (Xuan et al., 2016; Chisholm et al., 2018). Cultural differences regarding alcohol consumption or social dynamics, including gender roles and peers' and family behaviors (Hemström, 2002; Anderson et al., 2017), should also be considered for alcohol policies to be effective.

Numerous studies have examined the relationship between alcohol policy interventions and suicide, showing an overall protective effect on reducing suicide (Pridemore and Snowden, 2009; Sauliune et al., 2012; Xuan et al., 2016). Alcohol control policies can act on suicide prevention indirectly. More specifically, increases in alcohol taxes and decreases in its availability can, for instance, reduce alcohol's affordability,

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https://doi.org/10.1016/j.psychres.2024.115729
Received 12 June 2023; Received in revised form 6 January 2024; Accepted 10 January 2024
Available online 12 January 2024

consumption (Babor et al., 2010; Razyodovsky, 2019; Lange et al., 2021; Zupanc et a, 2012), and intoxication (Kaplan et al., 2014; Xuan et al., 2016). By reducing alcohol intoxication, these policies can decrease associated suicide risk factors such as pain perception, worsened mood, worsening social bonds, and interpersonal conflict (Velleman and Templeton, 2003; Copello et al., 2005; Chikritzhs and Livingston, 2021). Inversely, the privatization of alcohol sales, associated with increased alcohol abuse has been associated with temporary or permanent increases in suicide mortality rates (Zalcman and Mann, 2007). Alcohol policies can be a promising strategy for reducing this public health challenge (Stockwell et al., 2012; Lange et al., 2021).

While these studies have provided important conclusions regarding the association between alcohol policies and suicides, three critical challenges should be acknowledged. First, despite investigating alcohol policies and suicide, suicide prevention programs have not been explicitly considered in these studies. Cross-national studies in OECD countries indicate a strong association between suicide prevention programs and suicide reduction (Matsubayashi and Ueda, 2011). Second, most of these studies have been concentrated in countries whereby alcohol policies are relatively consolidated (North America and Europe) (Xuan et al., 2016). Third, suicide is a multidimensional phenomenon where multiple social and individual determinants interact. For instance, suicidal behavior has been associated with mental health disorders, impulsivity, hopelessness, substance abuse, childhood trauma (Klonsky et al., 2016; Franklin et al., 2017; Stone et al., 2019), economic inequality (Padmanthan et al., 2020), domestic violence (Fedina et al., 2021; MacIsaac et al., 2017), and gender differences (Freeman et al., 2017). Interestingly, women face specific issues associated with sociocultural norms and values that can contribute to suicide risks. Some of these issues include an excessive drinking culture, distressful events, and domestic violence (Grucza et al., 2012).

Therefore, research on the association between alcohol policies and suicide variation should move toward approaches focused on jurisdictions where alcohol policies are relatively emerging, while simultaneously considering other factors associated with suicide variation, including suicide prevention programs, economic crises, and domestic violence. Thus, our study aims at understanding how suicide rates may have varied over time in Chile, a jurisdiction wherein both alcohol policies and suicide programs are recently emerging and where domestic violence is prevalent.

2. Study context

Chile is a high-income Latin American country that presents a unique threefold conjugation of factors meriting the study of the social determinants of suicide. First, substantial variations in suicide mortality rates have been observed: 2010 marked a peak in the sustained rise of these rates (12.6 deaths per 100,000 inhabitants), ending the following decade with a downward trend (10.6 deaths per 100,000 inhabitants) (Ministerio de Salud de Chile, 2022). In 2004, the Alcohol Act (Law 19.925) was enacted to prohibit the sale of alcohol without a license, the sale of alcohol to minors, and alcohol intoxication in public places, and community programs to prevent the harmful use of alcohol were introduced (Ministerio del Interior, 2004; Peña et al., 2021). However, it suffered from several design flaws—weakening measures to control the availability of alcohol—and poor enforcement of the law (Peña et al., 2021). There have been no impact evaluations of the Alcohol Act and, its actions have not been linked to observed variations in suicide mortality rates in Chile.

Second, since 2002, Chile has significantly improved mental healthcare, promoting primary healthcare for mental disorders and psychosocial problems linked to suicide, such as depression (Araya et al., 2009; Minoletti et al., 2014). Moreover, by the mid-2000s, Chile's major healthcare reform guaranteed access and financial protection to depression, bipolar disorder, schizophrenia, and alcohol and other drug use disorders, all associated with suicide (Araya et al., 2009; Minoletti et al., 2014). However, these significant advances did not have a direct impact on suicide mortality rates (Echávarri et al., 2015). Therefore, a National Suicide Prevention Program was developed in 2007 and formalized in 2013 (Echávarri et al., 2015). This program incorporated four strategies: awareness raising and resource mobilization among different sectors (e.g., health, education, and labor, among others), detection of at-risk cases, coverage and quality of care, and epidemiological surveillance (Echávarri et al., 2015).

Lastly, domestic violence is part of Chile's contemporary characterization. Studies have found that domestic violence considerably impacts suicide-related behaviors and the associated mental health issues (e.g., depression). Domestic violence, particularly toward women, contributes to suicide ideation and attempts in females (Nuñez et al., 2022). The most salient mechanism in this association has been the increase in the prevalence of depression (Cancino et al., 2018).

3. Methods

3.1. Study design

Given the critical differences across and within regions in Chile over time, we applied an instrumental variable time-series cross-regional design to assess the indirect impact of the Alcohol Act (Law 19.925), and the overall impact of the suicide prevention program and domestic violence claims, from 2002 to 2015, on three outcomes: total number of suicides, total number of suicides in males, and total number of suicides in females, each of these per 100,000 population.

3.2. Data variables

We used public and official information from surveys conducted and reports written by the government of Chile. The National Statistics Institute was consulted to compile information on suicide, population, and economic variables. The Crime Prevention Undersecretariat statistics were accessed for the domestic violence claims' variable CEAD (2022). The National Service for the Prevention and Rehabilitation of Drug and Alcohol Abuse (SENDA) was consulted to obtain data on alcohol abuse. We used cubic spline interpolation methods to estimate missing values in the Ministry of Social Development (MIDESO) and SENDA data—whose surveys have a biennial or triennial recurrence. The data were consolidated into a time series for Chile's 13 superior administrative divisions (i.e., regions) from 2002 to 2015. The database included 182 observations due to the combination of years and regions.

3.3. Study variables

All the study variables were repeated measures at the population level observed at year i within region j.

Dependent variable

Counts of suicides in all population (Y_{ij}), counts of suicides for men (YM_{ij}) and women (YW_{ij}).

Time-varying covariates

Alcohol Act (Law 19.925) ($\beta_2 AA_{ij}$) (Indirect variable): dummy covariate for observations recorded the years before and after the Alcohol Act: 0 for the years 2002 to 2004, and 1 for the year 2005 and thereafter, when the act was set in place.

Alcohol Abuse ($\beta_3 AAb_{ij}$) (Direct variable): a variable that represents the proportion of people who have reported having abused alcohol consumption in the last year is extracted from the SENDA surveys on drugs in the general population. To be classified as having abused alcohol, individuals must have declared at least one positive response in the following five items: i) having problems at home, work, school, or university; 2) having problems with authority or the law; 3) having problems with family members or friends; 4) having risked their physical integrity; and 5) having a physical fight or assaulted someone. (The wordings of the questions for each item in English and Spanish are

presented in the supplementary material).

National Suicide Prevention Program ($\beta_4 NSPP_{ij}$) (Direct variable): a threefold variable representing two changes in this program: 0 for the years 2002–2006; 1 for the years 2007–2011, when the program was launched; and 2 for the years 2013–2015, when the program was improved.

Domestic Violence Claims ($\beta_5 DVC_{ij}$) (Direct variable): a variable representing the rates of domestic violence claims made by citizens before public authorities per 100,000 population, as extracted from the Crime Prevention Undersecretary statistics. In Chile, domestic violence is defined as any mistreatment that affects the life or physical or psychological integrity of someone who is or has been the spouse of the perpetrator or in a cohabitation relationship with them; or who is a relative by blood or by marriage in the direct line or within the collateral line up to the third degree of the perpetrator or their spouse or their current cohabitant.

Economic Crisis ($\beta_6 EC_{ij}$) (Control variable): a dichotomous variable representing the economic crisis experienced in Chile in 2009—which had an effect on increasing suicides (Baeza et al., 2022): 0 for the years 2002–2008 and 2010–2015, and 1 for the year 2009.

3.4. Statistical approaches

To assess the effects of alcohol abuse on suicide rates, we analyzed a longitudinal sample of Chile's 13 regions over 14 years using a cross-sectional time series approach. Failure to account for systematic variation in the factors that predict alcohol abuse can lead to biased estimates of their subsequent effects. We used random effect to assess the association between the Alcohol Act and alcohol abuse (Equation 2), whereafter we used two-stage least square (2SLS) regression with instrumental variable, following Equations 1 and 2.

$$Y_{it} = \beta_0 + \beta_1 Y_{i\text{-}1j} + \beta_3 AAb_{ij} + \beta_4 NSPP_{ij} + \beta_5 DVC_{ij} + \beta_6 EC_{ij} + \varepsilon \quad (1)$$

and

$$\beta_3 AABs_{ij} = \gamma_0 + \beta_2 AA_{ij} + \upsilon, \quad (2)$$

Alternatively, as depicted in Eq. (3), we used random effects models assuming alcohol abuse was not associated with the Alcohol Act considering the described direct and control variables on suicide rates.

$$Y_{it} = \beta_0 + \beta_1 Y_{i\text{-}1j} + \beta_3 AAb_{ij} + \beta_4 NSPP_{ij} + \beta_5 DVC_{ij} + \beta_6 EC_{ij} + \varepsilon \quad (3)$$

All analyses were done using Stata 18 (College Station, TX).

4. Results

Table 1 documents cross-regional variation in suicide rates and alcohol abuse in 2002 and 2015, the first- and end-year sample points. These numbers suggest significant cross-regional variation in suicide rates in the year 2002 but less variation for alcohol consumption rates. In 2002, Tarapacá, Atacama, O Higgins, Bío, La Araucanía, and Los Lagos had an average suicide rate of over 1.20 individuals per 100,000 population, Maule, Aysen, and Magallanes had an average of suicide rate of less than 1.20 and more than 1.00, and Antofagasta, Coquimbo, Valparaíso, and Metropolitana had rates lower than 1. Compared to 2015, suicide rates do not homogeneously decrease or increase across regions, further reinforcing the idea that a clear pattern over time across regions is absent. Subsequently, Alcohol abuse exhibits a consistent trend of convergence in all regions where the prevalence of alcohol abuse decreases. A magnitude of less than 5 % is only observed in Antofagasta, Coquimbo, and Maule.

5. Alcohol Act and alcohol abuse

Three models (Models 1–3) were assessed to estimate the association between the Alcohol Act and alcohol abuse over time (Table 2). First,

Table 1
Variation in suicide rates and alcohol abuse (2002–2015).

Regions	Suicide rates[1] 2002	2015	Difference between 2002 and 20,15[3]	Alcohol abuse[2] 2002	2015	Difference between 2002 and 20,15[3]
Tarapacá [4]	1.29	0.59	−0.70	0.14	0.05	−0.09
Antofagasta	0.88	0.67	−0.20	0.10	0.05	−0.05
Atacama	1.21	0.77	−0.45	0.13	0.07	−0.06
Coquimbo	0.82	0.91	0.09	0.09	0.07	−0.02
Valparaíso	0.99	1.04	0.05	0.15	0.07	−0.08
O'Higgins	1.21	1.16	−0.05	0.16	0.06	−0.10
Maule	1.06	1.19	0.13	0.11	0.07	−0.04
Bio Bío	1.29	0.97	−0.32	0.13	0.05	−0.08
La Araucanía	1.40	1.37	−0.02	0.13	0.07	−0.06
Los Lagos[d]	1.41	1.34	−0.07	0.17	0.06	−0.09
Aysen	1.17	1.48	0.31	0.12	0.05	−0.07
Magallanes	1.10	1.21	0.11	0.14	0.05	−0.09
Metropolitana	0.79	0.96	0.17	0.12	0.06	−0.06

[1] Number of suicides per 100,000 population [2] Proportion of individuals who self-identified as having abused alcohol consumption. [3]Negative values mean decreasing values from year 2002.[4] It includes Arica and Parinacota territories. [5]It includes Los Rios territory.

Model 1, relative to Model 2, has better Akaike's information criterion (AIC) and Bayesian information criterion (BIC), indicating a better performance. However, Model 2 has a larger R^2, suggesting that integrating regional random effects improves the error distribution of alcohol abuse. In Model 2, we observe a decrease of 6 % (95 % Confidence Interval [CI]: −7 % - 4 %) in alcohol abuse when the Alcohol Act is implemented. A lag of one year in the dependent variable was introduced in Model 3 to correct for autocorrelation. Compared to Models 1 and 2, Model 3 has better indicators to assess its overall performance. Its AIC and BIC are much lower, and the R^2 is 0.78. We observe a 2 % reduction (95 % CI: −3 % - 0 %, z= −4.19, p< 0.001) in alcohol abuse associated with the Alcohol Act. This association is suggestive of considering the Alcohol Act as an instrument when appraising the association between alcohol abuse and suicide changes.

6. Alcohol abuse and suicide rates under an instrumental approach

Notably, 2SLS models were assessed under the assumption that the Alcohol Act could be indirectly associated with suicide outcomes by influencing alcohol abuse changes. Model 4 includes the economic crisis, Model 5 adds domestic violence claims, and Model 6 considers the National Suicide Prevention Program (Table 3). Different tests are used to assess whether the validity of the Alcohol Act is warranted. First, in each model, we observe that the instruments are strong (F-test results > 10), thereby confirming the results obtained in Model 3. The test for endogeneity (X^2) fails to reject that instruments are exogenous in Models 1 and 2, thus indicating that suicide rates may not be assessed with the instruments introduced. However, in Model 3, this test signals that the instruments chosen may be associated with changes in the outcomes. Last, the test of overidentifying restrictions X^2 suggests that, in each model, the instruments are invalid, as these are not uncorrelated with the errors. Alcohol abuse under this instrumental approach in the three models is associated with non-significance at p<0.05 and volatile changes on suicide rates (23 %, 80 %, and 102% increases in Models 4, 5, and 6, respectively). This confirms the need of modeling these two variables with a different statistical method.

7. Suicide rates, the suicide prevention program, and domestic violence

In Tables 4–6, we observe results regarding each variable of interest, including economic crisis used as a control. First, in Table 4, this control

Table 2
Random and fixed effects models for the effect of the Alcohol Act on alcohol abuse.

	Random and Fixed effects models (Model 1) Coefficient	CI	95 %	(Model 2) Coefficient	CI	95 %	(Model 3) Coefficient	CI	95 %
Alcohol Act	**−0.06**	**−0.04**	**−0.07**	**−0.06**	**−0.04**	**−0.07**	**−0.02**	**−0.02**	**−0.01**
Lag of alcohol abuse							**0.81**	**0.75**	**0.88**
Constant	**0.13**	**0.12**	**0.14**	**0.14**	**0.12**	**0.16**	**0.02**	**0.01**	**0.04**
Region effects	No			Yes			Yes		
N (region-year observations)	182			182			169		
N (regions)	13			13			13		
R^2	0.29			0.34			0.84		
AIC	−707			−677			−861		
BIC	−704			−626			−808		

Note AIC: Akaike's information criterion; BIC: Bayesian information criterion.

Table 3
Two-stage least squares analyses with instrumental variables' for the indirect effect of the Alcohol Act on suicide rates (2002–2015).

	Two-Stage Least-Squares (Model 4) Coefficient	CI	95 %	(Model 5) Estimator	CI	95 %	(Model 6) Estimator	CI	95 %
Alcohol abuse	0.23	−0.50	0.97	0.80	−0.07	1.62	−1.02	−2.28	0.23
Economic crisis	**0.18**	**0.08**	**0.27**	**0.14**	**0.04**	**0.23**	**0.11**	**0.01**	**0.20**
Domestic violence claims				**0.001**	**0.000**	**0.001**	**0.001**	**0.000**	**0.001**
National Suicide Prevention Program							**−0.11**	**−0.17**	**−0.06**
Constant	0.85	0.73	0.97	0.29	−0.06	0.66	**0.68**	**0.28**	**1.09**
Year effects	Yes			Yes			Yes		
Region effects	Yes			Yes			Yes		
N (region-year observations)	169			169			169		
N (regions)	13			13			13		
R^2	0.53			0.56			0.59		
F test for instruments weakness	267.60 p <0.001			205.30 p <0.001			16.12 p <0.001		
Test of endogeneity X^2	1.85 p = 0.175			1.21 p = 0.271			3.93 p = 0.050		
Test of overidentifying restrictions X^2	39.31 p <0.001			30.03 p <0.001			56.26 p <0.001		

Table 4
Random effects models for the effect of alcohol abuse, economic crisis, domestic violence claims, and the National Suicide Prevention Program on suicide rates (2002–2015).

	Random effects models (Model 7) Coefficient	CI	95 %	(Model 8) Estimator	CI	95 %	(Model 9) Estimator	CI	95 %
Alcohol abuse	0.22	−0.64	1.08	0.82	−0.29	1.94	−0.49	−1.62	0.67
Economic crisis	**0.18**	**0.08**	**0.28**	**0.14**	**0.03**	**0.24**	**0.11**	**0.01**	**0.22**
Domestic violence claims				**0.001**	**0.000**	**0.001**	**0.001**	**0.000**	**0.001**
National Suicide Prevention Program							**−0.09**	**−0.15**	**−0.03**
Constant	**0.88**	**0.80**	**0.96**	0.37	−0.00	0.75	**0.69**	**0.26**	**0.95**
Region effects	Yes				Yes			Yes	
N (region-year observations)	182			182			182		
N (regions)	13			13			13		
R^2	0.56			0.55			0.57		
AIC	−73.06			−82.58			−89.19		
BIC	−63.45			−69.76			−73.71		

Note AIC: Akaike's information criterion; BIC: Bayesian information criterion.

variable is consistently associated with increases in suicide rates. More specifically, in Model 9, we note that economic crisis is associated with an 11 % (p<0.05) increase in suicide rates. The association of such crisis is slightly different for women than for men. While in women, suicide rate changes are associated with a 10 % (p<0.05) increase (Model 11), in men, a non-concomitant increase of 14 % (p = 0.13) (Model 15) is observed. Second, domestic violence is associated with a 0.1 % increase over time in suicide rates (Model 9). While the magnitude of this result is relatively similar across men and women outcomes, the association is only significant in men with an increase of 0.1 % (p<0.01) (Model 15). Third, the overall effect of the National Suicide Prevention Program is associated with an overall reduction of 9 % (Model 9). This program however has different magnitudes when analyses of women and men are done separately. While its association with women's outcomes entails a significant decrease of 2 % (p = 0.04), in men, a 15 % (p<0.01) reduction is observed. Lastly, whereas alcohol abuse is not associated with concomitant suicide rate changes in women, in men, a unique situation is observed in Model 14. Alcohol abuse is associated with a 1.89 % (95 % CI: 0.56 – 3.22, z = 2.79, p< 0.01) increase of suicide rates. Analyses performed to understand this pattern considered an interaction effect between the crisis and alcohol abuse (Table S1). Results suggest that in the year marked by economic crisis, relative to years without such an event, alcohol abuse, is associated with a 13-fold increase (p<0.05) (Model S1.3) in suicide rates among men.

8. Discussion

Our results suggest that while the Alcohol Act may have reduced

Table 5
Random effects models for the effect alcohol abuse, economic crisis, domestic violence claims, and the National Suicide Prevention Program on women's suicide rates (2002–2015).

	Random effects models (Model 10)			(Model 11)			(Model 12)		
	Coefficient	CI	95 %	Estimator	CI	95 %	Estimator	CI	95 %
Alcohol abuse	−0.59	−1.05	0.10	0.06	−0.29	0.42	−0.68	−1.55	0.18
Economic crisis	**0.13**	**0.04**	**0.21**	**0.10**	**0.02**	**0.24**	0.09	−0.03	0.22
Domestic violence claims				**0.001**	**0.000**	**0.001**	0.001	−0.00	0.001
National Suicide Prevention Program							**0.02**	**−0.04**	**−0.01**
Constant	0.38	0.23	0.53	−0.01	−0.33	0.32	**0.52**	**0.06**	**0.99**
Region effects	Yes			Yes				Yes	
N (region-year observations)	182			182			182		
N (regions)	13			13			13		
R^2	0.17			0.20			0.20		
AIC	−186.46			−159.42			−187.70		
BIC	−176.85			−101.75			−171.70		

Note AIC: Akaike's information criterion; BIC: Bayesian information criterion.

Table 6
Random effect models for the effect alcohol abuse, economic crisis, domestic violence claims, and the National Suicide Prevention Program on men's suicide rates (2002–2015).

	Random effects models (Model 13)			(Model 14)			(Model 15)		
	Coefficient	CI	95 %	Estimator	CI	95 %	Estimator	CI	95 %
Alcohol abuse	0.97	−0.19	2.13	**1.89**	**0.56**	**3.22**	−0.31	−2.22	1.60
Economic crisis	**0.24**	**0.06**	**0.43**	0.18	−0.01	0.38	0.14	−0.04	0.33
Domestic violence claims				**0.001**	**0.000**	**0.001**	**0.001**	**0.000**	**0.001**
National Suicide Prevention Program							**−0.14**	**−0.24**	**−0.05**
Constant	**1.39**	**1.18**	**1.60**	**0.60**	**0.05**	**1.16**	**1.04**	**0.22**	**1.86**
Region effects	Yes			Yes				Yes	
N (region-year observations)	182			182			182		
N (regions)	13			13			13		
R^2	0.57			0.59			0.61		
AIC	141.94			134.31			127.70		
BIC	196.42			191.99			188.58		

Note AIC: Akaike's information criterion; BIC: Bayesian information criterion.

alcohol abuse, its indirect effect on suicide rates over time is likely unobserved. Furthermore, alcohol abuse was not consistently associated with an increase in suicide rate. Relatedly, we observed that this crisis, as indicated in other studies in Chile (Baeza et al. 2022), was associated with an overall increase in suicide rates. Interestingly, increase in suicide rates among men may have been associated with increase in alcohol abuse only during Chile's economic crisis. In terms of domestic violence claims, we also observed a significant association with suicide rates. However, relative to the other assessed variables, its magnitude was much lower. Last, Chile's Suicide Prevention Program was associated with significant reductions in the suicide rates of men and women. This is in line with what has been suggested by other authors analyzing this topic in other upper-middle- and high-income countries, where the magnitude of the reduction has been between 5 and 9 % (Matsubayashi and Ueda, 2011).

At least three elements should be mentioned regarding the absence of a potential indirect effect of the Alcohol Act on suicide rates in Chile. First, certain policies targeting alcohol availability may require more specific measures to target alcohol abuse behavior, which in turn should affect suicidal behavior. A significant decrease of alcohol abuse was observed with the enactment of the Alcohol Act; however, its magnitude was approximately 2 %. A much larger number of individuals struggling with alcohol abuse should have been reached by the Alcohol Act to observe changes in suicide rates. Second, the impact of the Alcohol Act may have been observed in the long term, and while we also modeled the Alcohol Act with a lag of one year and its effect captured a 3 % reduction (Table S2) on alcohol abuse, its indirect effect on the suicide rates remained null (Table S3). Last, as observed by Peña et al. (2021), the Alcohol Act did not adequately consider measures to consistently control the availability of alcohol at its inception, rendering it inadequate in properly addressing alcohol abuse. As such, any potential indirect effect on suicides would have been observed if a more consistent enforcement plan had been set in place.

One important finding of this study revealed that at the population level, alcohol abuse might not be directly associated with suicide rate changes over time. Indeed, while alcohol consumption and abuse (Isaacs et al., 2022) can impair judgment and increase impulsivity, leading to an elevated risk of self-harm (Conner and Bagge, 2019), it is important to reinforce the notion that not all individuals who abuse alcohol exhibit suicidal tendencies. Our null finding could also be explained by eventual discrepancies on how alcohol abuse was reported across Chile's regions. Even though we used data from a national representative survey, this survey modified its weights in 2008, making it difficult to obtain accurate estimates at the regional level.

Consistent with Baeza et al.'s (2022) study, we observed a significant increase in suicide rates during the economic crisis. While our study found an increase of 11 %, Baeza et al. (2022) reported a rise of 18 %. One element that might explain this difference between these two results could be the consideration of regional effects which were part of our statistical approach strategy, and these were not estimated in the other study. However, the other study analyzed data on a monthly basis, whereas our study was conducted on a yearly basis. In the case of Chile, studies (Baeza et al., 2022) have suggested that the economic crisis negatively impacted populations whose labor market trajectories were more precarious and intermittent, which subsequently affected the mental health of such populations when becoming unemployed or experiencing financial difficulties.

Although our study did not find direct associations between alcohol abuse and the studied outcome, the interaction between the economic crisis and alcohol abuse among men warrants further discussion to

understand the observed increase in suicide rates in this population. Men, especially during times of economic uncertainty, might be more inclined to turn to alcohol. This phenomenon is described in the literature as the "deterioration in the social situation" mechanism (De Goeij et al., 2015). Scholars suggest that unemployment and reduced income can lead men to experience more negative health effects, such as increased binge drinking, as they struggle to fulfill their traditional role as family protectors and providers. Similar patterns have been observed in various countries, including Albania, Australia, Russia, and the United States (De Goeij et al., 2015). In the case of Chile, alcohol abuse can be considered as one of the mechanisms that explains suicide increases during its economic crisis, as this population may have turned to this substance to cope with unemployment or considerable income reductions.

Although domestic violence claims have a lower magnitude compared to other variables in this study, its association highlights significant aspects investigated in the suicide literature (Devris et al., 2011). For individuals who are susceptible to factors such as a family history of suicide attempts or high impulsiveness, domestic violence can potentially act as one of the precipitating factors for suicide attempts. Exposure to domestic violence increases feelings of depression and thus affects the capability to cope with life stressors, which can be related to suicidal outcomes. Domestic violence is also associated with restricted autonomy and loss of control, engendering poor mental health statuses in individuals. Surprisingly, our results do not indicate considerable differences between men and women's suicide rates; as such, some mechanisms, as explained above, may apply to both. Nevertheless, an important limitation of our study was the inability to identify who made the domestic violence claim nor who was the perpetrator. In Chile, men are generally the perpetrators of domestic violence (CEAD, 2020). Nevertheless, studies have suggested that when men are perpetrators of domestic violence, both suicide attempts and suicides can also be expected outcomes (Baber et al., 2008). Certain mechanisms, such as loss of power and control over their own lives when their abusive behaviors are exposed, can lead to feelings of helplessness and desperation, preceding to suicidal attempts and suicides. Our study suggests that to understand differences between the suicide rates among men and women in Chile's, future studies should consider distinctions between perpetrators and victims of domestic violence, as well more precise methods to assess and operationalize domestic violence.

A noteworthy discovery from this study revealed that Chile's Suicide Prevention Program had a greater impact on reducing suicide rates among men compared to women. There is one possible explanation for this gender-specific difference: Chile's Suicide Prevention Program explicitly incorporated a gendered approach to distinguish between potential interventions for men and women. This observation is somewhat speculative, and it is crucial to await more refined analysis in the future to gain a comprehensive understanding of why Chile's program appears to be most effective in reducing male suicide rate. Continued research and in-depth examination will help shed light on the underlying factors contributing to this gender-specific discrepancy and provide more concrete insights into the effectiveness of the situation in Chile.

Our study has some limitations. One initial constraint of the study is its ecological design, which limits our ability to establish causal relationships at the individual level. However, while it remains uncertain which specific individuals have died by suicide, as a result of the economic crisis and/or domestic violence, the findings do point that Chile's Suicide Prevention Program may have had a positive impact on the psychological well-being of Chile's adult population. Second, as expressed above, both alcohol abuse and domestic violence claims had considerable limitations. The former did not consider more grained scales as those proposed by the Alcohol Use Disorders Identification Test (AUDIT), whereas the latter did not distinguish between victims and perpetrators.

9. Conclusion

The reduction in suicide mortality following the implementation of Chile's Suicide Prevention Program leads us to the conclusion that, despite using a crude operationalization, this policy incorporates changes that help anticipate triggers of suicidal behavior in targeted populations. Future research as well improvements in Chile's Suicide Prevention Program should aim to better understand the mechanisms linking alcohol abuse, domestic violence, and suicide. From a research perspective, better relevant variables, including policy implementation and design, and other measurements of alcohol abuse and domestic violence should be explored further. From a suicide prevention policy perspective, it is advisable to consider a more explicit integration of at-risk groups, such as victims of domestic violence and/or individuals with alcohol related risks, into the early warning systems of Chile's Suicide Prevention Program.

Data sharing statement

All data collected for the study, included a data dictionary, are available from the corresponding author upon reasonable request.

Funding

This research was supported by the Fonds de recherche du Québec [José Ignacio Nazif-Munoz Junior 2 Grant 330642], Charles Le Moyne scholarship of Karen Domínguez and Pablo Martínez.

Author agreement statement

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We understand that the Corresponding Author is the sole contact for the Editorial process. He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

CRediT authorship contribution statement

José Ignacio Nazif-Munoz: Writing – review & editing, Writing – original draft, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Camila Corrêa Matias Pereira:** Writing – original draft, Investigation, Data curation. **Pablo Alberto Martinez:** Writing – review & editing, Software, Data curation. **Vahid Najafi Moghaddam:** Writing – review & editing, Formal analysis, Data curation. **Karen Domínguez-Cancino:** Writing – review & editing, Investigation, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2024.115729.

References

Amiri, S., Behnezhad, S., 2020. Alcohol use and risk of suicide: a systematic review and Meta-analysis. J. Add. Diseases 38 (2), 200–213. https://doi.org/10.1080/10550887.2020.1736757.

Anderson, P., Chisholm, D., Fuhr, D., 2009. Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol. Lancet 373, 2234–2246.

Anderson, P., O'Donnell, A., Kaner, E., Gual, A., Schulte, B., Gómez, A.P., de Vries, H., Rey, G.N., Rehm, J., 2017. Scaling-up primary health care-based prevention and management of alcohol use disorder at the municipal level in middle-income countries in Latin America: background and pre-protocol for a three-country quasi-experimental study. *F1000* Research 6.

Araya, R., Alvarado, R., Minoletti, A., 2009. Chile: an ongoing mental health revolution. Lancet 374 (9690), 597–598. ISSUE.

Babor, T., Caetano, R., Casswell, S., Edwards, G., Giesbrecht, N., Graham, K., Grube, J., Hill, L., Holder, H., Homel, R., Livingston, M., Osterberg, E., Rehm, J., Room, R., Rossow, I., 2010. Alcohol: No Ordinary Commodity—Research and Public Policy, Revised. Oxford University Press, Oxford, UK.

Baeza, F., González, F., Benmarhnia, T., Vergara, A.V., 2022. Effects of the Great Recession on suicide mortality in Chile and contributing factors. SSM-Ment. Health 2, 100104.

Barber, C.W., Azrael, D., Hemenway, D., Olson, L.M., Nie, C., Schaechter, J., Walsh, S., 2008. Suicides and suicide attempts following homicide: victim–suspect relationship, weapon type, and presence of antidepressants. Homi. Stud. 12 (3), 285–297.

Borges, G., Bagge, C., Cherpitel, C., Conner, K., Orozco, R., Rossow, I., 2017. A meta-analysis of acute use of alcohol and the risk of suicide attempt. Psyc. Medicine 47 (5), 949–957. https://doi.org/10.1017/S0033291716002841.

Cancino, A., Leiva-Bianchi, M., Serrano, C., Ballesteros-Teuber, S., Cáceres, C., Vitriol, V., 2018. Factors associated with psychiatric comorbidity in depression patients in primary health care in Chile. Dep. Res. Treat. 9 https://doi.org/10.1155/2018/1701978. Article ID 1701978pages.

CEAD (Centro de Estudios y Análisis del Delito. Estadísticas, 2022. Available at. http://cead.spd.gov.cl/estadisticas-delictuales/ (accessed June 3, 2023).

Conner, K.R., Bagge, C.L., 2019. Suicidal behavior: links between alcohol use disorder and acute use of alcohol. Alcohol Res. 40 (1) https://doi.org/10.35946/arcr.v40.1.02.

Copello, A., Velleman, R., Templeton, L., 2005. Family interventions in the treatment of alcohol and drug problems. Drug Alcohol Rev. 24, 369–385.

Chikritzhs, T., Livingston, M., 2021. Alcohol and the risk of injury. Nutrients 13 (8), 2777. https://doi.org/10.3390/nu13082777.

Chisholm, D., Moro, D., Bertram, M., Pretorius, C., Gmel, G., Shield, K., Rehm, J., 2018. Are the "best buys" for alcohol control still valid? An update on the comparative cost-effectiveness of alcohol control strategies at the global level. J. Stud. Alcohol Drugs 79, 514–522.

Choi, N.G., DiNitto, D.M., Sagna, A.O., Marti, C.N., 2018. Postmortem blood alcohol content among late-middle aged and older suicide decedents: associations with suicide precipitating/risk factors, means, and other drug toxicology. Drug. Alc. Dep. 187, 311–318.

De Goeij, M.C., Suhrcke, M., Toffolutti, V., van de Mheen, D., Schoenmakers, T.M., Kunst, A.E., 2015. How economic crises affect alcohol consumption and alcohol-related health problems: a realist systematic review. Soc. Sci. Med. 131, 131–146.

Devries, K., Watts, C., Yoshihama, M., Kiss, L., Schraiber, L.B., Deyessa, N., Heise, L., Durand, J., Mbwambo, J., Jansen, H., Berhane, Y., 2011. Violence against women is strongly associated with suicide attempts: evidence from the WHO multi-country study on women's health and domestic violence against women. Soc. Sci. Med. 73 (1), 79–86.

Fedina, L., Mushonga, D.R., Bessaha, M.L., Jun, H.J., Narita, Z., DeVylder, J., 2021. Moderating effects of perceived neighborhood factors on intimate partner violence, psychological distress, and suicide risk. J. Interpersonal Vio 36 (21–22), 10546–10563.

Echavárri Vesperinas, M., Maino, M., Fischman, R., Morales Silva, S., Barros Beck, J.A., 2015. Aumento sostenido del suicidio en Chile: un tema pendiente. Centro de Polít. Públ. UC 10 (79), 15. Available at. https://politicaspublicas.uc.cl/wp-content/uploads/2015/07/N%C2%B0-79-Aumento-sostenido-del-suicidio-en-Chile.pdf. Accessed January 5 2024,.

Franklin, J., Ribeiro, J., Fox, K., Bentley, K., Kleiman, E., Huang, Nock, M., 2017. Risk factors for suicidal thoughts and behaviors: a meta-analysis of 50 years of research. Psyc. Bull. 143 (2), 187–232. https://doi.org/10.1037/bul0000084.

Freeman, A., Mergl, R., Kohls, E., Székely, A., Gusmao, R., Arensman, E., Koburger, N., Hegerl, U., Rummel-Kluge, C., 2017. A cross-national study on gender differences in suicide intent. BMC Psychiatry 17 (1), 1–11.

Grucza, R., Hipp, P., Norberg, K., Rundell, L., Evanoff, A., Cavazos-Rehg, P., Bierut, L., 2012. The legacy of minimum legal drinking age law changes: long-term effects on suicide and homicide deaths among women. Alc: Clin. Exp. Res. 36 (2), 377–384.

Ilhan, M., Yapar, D., 2020. Alcohol consumption and alcohol policy. Turk. J. Med. Sci. 50 (5), 1197–1202. https://doi.org/10.3906/sag-2002-237. Aug 26.

Isaacs, J., Smith, M., Sherry, S., Seno, M., Moore, M., Stewart, S., 2022. Alcohol use and death by suicide: a meta-analysis of 33 studies. Suic. Life-Threaten. Beh 52 (4), 600–614. https://doi.org/10.1111/sltb.12846.

Kaplan, M., Huguet, N., McFarland, B., Caetano, R., Conner, K.R., Giesbrecht, N., Nolte, K., 2014. Use of alcohol before suicide in the United States. Ann. Epi 24 (8), 588–592. https://doi.org/10.1016/j.annepidem.2014.05.008 e5922.

Klonsky, E., May, A., Saffer, B., 2016. Suicide, suicide attempts, and suicidal ideation. Ann. Rev. Clin. Psychol. 12, 307–330. https://doi.org/10.1146/annurev-clinpsy-021815-093204.

Lange, S., Jiang, H., Štelemėkas, M., Tran, A., Cherpitel, C., Giesbrecht, N., Gostautaite Midttun, N., Jasilionis, D., Kaplan, M.S., Manthey, J., Xuan, Z., Rehm, J., 2021. Evaluating the impact of alcohol policy on suicide mortality: a sex-specific time-series analysis for Lithuania. Arch. Suicide Res. 1–14. https://doi.org/10.1080/13811118.2021.1999873. Nov 13.

MacIsaac, M., Bugeja, L., Jelinek, G., 2017. The association between exposure to interpersonal violence and suicide among women: a systematic review. Aust. New Zea. J. Public Health 41 (1), 61–69.

Matsubayashi, T., Ueda, M., 2011. The effect of national suicide prevention programs on suicide rates in 21 OECD nations. Soc. Sci. Med. 73 (9), 1395–1400.

Ministerio de Salud de Chile., 2022. *Informe de Mortalidad Por Suicidio En Chile: 2010-2019*. Ministerio de Salud de Chile. Available at http://epi.minsal.cl/wp-content/uploads/2022/06/2022.06.10_Informe.de.la.decada.pdf (Accessed January 5 2024).

Ministerio Del Interior. Ley 19925. Ley sobre Expendio y Consumo de Bebidas Alcohólicas [Minister of Interior. Law 19925. Law about the provision and consumption of alcoholic beverages]; 2004. Available at: https://www.leychile.cl/Navegar?idNorma=220208 (Accessed January 4, 2024).

Minoletti, A., Sepúlveda, R., Horvitz-Lennon, M., 2014. Twenty years of mental health policies in Chile. Int. J. Ment. Health 41 (1), 21–37.

Norström, T., Rossow, I., 2016. Alcohol consumption as a risk factor for suicidal behavior: a systematic review of associations at the individual and at the population level. Arc. Sui. Res. 20 (4), 489–506. https://doi.org/10.1080/13811118.2016.1158678.

Núñez, D., Gaete, J., Guajardo, V., Libuy, N., Araneda, A.M., Contreras, L., Donoso, P., Ibañez, C., Mundt, A.P., 2022. Brief report: the association of adverse childhood experiences and suicide-related behaviors among 10th-grade secondary school students. Arc. Suicide Res. 1–12.

Hemström, Ö., 2002. Informal alcohol control in six EU countries. Contemp. Drug Probl. 29, 577–604.

Padmanathan, P., Bould, H., Winstone, L., Moran, P., Gunnell, D., 2020. Social media use, economic recession and income inequality in relation to trends in youth suicide in high-income countries: a time trends analysis. J. Aff. Disord. 275, 58–65.

Peña, S., Sierralta, P., Norambuena, P., Leyton, F., Pemjean, A., Roman, F., 2021. Alcohol policy in Chile: a systematic review of policy developments and evaluations. Addiction 116 (3), 438–456.

Perez, J., Beale, E., Overholser, J., Athey, A., Stockmeier, C., 2022. Depression and alcohol use disorders as precursors to death by suicide. Death Stud. 46 (3), 619–627. https://doi.org/10.1080/07481187.2020.1745954.

Pridemore, W., Snowden, A.J., 2009. Reduction in suicide mortality following a new national alcohol policy in Slovenia: an interrupted time-series analysis. Am. J. Public Health 99 (5), 915–920. https://doi.org/10.2105/AJPH.2008.146183.

Razvodovsky, Y., 2009. Alcohol and suicide in Belarus. Psych. Danub. 21 (3), 290–296. https://doi.org/10.1016/S0924- 9338(09)70422-5.

Sauliune, S., Petrauskiene, J., Kalediene, R., 2012. Alcohol-related injuries and alcohol control policy in Lithuania: effect of the year of sobriety, 2008 Alc. Alcoholism 47 (4), 458–463. https://doi.org/10.1093/alcalc/ags033.

Son, C.H., Topyan, K., 2011. The effect of alcoholic beverage excise tax on alcohol-attributable injury mortalities. Eur. J. Health Econ. 12, 103–113.

Stockwell, T., Zhao, J., Giesbrecht, N., Macdonald, S., Thomas, G., Wettlaufer, A., 2012. The raising of minimum alcohol prices in Saskatchewan, Canada: impacts on consumption and implications for public health. Am. J. Public Health 102, e103–e110.

Stone, D.M., Holland, K.M., Bartholow, B., Crosby, A.E., Davis, S., Wilkins, N., 2019. Preventing suicide: a technical package of policies, programs, and practices. National Center for Injury Prevention and Control. Centers Dis. Control Prevent. Available at https://www.cdc.gov/violenceprevention/pdf/suicideTechnicalPackage.pdf Accessed January 5, 2024.

Velleman, R., Templeton, L., 2003. Alcohol, drugs and the family: results from a long-running research programme within the UK. Eur. *Addict. Res.* 9, 103–112.

World Health Organization, 2021. Suicide worldwide in 2019: global health estimates. World Health Organization, ISBN 978-92-4-002664-3 (electronic version). Available at: https://iris.who.int/bitstream/handle/10665/341728/9789240026643-eng.pdf (Accessed January 5, 2024).

Xuan, Z., Naimi, T.S., Kaplan, M.S., Bagge, C.L., Few, L.R., Maisto, S., Saitz, R., Freeman, R., 2016. Alcohol policies and suicide: a review of the literature. Alcohol.: Clin. Exp. Res. 40 (10), 2043–2055.

Yeskendir, A., Eisenberg, D., Kaplan, M.S., 2022. Acute use of alcohol before suicide in Kazakhstan: a population-wide study. J Affect. Disord. 321, 134–139. https://doi.org/10.1016/j.jad.2022.10.017. Jan 15.

Zalcman, R.F., Mann, R.E., 2007. The effects of privatization of alcohol sales in Alberta on suicide mortality rates. Cont. Drug Problems 34 (4), 589–609.

Zupanc, T., Agius, M., Videtič Paska, A., Pregelj, P., 2012. Reduced blood alcohol concentration in suicide victims in response to a new national alcohol policy in Slovenia. Eur. Add. Res. 19 (1), 7–12.