Major societal crises and suicide

Gonzalo Martínez-Alés

Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2022

Abstract

Major societal crises and suicide

Gonzalo Martínez-Alés

Suicide is the leading cause of violent death and a major public health and clinical concern. Globally, suicide mortality has decreased over the last three decades, largely due to dramatic declines in pesticide poisonings in Asia. Recent suicide mortality trends, however, have been heterogeneous, and there have been increases in suicide in several countries and regions (e.g., the United States, Jamaica, Cameroon). Monitoring suicide rates is important for surveillance reasons as well as to generate causal hypotheses, two key components of suicide prevention efforts.

Suicide increases following major societal crises, such as economic recessions, are often characterized by heterogeneity across population subgroups – with larger increases among vulnerable groups. Examining subgroups, even if evidence of an increase in suicide overall is absent, can guide identification of at-risk groups and development and implementation of targeted prevention strategies. In Spain, a country with one of the lowest suicide rates across Europe, there has been scientific debate regarding whether suicide increased following the 2008 economic recession. Most recent research suggests that suicide remained largely unchanged, but data are scarce on vulnerable groups among whom the downstream economic effects of the recession might have been more intense than in the general population.

Following the initial COVID-19 pandemic outbreak, there was generalized concern that suicide rates would go up due to increases in bereavement and loss of loved ones, fear of contagion and death, increases in prevalence of mental health conditions, and negative economic effects of the pandemic and contagion control measures. Initial examinations of suicide trends,

however, indicated that suicide mortality either remained unchanged or decreased in most locations across the globe during the initial months following the pandemic onset. Subsequent evidence of delayed increases in suicide in specific places (e.g., Japan), however, pointed out the importance of continued monitoring of suicide rates. In addition, there is increasing evidence that suicide rates during the COVID-19 era have changed heterogeneously across sociodemographic groups with higher vulnerability to specific pandemic-related stressors (e.g., higher suicide risk among minoritized people in the United States or women in Japan). There are no systematic reviews examining suicide during the COVID-19 era beyond the initial 6 months of the pandemic, and there has been no systematic assessment of the variation in suicide changes after the onset of the pandemic across place, over time, and across population subgroups. In Spain, there has also been substantial debate regarding the impact of the pandemic on suicide rates: two studies using a suboptimal methodological approach found somewhat contradictory results. No studies have examined suicide among population subgroups during the pandemic in Spain.

The aim of this dissertation is to examine variations in suicide across population groups as defined by sociodemographic characteristics during major societal crises (i.e., the 2008 recession and the COVID-19 pandemic) in Spain, and variations across place, over time, and across sociodemographic groups globally.

The first chapter uses two different approaches to age-period-cohort modelling to examine suicide between 2000 and 2019 in Spain, stratifying analyses by foreign-born status – the most salient marker of disadvantage in Spain, and further analyzing suicide among foreign-born individuals without Spanish citizenship – a proxy for lack of residency permit. I found that, while suicide following the recession remained stable among native-born men, it increased slightly among native-born women – largely due to cohort effects affecting middle-aged women, and markedly among foreign-born individuals – largely due to period effects. Suicide increased especially among foreign-born individuals without Spanish citizenship. Notably, access to specialized healthcare and welfare was interrupted for migrants without residency permit shortly following onset of the recession, in the context of austerity politics undertaken across Europe. These results highlight the moderating role of socioeconomic vulnerability on suicide risk during major economic crises.

The second chapter is a systematic integrative review of the variation of population-based suicide estimates following the initial pandemic outbreak globally. In this review, I examine methodological features of all published studies examining suicide during the COVID-19 pandemic, highlighting the importance of addressing autocorrelation, non-stationarity, and seasonality in studies using an interrupted time-series analysis (ITSA) approach to test a causal question (i.e., to compare observed vs. expected or counterfactual suicide counts or rates). I also provide rationale to expect substantial heterogeneity in a so-called effect of the pandemic on suicide, given multiple versions of the exposure of interest that make it impossible to estimate a sole causal effect. I critically summarize the results overall with a focus on variation across place, over time, and across population subgroups. My findings indicate substantial geographical heterogeneity; a variable initial period of decreased suicide followed, in several locations, by delayed suicide increases – underscoring the importance of sustained monitoring of rates; and heterogeneity across population subgroups with larger suicide increases among groups at higher risk of suicide contagion and mortality (e.g., older adults, racially minoritized residents) and groups vulnerable to negative economic effects of the pandemic (e.g., groups overrepresented in hospitality and tourism jobs).

The third chapter uses Seasonal Autoregressive Integrated Moving Average (SARIMA) prediction models, an approach to ITSA that can adequately deal with autoregression, non-stationarity, and seasonality, to predict monthly suicide counts between April and December 2020 in Spain had the pandemic not taken place. I do so overall and by sex- and age-group, and by foreign-born status in a set of sensitivity analyses, and I then compare observed vs. predicted suicides to determine if suicide increased. I find generalized higher-than-expected suicide rates during spring and summer of 2020, overall and across subgroups – especially among older males during the summer months. I discuss potential explanations and implications for decision-making of these findings considering the theoretical framework developed in chapters 1 and 2.

Table of Contents

List of Charts, Graphs, Illustrations

Tables

Chapter 2

Appendix A

Figures

Chapter 1

Chapter 2

Chapter 3

Appendix A

Acknowledgments

During the initial phases of my doctoral training, I was supported by a 'La Caixa' Foundation International Scholarship (grant number LCF/BQ/AA17/11610021). Later, I supported myself with positions as Graduate Research Assistant at Columbia University and as Postdoctoral Research Fellow at Harvard University.

I would also like to thank Liliane Zaretsky; my dissertation committee – including my mentors Ezra Susser (sponsor) and Katherine Keyes (chair), as well as Christopher Morrison (first reader), Miguel Hernan, and Barbara Stanley (external readers); my collaborators from Madrid, New York, and Boston – Teresa Lopez, Catherine Gimbrone, Caroline Rutherford, and Alejandro Szmulewicz; and my family and friends.

Dedication

To suicide loss survivors.

Introduction

Suicide is a major public health concern that takes around 800,000 lives globally every year, accounting for 57% of all violent deaths and roughly 1.5% of all mortality.[1] Moreover, grief and stigma following death by suicide are far-reaching and long-lasting, and reverberate in survivor families, communities, and society at large over generations – driving great emotional and economic impact. Preventing suicide is an urgent public health and clinical need.

Following Geoffrey Rose's taxonomy of preventative strategies,[2] suicide prevention efforts can be divided into (i) *high-risk* strategies – that seek to provide prevention efforts to individuals at risk for suicide, with virtually no effect for the low-risk majority (e.g., dialectical behavior therapy programs for mental health services patients enduring suicidal ideation);[3] and (ii) *population* strategies – intended to shift the risk of all people within a population, regardless of their individual risk, modifying the population distribution of causes for suicide, and with limited utility for the high-risk minority (e.g., legislative actions regulating access to pesticides in low and middle income countries).[4]

Examination of suicide rates is an important component of population-level suicide prevention for two reasons. First, monitoring suicide is critical for surveillance efforts (e.g., to guide resource allocation, to support public health planning). Second, examining variations in suicide over time and across place, as well as across population subgroups as defined by sociodemographic markers of potential vulnerability, can help generate new causal hypotheses or test existing ones – with implications for the development of public health interventions.

Social ecological designs to examine differences in suicide rates across contexts (i.e., across place, over time, across sociodemographic groups) are an important tool in the search for actionable population-level causes of suicide. The logic of ecological designs for population research is as follows:[5] Populations (i.e., groups of individuals) can have emerging sociological properties[5,6] and shared characteristics (sometimes referred to as integral variables)[7] of potential interest for population strategies. In fact, Rose intuitively linked integral variables to potential population-level prevention strategies because integral variables affect the whole group and hence may bear large population-attributable risks.[8] By definition, group-level emerging properties and shared characteristics cannot be examined by comparing individuals pertaining to the group – rather, designs must consider the whole group as a legitimate unit of analysis, examine suicide rates across contexts (i.e., across place, over time, across sociodemographic groups), and assess the contextual social, political, and economic characteristics to obtain clues to actionable population-level causes of suicide. It is important to mention that social ecological research has been a sociological cornerstone of psychiatric epidemiology in general and suicide research in particular for over 150 years: Emile Durkheim´s influential book *Le Suicide* pioneered a social ecologic design where "the social rate [was] taken directly as the object of analysis:" temporal and geographical variations in suicide were assessed to identify potential population-level causes of suicide.[9]

Over the last three decades, suicide mortality has declined by 33% globally – largely due to public health campaigns and demographic changes leading to marked decreases in pesticide poisonings in China and India.[4,10] Notwithstanding, there is marked geographical heterogeneity in recent suicide trends: Suicide went up between 1990 and 2016 in several countries (e.g., Zimbabwe, Mexico, Cameroon, or the United States).[10] Recent evidence regarding suicide in the United States illustrates the importance of examining variations in the geographical and temporal distribution of changes in suicide rate, as well as of focusing on sociodemographic markers of potential socioeconomic vulnerability and minoritization, both for surveillance purposes and to enhance causal theory and knowledge.

In the United States, suicide increased by approximately 30% between 2000 and 2018 – across sociodemographic groups and virtually in every U.S. state. Research has unveiled, however, interesting nuances that define a complex picture and have implications for prevention efforts. First, suicide increases were more marked in rural than urban areas[11] (especially in economically deprived rural areas)[12] and particularly salient after 2007. Second, while increases in suicide following 2007 were largely driven by a period effect (i.e., resulting from factors that impact societies during specific temporal periods, across age and birth cohort), cohort effects (i.e., resulting from factors that individuals born into a specific context share over the life course) were responsible for increases in suicide among racially minoritized youth.[13] Third, while firearm suicide increased especially after 2007, there is evidence that firearm ownership remained roughly stable between 2000 and 2016 in the United States and had only a marginal impact on period effects driving suicide rates.[14] Fourth, suicide mortality in the United States slightly decreased between 2018 and 2020, generating an atmosphere of guarded optimism. However, it is important to mention that decreases in U.S. suicide rates following 2018 were totally driven by declines in suicide among White individuals – suicide among ethno-racially minoritized groups either remained stable or continued to increase after 2018.[15] Taken together, this evidence underscores the potential role of distal social drivers of despair and uncertainty, such as downstream consequences of the 2008 economic recession ("distal" as compared to comparatively more proximal causes of suicide, such as firearm ownership) and ethno-racial marginalization, on recent increases in suicide in the United States. Further, this evidence has been used to advocate for the deployment of specific public health measures targeting economic despair during major economic crises (there is evidence that suicide can increase when unemployment rates increase, especially in the absence of strong social and economic safety nets)[16] and improving access to and cultural competency of mental healthcare for ethno-racially minoritized youth.

Spain has traditionally had one of the lowest suicide rates among all European countries. Whether suicide trends indicate a recent increase in suicide mortality in Spain has been debated in the literature,[17–21,22(p),23] especially because Spain's economy and welfare system took one of the hardest tolls across European countries after the 2008 economic recession.[24] The most recent studies indicate that suicide remained roughly stable over the last two decades in Spain.[23] There is, however, scarce evidence regarding potential changes in suicide trends among minoritized groups – which may get lost when data on all the population are lumped together, as seen in recent decreases in suicide mortality in the United States. Are we missing important *trees* with potential public health implications for the *forest*?[25] In very recent work, our team found initial evidence that, while suicide trends were largely stable between 2000 and 2019 in Spain, suicide did go up after onset of the economic recession among foreign-born individuals – migrant status is the best established marker of minoritization and disadvantage in Spain.[26] As shown extensively using U.S. data, identification of age-period-cohort effects can provide critical illumination into the emerging risk groups and potential causes of suicide mortality trends.[13,27–35] Accordingly, identifying and reporting age-period-cohort effect estimates is a logical next step to time trends monitoring in the causal hypothesis generating process. Examining the age-period-cohort effects underlying recent increases in suicide among migrants to Spain can help understand whether they have been driven by period or cohort effects, or a combination of both – an important research question with potential public health implications.

More recently, the initial phases of the COVID-19 pandemic outbreak have also generated major concern that suicide mortality rates would increase due to the combination of stressors such as fear of contagion and death, loss and bereavement of loved ones, disruptions to mental healthcare delivery, and negative economic effects of the pandemic and of contagion control measures[36] – in line with reported increases in the global prevalence of negative mental health outcomes such as depression or anxiety.[37] Initial reports including data from the initial 6-9 months of the pandemic, however, suggest a different picture regarding suicide trends during the COVID-19 era: According to a large international study[38] and a systematic review of 9 studies,[39] suicide either remained stable or decreased during the initial months of the pandemic in most study locations – although evidence of delayed increases in suicide was present in Austria, Puerto Rico, and Japan. Because there have not been additional systematic reviews examining evidence published afterwards, whether suicide remained lower than expected after the initial months of the pandemic or delayed increases were generalized, and which may be potential explanations to these dynamics remain unexplored.

Spain was one of the initial global COVID-19 hotspots, reaching the highest COVID-19 incidence across Europe during the first spring of the pandemic.[40] Moreover, according to Global Burden or Disease estimates, Spain also led Europe in terms of increases in prevalence of depression and anxiety in 2020 compared to 2019.[41] Whether suicide increased in Spain following the onset of the pandemic, however, remains unclear. Two studies have compared suicide risk in Spain between 2019 and 2020. The first study found no evidence of an increase in suicide mortality rates in 2020 in the Spanish region of Catalonia.[42] The second study suggested no annual differences but slightly increased rates during summer of 2020 using nationwide data.[43] Importantly, these two studies did not account for non-stationarity and seasonality, two common threats to validity in time-series analysis.[44] Also, these studies did not examine subgroups defined by sociodemographic characteristics, despite importance of examining populations with potentially increased vulnerability for public health purposes. From this it follows that examining suicide in Spain during the COVID-19 era using appropriate statistical methods and examining population subgroups is an important unmet research gap.

The goal of this dissertation is to clarify recent trends in suicide by sociodemographic groups and markers of socioeconomic disadvantage in Spain and globally, with a focus on the 2008 economic recession and the 2020 initial pandemic outbreak, through the following aims:

Research Aim 1: Examine age-period-cohort effects on recent suicide rates in Spain, overall and by foreign-born status

- Research Aim 1a: Estimate age-period-cohort effects on suicide in Spain between 2000 and 2019, stratified by foreign-born status (the most salient sociodemographic marker of ethno-racial minoritization and social and economic vulnerability in Spain)
- Research Aim 1b: Estimate age-period-cohort effects on suicide among foreign-born individuals residing in Spain between 2000 and 2019, stratified by Spanish citizenship (a proxy for permanent residence permit – a marker of further socioeconomic instability and of reduced access to specialized healthcare and welfare)

Research Aim 2: Conduct a systematic review of changes in suicide trends following the COVID-19 pandemic onset, with a focus on variations across place, over time, and across sociodemographic groups

- Research Aim 2a: Synthesize and build upon existing theoretical arguments for examining geographical and temporal variations in suicide rates during the COVID-19 pandemic, with a focus on the relationship between these variations and modern methodological developments in causal inference

- Research Aim 2b: Conduct a systematic literature review to identify all available evidence reporting population-based variations in suicide rates following onset of the pandemic
- Research Aim 2c: Summarize variations in changes in suicide following the initial pandemic outbreak across place, over time, and across sociodemographic groups
- Research Aim 2d: Critically review the methodological approaches used to examine changes in suicide during the pandemic, as well as the potential explanations to findings provided in the literature

Research Aim 3: Examine changes in suicide following the initial pandemic outbreak in Spain, overall and by sex and age groups

- Research Aim 3a: Estimate the monthly excess in suicide deaths in Spain between April and December 2022 overall, implementing an appropriate modeling strategy (i.e., minimizing statistical assumptions) for interrupted time series analysis
- Research Aim 3b: Estimate the monthly excess in suicide deaths in Spain between April and December 2022 by sex and age groups and by foreign-born status

Chapter 1: Role of foreign-born status on suicide mortality in Spain between 2000-2019: an age-period-cohort analysis

1.1 Introduction

Suicide is a major contributor to global mortality and the leading cause of violent death.[45] Suicide deaths generate significant emotional impact on families and communities and important consequences for society. Reducing suicide mortality is an urgent public health need.

Characterizing temporal variations in suicide mortality rates is important for public health and healthcare planning as well as to guide the generation of new causal hypotheses. While global suicide mortality has decreased over the last three decades, largely due to marked decreases in suicide in China and India,[10] trends in suicide rates vary across locations – for instance, they have increased markedly in specific countries, such as the United States.[46]

Spain has traditionally had one of the lowest suicide mortality rates across Europe and among high-income countries.[47] There is, however, generalized concern that suicide mortality rates may have increased in Spain over the last decade, in the context of the aftermath of the 2008 great economic recession, as major economic downturns[48(p)] and especially increases in unemployment[16] are generally associated with increases in suicide rates. Research has shown that suicide mortality increased following the 2008 great economic recession in most European countries, with particularly salient increases in male suicides.[16,49–51] Although Spain was one of the hardest hit European countries during and after the 2008 great economic recession, with a 300% increase in unemployment rates between 2007 and 2013,[24] whether there was a contemporaneous increase in suicide mortality has been largely debated in the literature and remains unclear:[17–21,22(p),23] While an initial interrupted time series analysis suggested an upward deviation in Spain's suicide mortality trends following onset of the economic downturn,[17] and a following analysis indicated moderate increases in suicide only among women,[21] the most recent evidence indicates that overall age-standardized suicide rates remained roughly stable between 2004 and 2018 in Spain.[23]

Age, period, and cohort effects can provide critical illumination into the patterns, risk groups, and potential causes of suicide mortality trends.[13,27–35] Age effects result from factors that are specific to developmental stages, period effects result from factors that impact individuals across age and birth cohort, and cohort effects result from factors that individuals born into a specific context share over the life course.[52(p)] Age, period, and cohort effects have important public health and clinical implications, as they can guide identification of potential actionable mechanisms for prevention. Recent age-period-cohort analyses of Spain's 1984-2018 suicide mortality data did not identify increasing period or birth cohort effects over the last two decades for the general population.[23]

Examining suicide trends among specific sociodemographic groups is also critical for suicide prevention efforts as it allows for early identification and targeting of emerging high-risk populations. For instance, evidence indicates that recent increases in suicide in the United States were driven by surges in suicide rates among racially minoritized youth.[13] The apparent lack of variation in suicide trends in Spain after the 2008 economic recession may have hidden increases in suicide rates among specific sociodemographic groups, particularly vulnerable to the effects of economic downturns. In Spain, foreign-born status is an important marker of socioeconomic and racial/ethnic minoritization in the general population. Following the 2008 great economic recession, foreign-born individuals living in Spain experienced harder increases in unemployment rates than native-born counterparts.[53] In addition, foreign-born individuals were targeted by specific austerity measures, such as the “Real Decreto Ley 16/2012” law,[54] based on which Spain’s universal health coverage was interrupted between 2012 and 2018, and non-urgent and specialized medical care became restricted for foreign-born individuals without legal permanent residence permit. The overall negative health effects of the 2008 great economic recession on Spain’s foreign-born population have been reported in the literature.[55] The objective of this study was to estimate the age-period-cohort effects underlying 2000-2019 trends in suicide in Spain, focusing on the role of foreign-born status. I examined differences between foreign-born individuals with and without Spanish citizenship – a proxy for access to permanent residence permit, longer time since migration, greater socioeconomic stability, and stronger social support networks, to better understand the potential role of social vulnerability.

1.2 Methods

Data source

I obtained 2000-2019 mortality data from Spain’s National Institute of Statistics.[56] These data are based on Spain’s National Mortality Registry, a single cause-of-death mortality database, and consist of International Classification of Disease, Tenth Revision (ICD-10) codes based on the underlying cause of death as indicated by medical examiners in death certificates. Deaths were designed as attributable to suicide using the following ICD-10 codes for underlying cause of death: X60-X84, and Y87.0, following widely adopted practices. I also retrieved information on sex (male/female), age in years, foreign-born status (foreign-born/native-born), and Spanish citizenship status (yes/no) for each death. I designated deceased individuals as foreign-born if they were born outside of Spain and resided in Spain, regardless of Spanish citizenship. Denominator data, used for the calculation of rates, were also obtained from the

National Institute of Statistics' Ongoing Register of Residents.[57] Suicide deaths of individuals not residing in Spain were excluded from rate calculations.

Analyses

Descriptive analyses

All study procedures were conducted separately for foreign- and native-born suicides. I began by generating an age-period contingency table where data were separated into age groups and periods, both grouped in five-year intervals. Then, I described suicide mortality rates by age, period, and cohort, using traditional two-dimensional graphical representations. These representations are informative for initial examination of the data as summarized in the initial contingency table, as they provide the initial evidence of presence of period or cohort effects. Two-dimensional plots can represent age variations in suicide rate across periods or cohorts, cohort variations across age or periods, and period variations across age or cohorts.[58] In addition, I implemented descriptive hexagonal grids, where each data point (i.e., each age-specific suicide rate at a specific year period, and thereby the corresponding birth cohort-specific suicide rate at a specific year period, as Cohort = Period-Age) is represented using a hexagonal piece.[59] By simultaneously representing age, period, and cohort-specific suicide rates, hexagonal grids allow for an intuitive visual interpretation, overcoming limitations of traditional two-dimensional graphical representations. Descriptive analyses were conducted using Stata 16 and R 3.6.2 with R Studio 1.4.1717.

Age-period-cohort analyses

Next, I modeled age, period, and cohort effects. In the epidemiological tradition, cohort effects are sometimes defined as the result of changing or new population-level causes that affect age groups differently (period by age interaction or effect modification), leading to short- or long-term consequences in the health of individuals from specific generations.[60] The usefulness of this definition varies, however, across studies and contexts. It is most clearly useful and applicable when the population-level exposure differentially affects age groups during specific developmental periods, impacting lifetime health outcomes:[61] for instance, risk of lifetime schizophrenia was 2-fold higher among the offspring of mothers exposed to severe food deprivation during the first semester of pregnancy during the 1944-1954 Dutch Hunger Winter.[62]

Age, period, and cohort effects cannot be estimated separately. In terms of statistics, birth cohort effects cannot be modeled as having a linear relationship with the outcome independent of (i.e., controlling for) the linear relationships of age and period ("first-order effects"), because of the linear dependance or collinearity among the three variables (Cohort = Period – Age). This has been termed the non-identifiability or overidentification problem in the age-period-cohort literature.[52] There is a large body of literature aimed at mitigating the overidentification problem, focusing on different aspects of the underlying data generating process – the most employed being non-linear variations in the first derivatives and median polishing methods,[58,63] variance and covariance matrix constraints in the intrinsic estimator method,[64] and multi-level nesting in the hierarchical age-period-cohort method.[65] All methods rely on, first, descriptive data analyses for qualitatively understanding patterns of temporal variation in the outcome suggesting presence of the three effects and, second, model fit statistics indicating that a three-factor age-period-cohort model is superior than any single- or two-factor model with no identification problem.[66] Because statistical assumptions vary across method, it is important to base choice on theoretical hypotheses and background. The intrinsic estimator method has been criticized for relying on assumptions hidden in the model estimation process (i.e., choice of model constrains), making results unpredictably sensitive to model parametrization and choice of reference.[67] The multi-level age-period-cohort framework only models age as a fixed effect – this has been considered an untenable assumption as it may assign variance to random effects inappropriately based on the underlying data generating structure.[68] In both cases, results can be especially biased if the underlying true age-period-cohort effects may be close to linear – as suggested by our descriptive hexmaps (see results). Accordingly, I implemented first derivative methods based on the approach developed by Clayton and Schiffer.[69,70] This model considers that only non-linear effects of period and cohort can be separated, and regular variations – termed here 'drift', may be attributable to linear period, linear, cohort, or both. Accordingly, this method disregards linear variations and uses non-linearities of the magnitude of change in overall temporal variations to assess relative increases/decreases in linear variation over time that are associated with period and cohort. In practical terms, there are several possible ways of displaying three effects that sum to the rates, and further assumptions are required to parametrize the quantities of interest (i.e., the function of age should be interpretable as log age-specific rates in the reference cohort after adjusting for the period effect, the function of the cohort effect is set to be 0 at the reference cohort, the period function is set to be 0 at the reference period). Model choices can be maximized by examining model fit statistics to select the ideal number of parameters. Notably, the derivative approach is most stable for rare outcomes, such as suicide.

First, I estimated a categorical age predictor of suicide mortality rates over time. Second, I introduced a 'drift' parameter, which is the sum of the linear period and cohort effects over time. Third, I estimated first and second derivatives of the 'drift' parameter and regressed them on period and cohort and attributed them to specific periods and cohorts, in order to estimate the extent to which suicide mortality trends accelerated or decelerated for each period and cohort. Fourth, I calculated relative rates for each period- and cohort- specific deviation from of the ‘drift’ parameter, using 2010 as reference period. At each stage, I assessed model fit by including age + ‘drift’ compared to age alone and then iteratively adding period and cohort effects, examining whether model fit improved with parameters addition, and iteratively removing each parameter, examining whether model fit worsened following parameter removal. Age-period-cohort modelling was conducted using the ‘apc.fit’ function from the R package ‘Epi’.

Sensitivity analyses

As a first sensitivity analysis, I obtained stratified age-period-cohort effect estimates for suicide mortality for foreign-born individuals with and without Spanish citizenship, a proxy for permanent residence permit, given that only foreign-born people with permanent residence permit could access specialized healthcare and welfare services for a large proportion of the study period, due to specific austerity measures. Also, like permanent residence permit, Spanish citizenship is usually granted several years after migrating to Spain,[71] and immigrants who have resided in a host country for a longer period tend to have more socioeconomic stability and stronger social and familial support networks, two important correlates of suicide mortality risk. Data on Spanish citizenship was only available for the 2003-2019 period.

In addition, I implemented an alternative approach to age-period-cohort modelling, based on the multi-phase method,[58] to test the extent to which estimates were robust to model misspecification. This method explicitly defines birth cohort effects as age by period interactions, unambiguously applying the epidemiological definition of cohort effect. Like the first derivative method, the median polishing method models non-linearities – it captures non-linearities in the age and period effect and partitions them into a systematic effect (the cohort effect) and random error. The difference with the first derivative method is that median polishing does not estimate first-order effects at all – that is, only the second-order joint effect of age and period is estimated and interpreted. In other words, first derivatives conceptualize the cohort effect as a second-order function in a model where first- and second-order age and period effects are confounders of first- and second-order cohort effects; median polishing estimates the cohort effect as a partial interaction (second-order only effect) of age and period. For this method, I (i) log-transformed suicide mortality rates per age group and period, (ii) conducted a median polish analysis by removing the log-additive effect of age (row) and period (column) by iteratively subtracting the median value of each row or column until the row and column medians approximated zero, (iii) plotted the residuals by cohort, (iv) and assessed cohort effects by conducting a linear regression where residuals were regressed on cohort category – exponentiation of a cohort's beta parameter yields an excess suicide rate attributable to each cohort that can be compared to the referent cohort. I repeated this procedure to obtain age and period effects. Multi-phase age-period-cohort modelling was conducted using Stata 16.

1.3 Results

Between 2000-2019, there were 68,549 deaths by suicide in Spain, for the following annual suicide rates: 13.8 per 100,000 men, 4.2 per 100,000 women, and 8.9 per 100,000 people overall. Among native-born people, annual suicide rates were as follows: 14.4 per 100,000 men, 4.3 per 100,000 women, and 9.2 per 100,000 people overall. Among foreign-born people, annual suicide rates were as follows: 9.10 per 100,000 men, 3.2 per 100,000 women, and 6.2 per 100,000 people overall.

Descriptive analyses

Figure 1.1 represents variations in period-specific suicide mortality rates across age among native-born individuals in Spain between 2000-2019, stratified by gender. Supplementary Figure 1 shows variations in age-specific suicide rates over time among native-born individuals in Spain between 2000-2019, stratified by gender. Supplementary Figure 2 displays the rate of suicide among native-born individuals in Spain between 2000-2019, stratified by gender, across age, period, and cohort. Suicide rates for each birth cohort can be visualized along the diagonal 'C' isolines, with corresponding ages and periods along 'A' and 'P' isolines, respectively. Suicide rates among the native-born increased with age, especially among men, and remained stable or decreased over time except for individuals aged 40-54, for whom rates went up after 2010.

Figure 1.1 Period-specific suicide mortality rates across age among native-born males and females between 2000-2019 in Spain

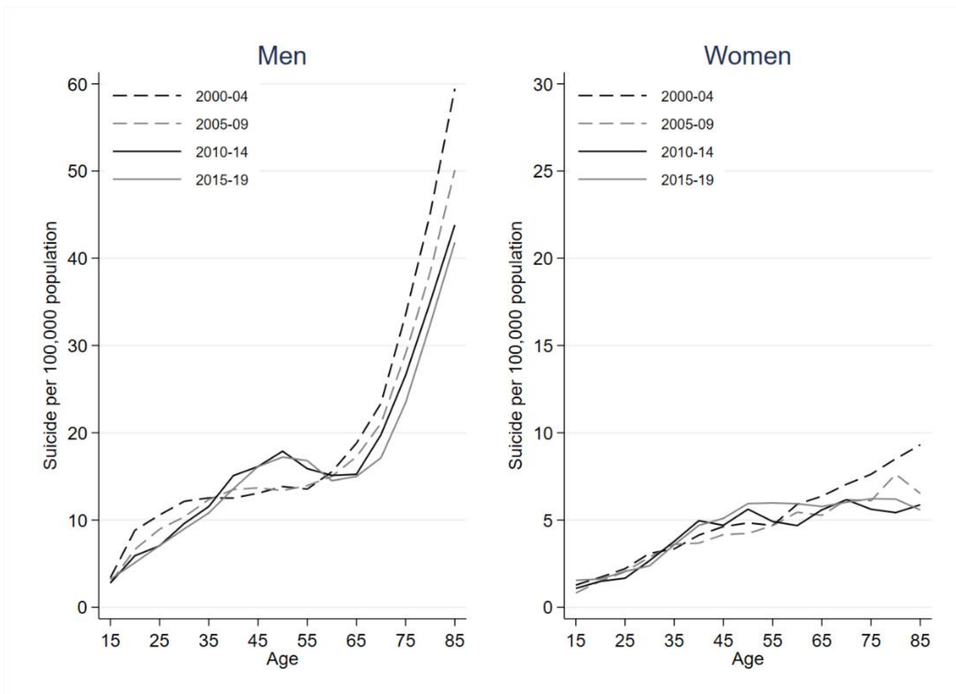
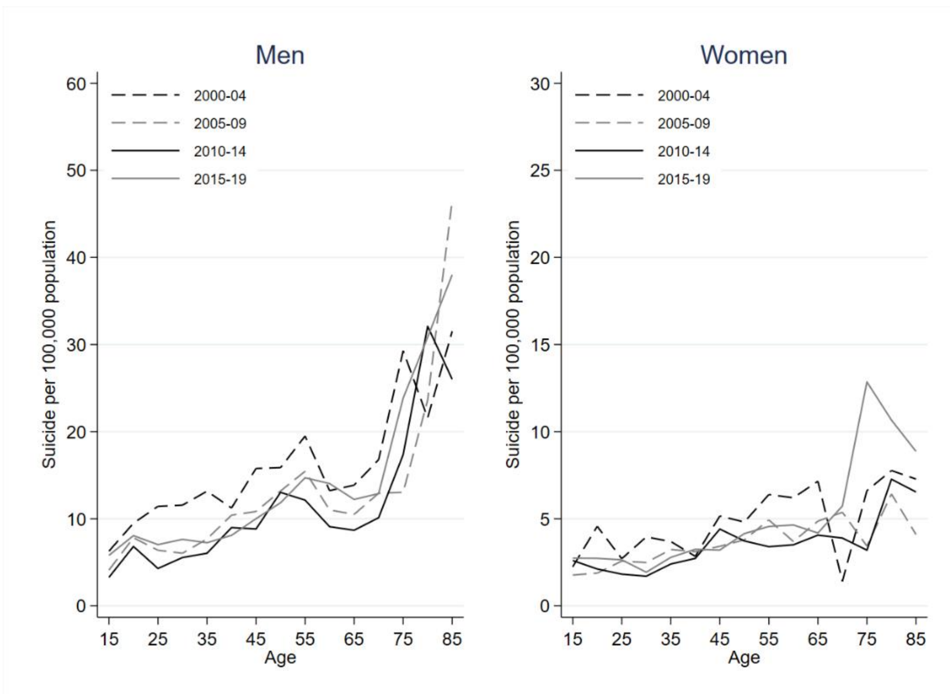


Figure 1.2 represents variations in period-specific suicide mortality rates across age among foreign-born individuals in Spain between 2000-2019, stratified by gender. Supplementary Figure 3 shows variations in age-specific suicide rates over time among foreign-born individuals in Spain between 2000-2019, stratified by gender. Notably, lines representing period-specific suicide rates over time are more heterogeneous and intersect more frequently in

foreign-born than native-born suicides. Supplementary Figure 4 displays the rate of suicide among foreign-born individuals in Spain between 2000-2019, stratified by gender, across age, period, and cohort. Again, age effects are also evident, especially among men. Suicide rates among the foreign-born increased after 2010 across age groups except in men aged 40-54, with most notable increases taking place among older women.

Figure 1.2. Period-specific suicide mortality rates across age among foreign-born males and females between 2000-2019 in Spain

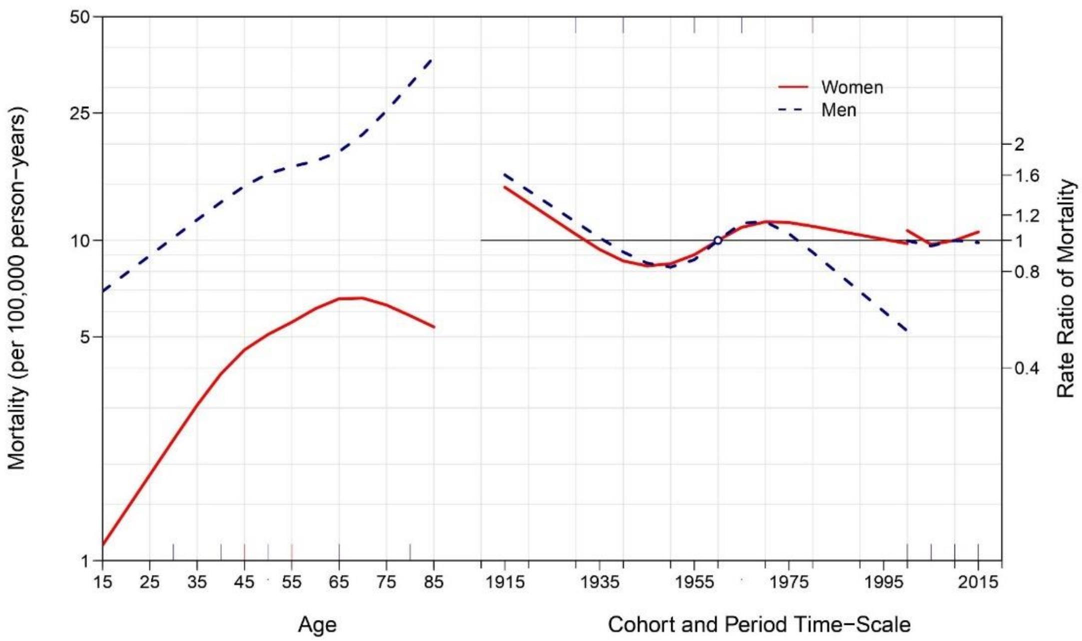


Age-period-cohort models

Supplementary Tables 1 and 2 provide the model fit statistics for overall age, period, and cohort contributions to native- and foreign-born suicide rates. Including age, period, and cohort parameters all improved model fit, and removing them all reduced model fit, indicating that all three parameters are sufficiently predictive of variance to be included in a final model.

Figure 3 estimates age, period, and cohort effects in suicide mortality among native-born individuals residing in Spain between 2000-2019. In the left axis, the age effect is expressed as suicide rate per 100,000 person-years, anchored to the reference cohort (1960). Among native-born men, suicide mortality increased roughly linearly with age. Among native-born women, suicide mortality increased rapidly through adolescence and early and mid-adulthood, peaking at around age 60, and declining very slightly through late life. In the right axis, rate ratios allow for the comparison of each period and cohort with the reference period (2010) and cohort (1960).

Figure 1.3 Age, period, and cohort effects on suicide among native-born males and females between 2000-2019 in Spain



Among native-born men, suicide risk increased for birth cohorts born between 1950-1965 and decreased markedly for cohorts born thereafter. There was no evidence of a period effect. Among native-born women, suicide rates also increased in cohorts born between 1950-1970 and, as opposed to male cohorts, remained heightened thereafter, decreasing only slightly in birth cohorts born between 1975 and 2000. Period effects indicate that native-born female suicide rates decreased between 2000-2005 but have increased slightly since 2010.

Figure 1.4 represents age, period, and cohort effects in suicide mortality among foreign-born individuals residing in Spain between 2000-2019. While suicide rates increased markedly among foreign-born men after age 45, age effects were clearer among foreign-born females, with starker increases in suicide rates across middle and late lives. Among foreign-born men, suicide rates decreased continuously across birth cohorts. Among cohorts of foreign-born women, suicide initially increased, peaking among women born in 1950, and subsequently decreased in younger cohorts. There were clear period effects for foreign-born men and women, indicating initial decreases in suicide rates during the early 2000s, followed by increases after 2010.

Figure 1.4 Age, period, and cohort effects on suicide among foreign-born males and females between 2000-2019 in Spain

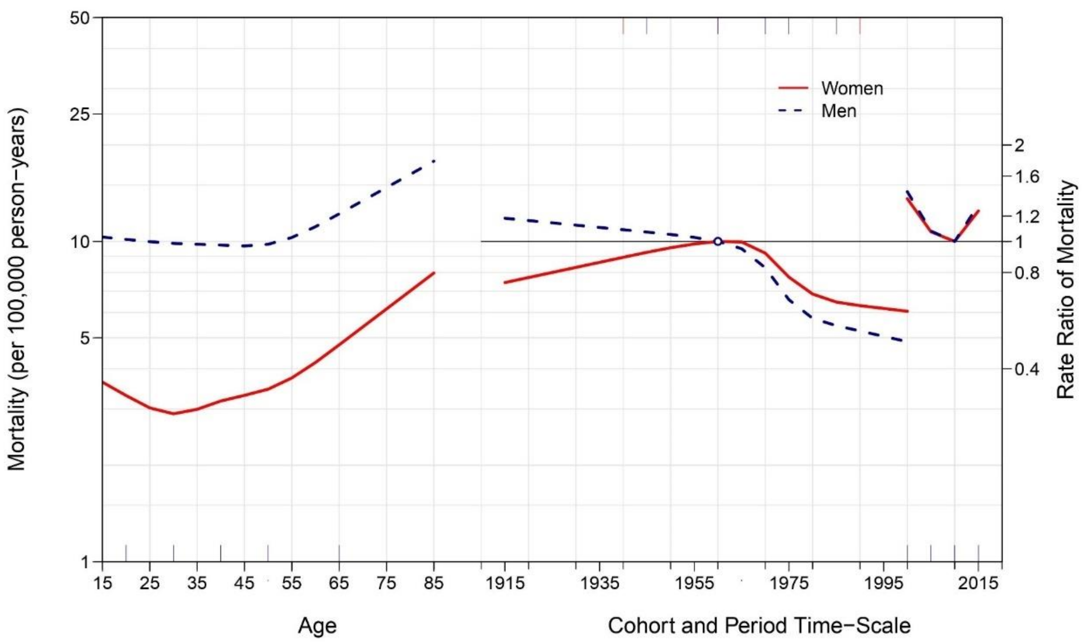
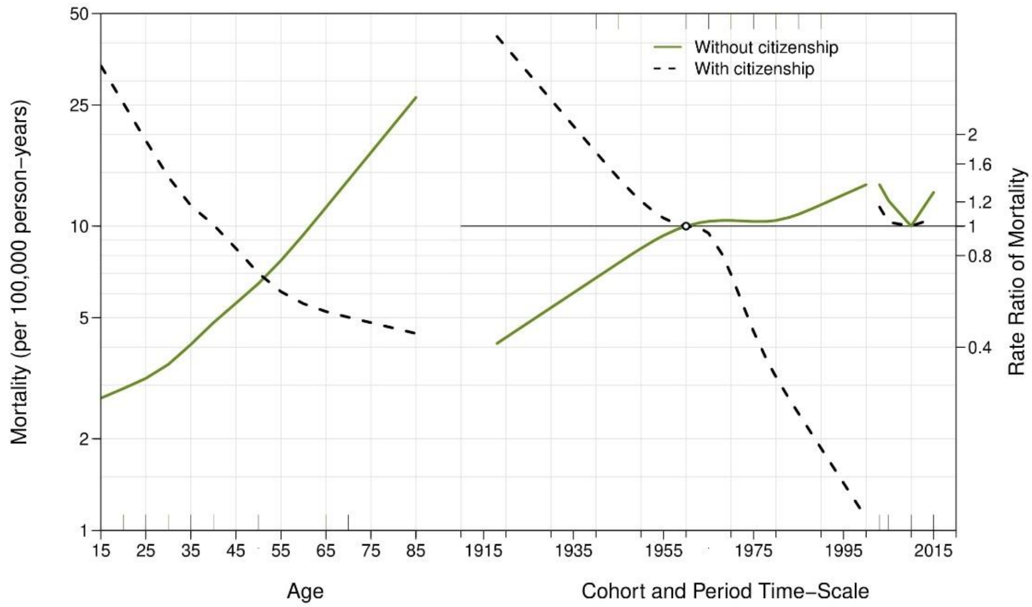


Figure 1.5 represents age, period, and cohort effects on suicide rates among foreign-born individuals with and without Spanish citizenship, respectively. Results indicate that suicides among foreign-born individuals without citizenship increased markedly among recent birth cohorts and, across age groups and birth cohorts, after 2010. Supplementary Figures 5 and 6 show age-period-cohort effect estimates among native-born and foreign-born people,

respectively, based on the multi-phase method: interpretation of the results did not change. Supplementary figures 7, 8, and 9, show age-period-cohort effect estimates among native- and foreign-born individuals and after stratification foreign-born suicides by citizenship status, respectively, obtained using a different cohort reference year (1935): interpretation of the results did not change.

Figure 1.5 Age, period, and cohort effects on suicide among foreign-born individuals between 2000-2019 in Spain, stratified by Spanish citizenship status



1.4 Discussion

Between 2000-2019 in Spain, foreign-born individuals had overall lower suicide mortality rates than native-born counterparts. Age-period-cohort models, however, revealed that suicide mortality increased markedly after 2010 among foreign-born individuals, with a specific peak among foreign-born females born around 1950; and slightly among native-born women – especially among female cohorts born after the 1960s. Meanwhile, suicide rates remained roughly stable for native-born men, decreasing for cohorts born after the 1960s. To the best of my knowledge, this is the first study to examine the age-period-cohort effects-underlying recent suicide trends among migrants to a Southern European country after the 2008 great economic recession. These results highlight that foreign-born individuals and native-born women – especially young adult female cohorts, are emerging high-risk groups for suicide in Spain.

The finding that recent increases in suicide mortality rates among foreign-born people living in Spain were largely driven by period effects (i.e., external factors circumscribed to a specific temporal moment that manifest in changing rates across age groups and birth cohorts) highlights the potential role of downstream consequences of the 2008 great economic recession. There is long-standing evidence that the negative social and health effects of major economic downturns disproportionately impact migrants [53,72]. Substantial attention has been directed towards the mediating role of unemployment, an important risk factor for suicide [73,74], in suicide rate increases during and after economic crises.[75] In Spain, following the great recession, the unemployment rate went from 8.7% in 2005 to 17.9% in 2010 and 22.1% in 2012 among native-born individuals; and from 14.7% in 2005 to 30.5% in 2010 and 36.8% in 2012 among the foreign-born. Moreover, recovery during the aftermath of the economic recession also was heterogeneous between both sociodemographic groups: in 2019, unemployment affected 13.8% native-born and 20.8% foreign-born people residing in Spain.[24] It is important to mention that suicide risk is particularly high among people experiencing long-term unemployment.[76]

There are additional stressors brought about by the great economic recession whose role was more salient among foreign- than native-born people residing in Spain. First, between 2010 and 2015, foreign-born individuals residing in Spain migrated massively to their original countries as well as to countries with less adverse socioeconomical conditions,[53] conditioning a negative migratory balance and contributing to the socioeconomic and emotional erosion of their families and communities. Second, as mentioned, austerity measures adopted following the onset of the 2008 economic recession included the interruption of universal health coverage for immigrants without residency permit, leading to major negative health impacts on Spain's foreign-born population.[55] Results from sensitivity analyses focusing on immigrants without Spanish citizenship, a proxy category to identify individuals with reduced access to healthcare and welfare systems and at higher risk of social and economic deprivation, indicate that recent increases in suicide among foreign-born individuals were almost entirely driven by increases among the individuals without Spanish citizenship. Notably, in addition to period effects, I found remarkable increases in foreign-born individuals without citizenship born after 1975.

These results have important implications in terms of etiology as well as for clinical and public health stakeholders. First, recent increases in suicide risk among the foreign-born in Spain seem partially explained by trends in broader threats to the health of minoritized communities which were worsened by the great economic recession, its aftermath, and the subsequently adopted austerity policies. Avoiding or reversing austerity policies and expanding access to the welfare state to groups at risk of social and economic exclusion and minoritization, such as foreign-born individuals without Spanish citizenship, seems a straightforward solution to reduce the overall health impacts of economic recessions and, in particular, their effect on suicide mortality. In fact, the role of short- and long-term unemployment on suicide risk can be buffered by generous unemployment protection and overall expanded access to welfare.[75] Second, by characterizing a specific high-risk population group, these findings enhance suicide prevention efforts, especially in terms of identifying unmet needs regarding development and implementation of interventions. In addition to making healthcare universally available, enhancing immigrants' access and engagement with healthcare, regardless of age and birth cohort, through deployment of cultural adaptive programs[77] that ensure culturally- and structurally-competent,[78] easy to access mental healthcare and suicide-specific interventions is critical.

I characterized birth cohort and period effects in suicide mortality rates among native-born women, hence expanding previous work by Cayuela et al.[21] that suggested a moderate 2000-2016 increase in suicide risk among women in Spain. This is in line with recent evidence indicating that, while population-based estimates of the prevalence of depression may be decreasing in Europe, they are on the rise among Spanish young and middle-aged women[79] and with a previous population-based study that identified young women as particularly at risk for suicidal ideation and behaviors.[80] In addition, previous research has identified the great recession as a root cause of recent increases in mental health problems among the Spanish population.[81] There also were gender differences in the impact of the aftermath of the 2008 economic recession: while the initial years of economic recession reduced the gender gap in unemployment (the unemployment rate went from 7.8% in 2005 to 23.9% in 2012 among men, and from 13.5% in 2005 to 24.5% in 2012 among women), employment recovery was markedly slower for women, with 2018 rates sitting at 15.1% for men and 18.5% for women. Importantly, adolescents and young adults were the most hardly hit demographic group, with 2012 unemployment rates of 71.4% and 47.7% for individuals aged 16-19 and 20-24 years respectively. While the gender gap in unemployment is reduced during crises, overall increases in part-time and precarious work ultimately re-establish women as a family dependent and flexible labor supply, increasing their socioeconomic vulnerability.[82] Accordingly, the combination of high and long-lasting unemployment rates among young women with other medium- and long-term gendered effects of the 2008 economic recession may partially explain these period and birth cohort effects.

Whether suicide rates increased in Spain during the aftermath of the great economic recession has been largely debated in the literature.[17–21,22(p),23] While most recent research found no evidence of an overall increase, this was largely because suicide mortality rates in Spain are mostly driven by rates among native-born men and, as shown in these results, suicide mortality has remained stable in this sociodemographic groups since 2000. I found, however, marked age effects among native-born men, with remarkably high suicide rates in individuals aged 65 years and older. This finding is common in most Western cultures and is seemingly explained by elders experiencing barriers in access to mental healthcare during crises due to internalized stigma, social disconnectedness,[83] and physical impairment,[84] their higher rates of chronic medical comorbidity and disability, and their use of more lethal suicide methods than younger counterparts.[85] Despite this, suicide prevention interventions are typically targeted at other groups at risk, such as people with mental disorders or adolescents. Developing, implementing and scaling up age-friendly interventions to favor elders' access to prevention efforts during crises is a largely unmet clinical and public health need.[85,86]

This study has limitations. First, data on suicide mortality are subject to potential errors in suicide mortality certification.[87–89] Second, as with any age-period-cohort study, where regression identification issues make models vulnerable to potential model misspecification problems, validity of these results is dependent on appropriateness of modelling choices. However, I implemented two different approaches to age-period-cohort modelling and, in addition, conducted sensitivity analyses varying reference periods and cohorts, obtaining similar results that suggest robustness. Third, I lacked information on important correlates of vulnerability, especially as regards to foreign-born individuals (such as time since migration, legal residence permit, or socioeconomic status). While I was able to analyze foreign-born suicides separately by Spanish citizenship status, a proxy for permanent residence permit and hence for socioeconomic stability, social and family support networks, and access to specialized healthcare and social welfare, future research should incorporate data on additional social covariables to further advance understanding of recent trends in suicide in Spain.

In conclusion, suicide rates increased among native-born females and, especially, among foreign-born individuals after 2010. Suicide increases among foreign-born people were entirely driven by increases among individuals without Spanish citizenship – which were particularly stark in birth cohorts born after 1975. These results highlight the importance of examining suicide rates among especially vulnerable sociodemographic groups and lend support for an association between the downstream effects of the 2008 economic recession and an increase in suicide rates in foreign-born individuals living in Spain, who experienced the starkest increases in unemployment following onset of the recession and also were subject to specific austerity measures limiting access to specialized healthcare and welfare services.

Chapter 2: Suicide following the COVID-19 pandemic outbreak: variation across place, over time, and across sociodemographic groups. A systematic integrative review

2.1 Introduction

The SARS-CoV-2 pandemic has brought about a substantial burden of psychosocial stressors (e.g. bereavement of loved ones, fear of contagion and death, isolation and loneliness, downstream negative economic effects), affecting mental health and psychological wellbeing of the general population.[90(p19),91] Initial evidence from representative longitudinal surveys suggests that prevalence of symptoms indicative of common mental health conditions, such as symptoms of depression or anxiety, may have increased notably following the onset of the pandemic.[92–97] According to Global Burden of Disease estimates, prevalence of depression and anxiety increased by around 25% across the globe in 2020.[37]

Additionally, early reports also suggested increases in suicidal ideation in the general population,[98,99] leading to concern that suicide deaths would increase following the initial pandemic outbreak.[36] The first available evidence, however, did not confirm such increases in suicide mortality for most countries with available data shortly following the initial pandemic outbreak. A large interrupted time-series analysis including population-based data from 21 study locations found suicide mortality to have dropped or remained stable between April and July, 2020.[38] As the pandemic unfolded, however, it became progressively clear that the impact of the pandemic on suicide across the globe is heterogeneous across place and population subgroups as well as over time. For instance, including data through October, 2020 on the same 21 locations identified increases in suicide in Vienna, Austria; Puerto Rico; and Japan (suicide remained stable or decreased in the other 18 study locations)[38] A systematic review, published in June 2021 and based on 9 original reports of population-based suicide mortality data, also highlighted increases in suicide rates in Japan, noticeable after the summer of 2020, with particularly concerning trends among young females.[39]

Variations across place and population subgroups and over time in the impact of the pandemic on suicide should be expected because the intensity of pandemic-related stressors (e.g., COVID-19 incidence and mortality, physical distancing measures, negative downstream economic effects) varied across place and population subgroups and over time, generating multiple versions of the exposure of interest (i.e., the COVID-19 pandemic). Under multiple versions of an exposure, the consistency assumption of causal inference is violated:[100,101] in other words, one effect of the pandemic on suicide cannot be estimated. For instance, across the globe and over time, physical distancing measures have had variable intensity and public uptake, resulting in different combinations of limitation of public events, closure of schools and workplaces, and stay-at-home mandates. In addition, variation in the distribution of potential effect measure modifiers can lead to non-transportability of effects across contexts and persons[102] and be an additional source of heterogeneity in the effects of the pandemic on suicide. For example, the potential negative mental health impact of stay-at-home mandates may be more intense among individuals unable to secure income working from home, especially in the absence of social welfare support. Examining geographical and temporal variations in the effect of the pandemic on suicide and differences across population subgroups (i.e., assessing different versions of the exposure of interest) can enhance understanding of which pandemic-related stressors impacted suicide risk and which factors functioned as effect measure modifiers, guiding the identification of potentially actionable public health drivers of suicide increases during the pandemic. Moreover, examining variations in suicide rates and trends by sociodemographic groups (e.g., defined by age, sex, ethno-racial background, or socioeconomic status) during the COVID-19 era can help identify emerging high-risk groups for prioritization of targeted interventions (e.g., culturally adaptive suicide prevention interventions).[103]

No study has systematically reviewed the heterogeneity across place and population groups and over time in variations in suicide during the COVID-19 era, despite potential implications for suicide prevention efforts. The goal of this review was to systematically examine and summarize the existing evidence on changes in population-based suicide trends during the period following the initial pandemic outbreak, with a focus on assessing geographical and temporal heterogeneity as well as differences across population groups defined by sociodemographic characteristics.

2.2 Methods

Search strategy and databases

The goal of this review was to provide a critical and comprehensive understanding of variations in suicide following onset of the COVID-19 pandemic, including all existing original research and with a focus on heterogeneity across place, time, and sociodemographic characteristics. Accordingly, I conducted a systematic integrative literature review, combining the rigor of a systematic review (e.g., in terms of search strategy and individual study evaluation) with the flexibility of an integrative review (which focuses on critiquing and synthesizing the literature in an integrated way to enhance understanding of the phenomenon under study, contribute to theory development, and impact practice and policy).[104] I searched the following databases: PubMed, ProQuest Central, and Ebscohost (restricted to PsycInfo and SocINDEX).

These databases were searched on July 10, 2022. Search terms were: suicide and (COVID-19 or pandemic or coronavirus or SARS-CoV-2). This review followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 guidelines (Appendix B).[105]

Inclusion and exclusion criteria

Table 2.1 outlines the criteria for inclusion in the review. In brief, studies were included if they reported original, peer-reviewed research published between 01/01/2020 and 07/10/2022, and included population-based estimates of suicide counts or suicide mortality rates before and after the initial COVID-19 pandemic outbreak, with or without explicitly estimating the effect of the pandemic on variations in suicide.

Table 2.1 Inclusion and exclusion criteria, systematic integrative review

Inclusion criteria	**Exclusion criteria**
- Original research - Peer-reviewed - Published between 01/01/2020 and 07/10/2022 - Written in English, French, or Spanish (or data accessible from an abstract in English, French, or Spanish) - Population-based - Reports suicide counts or suicide mortality rates before and after the initial COVID-19 pandemic outbreak	- Non-original research (e.g., non-research letters, editorials, commentaries, viewpoints, reviews) - Outcome is not suicide counts or suicide mortality rate (e.g., suicidal behaviors, suicide attempts, suicidal ideation) - Outcome is not measured systematically for the whole population included (e.g., studies using single-forensic facility data)

I excluded non-population-based studies (e.g., studies reporting data from a single clinical facility), non-original research (e.g., reviews, editorials, viewpoints, and non-research letters), as well as original research not reporting suicide counts or suicide mortality rates (e.g., studies reporting suicidal ideation rates, emergency department visits due to suicide attempts, etc.). In addition, to be included studies needed to be written in English, Spanish, or French, or data on the outcome of interest accessible in any of these languages – e.g., included in a translated abstract.

Study screening and full-text review

I used Covidence software to implement the initial title and abstract screening of all articles identified. Two independent researchers screened all titles and abstracts separately. In 12 out of 8414 (0.1%) papers initially screened, the screening process had to be discussed by the reviewers to come to a consensus on the appropriateness of full-text review. In 2 out of 48 (4%) papers reviewed in full-text, the full-text review process had to be discussed to come to a consensus on the appropriateness of inclusion.

Data extraction, synthesis, and analysis

I used an abstraction form to capture all relevant study details, including data on general manuscript information (authors, publication year, setting), methods (time period examined; definition of the COVID-19 period; statistical method; outcome measure; whether results were reported by sex; whether additional covariates were measured; whether results considered pre-existing trends, seasonality, and autoregression; and an assessment of risk of bias), and results (main findings and, when appropriate, results by subgroups as defined by additional covariates included). We did not assess quality of suicide data as papers did not include such information.

Analyses of time series data where a potential interruption of the time series (e.g., emergence of the COVID-19 pandemic) is of interest are typically referred to as interrupted time-series analyses (ITSA). There are three common threats to validity in ITSA studies: autocorrelation, seasonality, and non-stationarity. Autocorrelation can be assessed with Durbin-Watson tests or graphically, and controlled for with appropriate modelling techniques.[106] Seasonality (which should be expected in studies on suicide – for instance, suicide in Western societies typically peaks in spring and summer and decreases in fall and winter) can be controlled for using various strategies – e.g., including month as a correlate, using Fourier terms (pairs of sine and cosine functions), or including time as a spline in segmented regression models, or via differencing in ARIMA models.[107] Non-stationarity (i.e., variation over time of the statistical properties of a time series, or of the data generating process, such as a pre-existing time trend that has no relation with the interruption of time series of interest – which can also be referred to as *trend non-stationarity*) can be examined graphically or using the Dickey-Fuller test and, if present, data should be stationarized to enhance predictability – e.g., controlling for year in segmented regression models or, again, via differencing in ARIMA models.[44] Accordingly, the abstraction form included specific variables to indicate if autocorrelation, seasonality, and non-stationarity were explicitly assessed and controlled for. Moreover, as explained in detail below, papers were assessed as possibly biased if they failed to address these possible threats to validity.

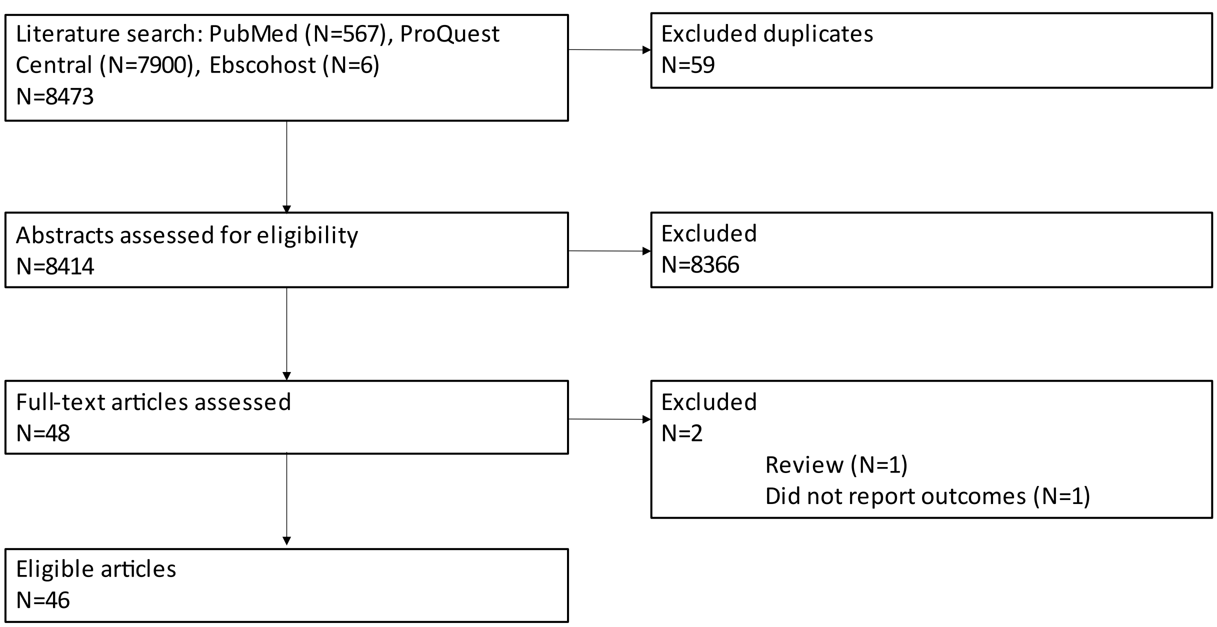
Two independent researchers performed an evaluation of the risk of bias of the articles, based on work by Hategeka et al.[108] assessing the following 7 characteristics of ITSA: Was the intervention independent of other changes? Was the shape of the intervention effect pre-specified? Was the intervention unlikely to affect data collection? Was the primary outcome measured objectively? Were incomplete outcome data adequately addressed if applicable? Was the study free of selective outcome reporting? Was the study analyzed appropriately using interrupted time series techniques? I dichotomized the scale between low and high risk of bias. Because designs were largely similar across studies, the difference between low and high risk of bias was in most cases defined by use of an appropriate ITSA technique (e.g., ARIMA models or segmented regression) with explicit control for autocorrelation, seasonality, and non-stationarity.

2.3 Results

Literature search

Figure 2.1 is a flowchart representing the manuscript review process. Of a total 8473 articles initially identified, 59 were duplicates and hence were excluded. I screened titles and abstracts of the remaining 8414 articles: 8366 articles were considered irrelevant and excluded for not meeting inclusion criteria at this stage. Of the remaining 48 articles, an additional 2 were excluded because they did not report original results (1 was a narrative review and 1 did not report outcomes at all).

Figure 2.1 Flowchart of articles, systematic integrative review



Study designs and methodological variation

Table 1.2 summarizes the characteristics of the included studies. A total of 27 studies used suicide counts as the outcome of interest.[38,109–134]

Table 2.2 Summary, articles examining suicide during the initial phase of the COVID-19 pandemic, systematic integrative review

Author, date	Setting	Time examined	COVID-19 period definition	Statistical approach	Outcome measure	Results by sex	Additional covariates measured	Change in suicide overall	Assessment of			Risk of bias
									Auto-correlation	Non-stationarity	Seasonality	
Acharya et al., 2021	Nepal	Not reported	After March 24 2020	Direct comparison vs. previous years	Number of suicides	No	None	↑	No	No	No	↑
Acharya et al., 2022	Nepal	July 1, 2017-June 30, 2021	April 1, 2020-June 30, 2021	ITSA via segmented regression	Monthly suicide rate per 100,000 persons	Yes	Region	↑	No	Yes	Yes	↑
Anzai et al., 2021	Japan	January 1, 2013-June 30, 2020	March 1-June 30, 2020	ITSA via segmented regression	Monthly suicide counts	Yes	Age groups	↓	No	Yes	No	↑
Arya et al., 2022	India	January 1, 2010-December 31, 2020	This study compared 2020 and 2017-2019	Joinpoint regression; direct comparison vs. year 2017	Annual suicide rates per 100,000 persons	Yes	Socioeconomic status	↑	No	Yes	No	↑
Barbic et al., 2021	British Columbia, Canada	January 1, 2010-August 31, 2020	March 1-August 31, 2020	ITSA via ARIMA model, adjusted for seasonality	Monthly suicide rate per 100,000 persons	No	None	↓	Yes	Yes	Yes (method is not specified)	↓
Borges et al., 2022	Mexico	January 1, 2010-December 31, 2020	April 1-December 31, 2020	ITSA via segmented regression	Monthly suicides	No	State-level unemployment rate, population density, marginalization index	↑	No	Yes	Yes	↓
Bray et al., 2021	Maryland, USA	January 1, 2017-July 7, 2020	March 5-July 7, 2020	ITSA via segmented regression	Daily suicide counts	No	Race groups (White, Black, Hispanic, Asian, Other)	Only race-specific variations are reported	No	Yes	Yes	↓
Calati et al., 2021	Milan, Italy	January 1, 2016-April 30, 2021	March 1, 2020-April 30, 2021	Direct comparison vs. 2019	Proportion of autopsies corresponding with suicides	No	None	↓	No	No	Yes	↑
Calderon-Anyosa and Kaufman, 2021	Peru	January 1, 2018-September 26, 2020	March 16-September 26,2020	ITSA via segmented regression	Biweekly suicide rate per 1,000,000 residents	Yes	None	↓	No	Yes	Yes	↓
Calderon-Anyosa et al., 2021	Peru	January 1, 2018-December 31, 2020	March 16-December 31,2020; divided into "lockdown" (March 16-June 30, 2020) and "post-lockdown" (July 1-December 31, 2020)	ITSA via segmented regression	Biweekly suicide rate per 10,000,000 residents	Yes	None	↓	No	Yes	Yes	↓
Chen et al., 2021	Taiwan	January 1, 2017-December 31, 2020	January 1-December 31, 2020	ITSA via segmented regression	Monthly suicide rates per 100,000 persons	No	Age groups	↓	No	No	No	↑

De la Torre-Luque et al., 2022	Spain	January 1, 2019-December 31, 2020	March 1-December 31, 2020	ITSA via segmented regression	Monthly suicide rates per 100,000 persons	No	None	No change in 2020; ↑ (during COVID-19 period)	No	Yes	No	↑
Deisenhammer and Kemmler, 2021	Tyrol, Austria	April 1-September 20, 2006-2019 and 2020	April 1-September 30, 2020	ITSA via segmented regression	Total suicide count during the COVID-19 period	No	None	↓	No	Yes	Yes	↓
Dwyer et al., 2021	Victoria, Australia	January 1, 2015-January 31, 2021	January 1, 2020- January 31, 2021	ITSA via segmented regression	Weekly suicide count	No	None	No change	No	Yes	No	↑
Eguchi et al., 2021	Japan	January 1, 2012-November 30, 2020	Not defined	ITSA via segmented regression	Weekly suicide counts	Yes	Age groups	↑ (after July 2020)	No	Yes	Yes	↓
Faust et al., 2021	USA	January 1, 2015-August 31, 2020	March 1-August 31, 2020	ITSA via SARIMA model	Monthly suicide counts	No	None	↓	Yes	Yes	Yes	↓
Faust et al., 2021	Massachussetts, USA	January 1, 2015-May 31, 2020	March 1-May 31, 2020	ITSA via SARIMA model	Suicides between March-May 2020. Incidence rate ratio (IRR) between March-May 2020 vs. 2019	No	None	No change	Yes	Yes	Yes	↓
Garnett et al., 2022	United States	January 1, 2000-December 31, 2020	This study compared 2000 and 2020	Joinpoint regression and pairwise comparison of trends via Z-tests	Annual suicide rates per 100,000 persons	Yes	Age groups, suicide method	↓	No	Yes	No	↑
Horita and Moriguchi, 2022	Japan	January 1, 2009-September 30, 2021	April 1-September 30, 2021	ITSA via segmented regression	Monthly suicide rates per 100,000 persons	Yes	Age groups	No change (April-June 2020), ↑ (July 2020-September 2021)	No	Yes	Yes	↓
Isumi et al., 2020	Japan	January 1, 2018-May 31, 2020	March 1-May 31, 2020	ITSA via segmented regression	Monthly suicide rates and monthly suicide counts	No	Study restricted to people aged <20	↓	No	Yes	Yes	↓
Kegler et al., 2022	USA	Januar 1, 2019-December 31, 2020	This study compared 2019 and 2020	Direct comparison vs. year 2019	Annual firearm suicide rate per 100,000 persons	Yes	Age groups, race-ethnicity (Asian or Pacific Islander, American Indian or Alaska Native, Black, White, Hispanic), US Census Bureau geographic division,	No change	No	No	No	↑

							urbanization level.					
Koda et al., 2022	Japan	December 1, 2014-May 31, 2021	January 1, 2020-May 31, 2021	ITSA via segmented regression	Monthly suicide counts	Yes	Age groups	↑ (July-November 2020)	No	Yes	Yes	↓
Leske et al., 2021	Queensland, Australia	January 1, 2015-August 31, 2020	February 1-August 31, 2020	ITSA via segmented regression	Monthly suicide rate per 100,000 persons	Yes	None	No change	No	Yes	Yes	↓
Lin et al., 2021	Taiwan	January 1, 2015-December 31, 2020	January 1-December 31, 2020	ITSA via segmented regression	Monthly suicide counts	No	Age groups	↓	No	Yes	Yes	↓
McIntyre et al., 2021	Canada	March 1, 2010-February 28, 2021	March 1, 2020-February 28, 2021	Direct comparison between the March 1-February 28 periods between 2010 and 2021	Annual suicide rate per 100,000 persons	No	None	↓	No	No	Yes	↓
Mitchell and Li, 2021	Connecticut, USA	March 10-May 20, 2014-2020	March 10-May 20, 2020	Direct comparison between March 10-May 20, 2020 and the same period between 2014-2019; comparisons via Chi-square and two sample t tests	Suicide rates per 100,000 person-years	No	Race groups (White vs. Non-White), suicide method	↓	No	No	Yes	↓
Nomura et al., 2021	Japan	December 1, 2010-December 31, 202	Not defined	ITSA via segmented regression	Monthly suicide counts	Yes	None	↑ (After September 2020)	No	Yes	No	↑
Nomura et al., 2021	Japan	December 1, 2010-September 30, 202	Not defined	ITSA via segmented regression	Monthly suicide counts	Yes	None	↑ (July-September 2020, only among women)	No	Yes	No	↑
Orellana and Ponte de Souza, 2022	Brazil	March 1, 2015-December 31, 2020	March 1-December 31, 2020	ITSA via segmented regression	Bimonthly suicide counts	Yes	Age groups, region, specific bi-monthly periods	No change	No	Yes	Yes	↓
Osaki et al., 2021	Japan	January 1, 2010-December 31, 2020	February 1-December 31, 2020	Direct comparison between 2020 and 2017-2019 period average	Monthly suicide rates per 100,000 persons	Yes	None	↓ (February-June 2020), ↑ (July 2020 onwards among women, October 2020 onwards among men)	No	No	Yes	↓
Osvath et al., 2021	Hungary	January 1 2010-December 31, 2020	March 1-December 31, 2020	ITSA via segmented regression	Monthly suicide counts	Yes	None	↑ (driven solely by men)	No	Yes	Yes	↓

Partonen et al., 2022	Finland	January 1, 2016-December 31, 2020	March 1, 2020-December 31, 2020	ITSA via segmented regression	Monthly suicide rate per 100,000 persons	Yes	None	No change	No	Yes	Yes	↓
Perez et al. 2022	Catalonia, Spain	January 1, 2019-December 31, 2020	This study compared 2019 and 2020	Direct comparison vs. 2019	Annual suicide rate per 100,000 persons	No	None	↓ (April 2020), ↑ (June-October 2020)	No	No	Yes	↓
Pirkis et al., 2021	Several locations*	Varied by location, as far back as January 1, 2016 and until as recently as October 31, 2020	Main analysis: April 1, 2020 - July 31, 2020. Secondary analyses: April 1, 2020 - October 31, 2020; March 1, 2020 - July 31, 2020	ITSA via segmented regression	Monthly suicide counts	No	None	Main analysis: No change. Analysis incorporating data up to October, 2020: ↑in Vienna, Japan, and Puerto Rico.	No	Yes	Yes	↓
Pokhrel et al., 2021	Nepal	Not reported	March 1-May31, 2020	Direct comparison vs. 2019	Suicide count during the COVID-19 period	No	None	↑	No	No	No	↑
Qin and Mehlum, 2020	Norway	March 1-May 31, 2014-2018 and 2020	March 1-May 31, 2020	Direct comparison vs. the 2014-2018 period	Quarterly and monthly suicide counts	Yes	Age groups	↓ (no confidence intervals)	No	No	No	↑
Radeloff et al., 2021	Leipzig, Germany	January 1, 2010-September 30, 2020	March 1-September 30, 2020	ITSA via segmented regression	Monthly suicide rates per 100,000 persons	No	None	No change	No	Yes	Yes	↓
Rogalska and Syrkiewicz-Switala, 2022	Poland	January 1, 2017-December 31, 2020	This study compared 2017, 2018, 2019, and 2020	Direct comparison vs. the 2017-2019 period	Annual suicide counts	Yes	Age groups, marital status	↑ (no confidence intervals)	No	No	No	↑
Rossom et al., 2022	Minnesota and Michigan, USA	January 1, 2019-December 31, 2020	March 1-December 31, 2020	ITSA via segmented regression	Annualized crude suicide rates per 100,000 persons	No	None	↓	No	Yes	No	↑
Sakamoto et al., 2021	Japan	January 1-November 30, 2016-2020	April 1-November 30, 2020	Difference-in-difference analysis	Monthly suicide rates per 100,000 persons	Yes	Age groups, occupational status (self-employed, student, homemaker, unemployed)	↑ (October and November 2020 for men and July-November 2020 for women)	No	Yes	Yes	↑
Schleihauf and Bowes, 2022	Nova Scotia, Canada	February 1, 2009-February 28, 2021	March 1, 2020-February 28, 2021	ITSA via segmented regression	Monthly suicide counts (excluding drug toxicity deaths)	Yes	Age groups	↓	No	Yes	Yes	↓
Stene-Larsen et al., 2022	Norway	January 1, 2020-December 31, 2020	March 1-December 31, 2020; divided in first wave	ITSA via segmented regression	Age-standardized quarterly suicide	Yes	Age groups, region	No change	No	Yes	Yes	↓

			(March-May 2020), intermediate period (June-September 2020), and second wave (October-December 2020)		rates per 100,000 persons							
Tanaka and Okamoto, 2021	Japan	November 1, 2016-October 31, 2020	February 1-October 31, 2020	Difference-in-difference analysis	Monthly suicide rates per 100,000 persons	Yes	Age groups, employment	↓ (February-June 2020), ↑ (July-October 2020)	Yes	Yes	Yes	↓
Watanabe and Tanaka, 2022	Japan	January 1, 2011-December 31, 2020	This study compared 2020 and 2011-2019	Joinpoint regression and ITSA via segmented regression	Annual suicide counts	Yes	Age groups	↑	No	Yes	No	↑
Wollschlager et al., 2021	Rhineland-Palatinate (Germany) and Emilia-Romagna (Italy)	January 1, 2010-December 31, 2020	This study compared 2010-2019 and 2020	ITSA via segmented regression	Monthly suicide counts	Yes	Age groups, region	No change	No	Yes	No	↑
Zheng et al., 2021	Guandong, China	January 1, 2019-June 30, 2020	January 1, 2020-June 30, 2020	Percentage change: (suicide rate during COVID-19 period - suicide rate during same period in 2019)/suicide rate during same period in 2019	Suicide rate per 100,000 persons during the COVID-19 period	Yes	Age groups	↓	No	No	No	↑

* Data include whole country data from Chile, Croatia, Ecuador, Estonia, Japan, Netherlands, New Zealand, Peru, Poland, South Korea. Regional data from Australia (New South Wales, Queensland, Victoria), Austria (Carinthia, Tyrol, Vienna), Brazil (Botucatu, Maceio), Canada (Alberta, British Columbia, Manitoba), UK (Thames Valley), Germany (Cologne and Leverkusen, Frankfurt, Leipzig), Italy (Udine and Pordenone), Mexico (Mexico City), Russia (Saint Petersburg), Spain (Las Palmas), USA (California, Illinois, Lousiana, New Jersey, Texas, Puerto Rico).

ITSA = Interrupted Time-Series Analysis

ARIMA = Autoregressive Integrated Moving Average

SARIMA = Seasonal Autoregressive Integrated Moving Average

Of them the majority examined monthly suicide counts, except for two reports from Nepal not specifying the time window (nonetheless included in the review to increase global representativeness),[109,128] a study examining daily suicides in Maryland, US,[112] two studies conducted in Peru assessing biweekly suicide counts,[113,114] and studies examining periods longer than one month.[118,119,125,129,130,132] In 20 studies, the outcome of interest was measured as suicide rate – and expressed as monthly suicide rate,[43,120,135–144] annual suicide rate,[145–148] or suicide rate using a different time window[149–152] – of note, the study from Japan by Isumi and colleagues reported results based on both absolute monthly suicide counts and monthly suicide rates.[120] Calati et al.'s study using data from Milan, Italy, also reported the monthly proportion of autopsies corresponding with suicides.[134]

There was between-study variation in the definition of the COVID-19 period, largely due to geographical variation in the timing of the first local case of SARS-CoV-2. While the majority (N=22) of studies defined March 2020 as the beginning of the pandemic,[43,109,110,112–114,118–120,125,127–129,131,134,140,141,144,148–151] another large group of studies (N=6)[38,111,115,135,137,142] – including Pirkis et al.'s study featuring data from 21 countries,[38] used April 2020 to define the initial pandemic outbreak. In addition, 11 studies established January 2020[116,121,122,126,130,132,133,136,146,147,152] and 3 studies established February 2020[138,139,143] as the beginning of the COVID-19 period. The studies by Eguchi et al.[117] and Nomura et al.[123] did not report a specific COVID-19 period.

There was substantial heterogeneity in choice of statistical approach to estimate the difference between expected and observed suicide counts or rates. In general, all approaches aimed at estimating the counterfactual outcome (e.g., monthly suicide count, or monthly suicide rate) had the COVID-19 pandemic outbreak not taken place – in order to then compare expected vs. observed outcomes. The majority of studies adopted an ITSA approach based on some specification of a segmented regression – e.g., Poisson,[38,43,110,111,114,115,120,131,132,138,140,145,151] quasi-Poisson,[117,121,123,125,127] negative binomial,[122,133,141] linear,[112,113,116,135,137] or non-specified segmented regression[136,144] model with a variety of additional covariables, such as unemployment rate,[110] sex,[114] intensity of travel restrictions,[141] and interaction terms between the covariates.[125] In 2 studies, Poisson models were operationalized using Joinpoint regression.[132,145] Several ITSA studies based on segmented regression explicitly controlled results for underlying trends (i.e., non-stationarity) including year as a covariate, and for seasonality either including month as a covariate or by design, comparing the same months in different years. Additional, common approaches to further control for seasonality were inclusion of month-fixed effects[135] and inclusion of Fourier terms.[38,111,115,122,127,131,138] Autocorrelation, on the other hand, was not assessed in ITSA studies based on segmented regression. Only 3 studies implemented ITSA based on seasonal autoregressive integrated moving average models,[118,119,149] an approach which can effectively control for autoregression, non-stationarity, and seasonality.[108] In addition, 2 Japanese studies used a difference-in-difference approach: both included appropriate control for seasonality and non-stationarity,[142,143] but only one used clustered standard errors, a commonly used approach to correct autocorrelation in difference-in-difference designs.[143] A total of 26 (56.5%) studies were considered at low risk of bias.

Geographical variation

Trends by country

I pay especial attention to studies classified as low risk of bias. I begin by summarizing the geographical variation in changes in suicide following the initial COVID-19 pandemic outbreak. Figure 2.2 represents suicide variations following onset of the pandemic across the globe. Regarding North America, evidence indicates that suicides decreased in Canada[148] and the

United States[146] but increased in Mexico. In Canada, February-March bimonthly suicide rates were 10.8 and 7.3 per 100,000 persons in 2019 and 2020, respectively;[148] decreases were also reported by studies focused on British Columbia, where a comparison of suicide rates between March-August 2020 vs. the average during the same months during the 2010-2019 period yielded an IRR (95% CI) = 0.92 (0.86, 0.98),[149] (and Nova Scotia, with 30 fewer suicides than expected between March 2020 and February 2021).[131] In the United States, suicide counts were an estimated (95% CI) 2432 (1071, 3791) lower than expected between March and August 2000.[118] One study highlighted that firearm suicide rates also did not change in the US in 2020, compared to 2019.[147] In Mexico, suicide increased by 3% (95% CI = 1%, 6%) between April-December 2020 – even though, as discussed below, there was substantial heterogeneity across states within Mexico.[111] In South America, studies detected no increases in suicide in Brazil[125] and evidence of an initial decrease following the initial pandemic outbreak in Peru.[113,114] In Asia, studies also revealed heterogeneity across place. There is some evidence of marked increases in suicide in Nepal (25% in 2020 compared to 2019)[128,135,135] and India (15% in 2020 compared to 2017).[145] In the Chinese region of Guangdong[152] and in Taiwan,[122,136] on the contrary, studies suggest decreases in suicide after January 2020, compared to expected rates: an 18.5% ($p<0.05$) decrease between January and June 2020 in Guangdong[152] and 0.08 fewer suicides per 100,000 persons per month ($p=0.05$) throughout 2020 in Taiwan.[136] Japan has been the subject of extensive reporting regarding suicide rates following the initial pandemic outbreak. Taken together, evidence indicates that suicide decreased between the pandemic outbreak and early summer of 2020[120,139,143] and subsequently increased throughout late summer, fall, and winter 2020-2021. According to the study by Tanaka and Okamoto, suicide rates in Japan first decreased by 14% (95% CI: 10%, 18%) between February and June 2020 and then increased by

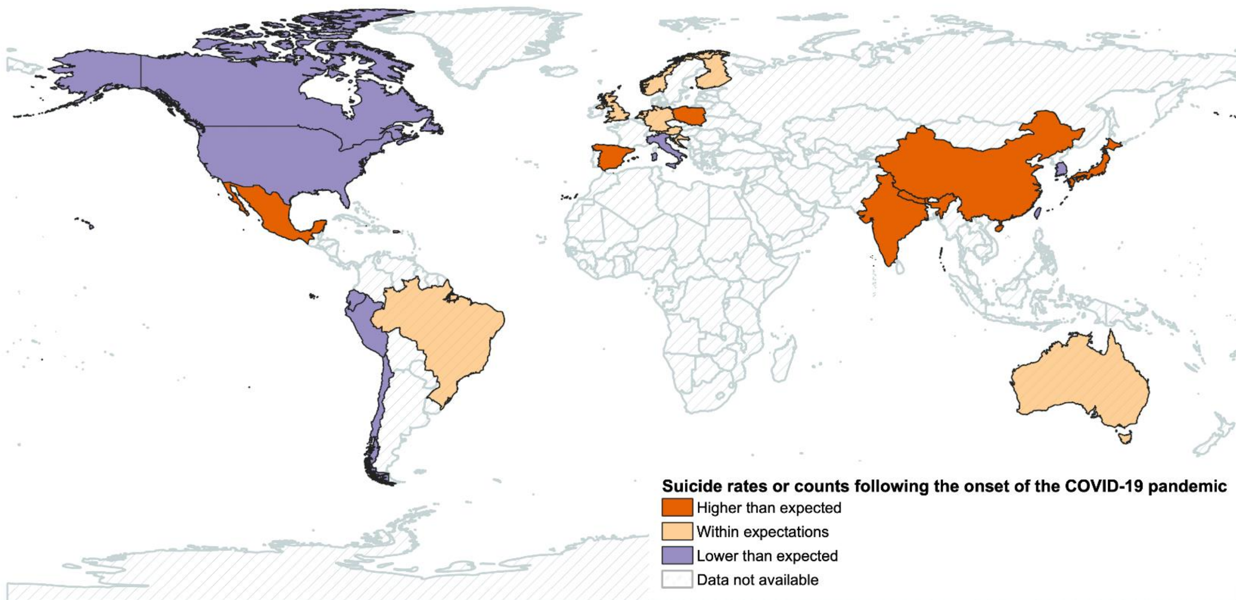
16% (95% CI: 11%, 21%) between July and October 2020.[143] Variation in suicide in Japan were heterogeneous across sex and age groups, as discussed below.[117,120,121,123,132,137,139,142,143]

At least two large studies suggest that suicide remained stable in Australia in 2020.[116,138] Regarding Europe, evidence is also mixed across place: Suicide decreased during the initial phases of the COVID-19 pandemic in Milan, Italy (in terms of suicide counts and in the proportion of autopsies corresponding with suicides between March-April 2020),[134] and the Austrian region of Tyrol (with around 20 fewer suicides than expected between April-September 2020).[115] On the other hand, between March and December 2020 there were 7% (95% CI: 2%, 12%) increases in suicide rates in Spain (although an initial decrease was detected in Catalonia),[43,126] and 16% increases in suicide counts in Hungary;[127] and there were increases in suicide in 2020 compared to 2017 – according to one suboptimal study directly comparing crude annual suicide counts.[130] In Norway,[129,151] Finland,[140] the Italian region of Emilia-Romagna,[133] and the German regions of Rhineland-Palatinate[133] and Leipzig,[141] suicide remained stable during the initial months of pandemic.

Within-country heterogeneity

Two studies from Nepal and Mexico reported notable within-country geographical variation – most salient increases took place in Sudurpaschim and Karnali provinces, in Nepal,[135] and in Mexico City, in Mexico (in fact suicide decreased in other Mexican states, such as Baja California).[111] Also, three studies examined specific US states: Suicide rates decreased by 13% between March 10 and May 20 2020 (compared to the same period between 2014-2019) in Connecticut[150] and by 0.45 per 100,000 persons per month Minnesota and Michigan,[144] though suicide counts remained roughly unchanged in Massachusetts.[119]

Figure 2.2 Worldwide geographical distribution of suicide following the onset of the pandemic, systematic integrative review



Studies from Nepal, Mexico, and the United States reported within-country geographical heterogeneity. Data used for the map on suicide in Australia, Austria, China, Canada, Germany, and Italy are not nationally representative but come from population-based studies restricted to specific regions.

Temporal variation

Some studies provide evidence that suicide rates changed dynamically over the months following onset of the pandemic. In several locales, an initial decrease in suicide was followed by a subsequent increase – yet the duration of the initial decrease was highly variable across place. In Peru, biweekly suicide counts dropped during the initial weeks of the pandemic, with a slope (95%CI) of 0.9 (0.8, 1.1), for a subsequent increase of 1.2 (0.9, 1.5) that ended up by the end of the stay-at-home mandate in June 2020, with suicide reaching back levels comparable to 2019. In Milan, Italy, compared to the same months in 2019, suicide counts were lower between April 2020 and March 2021, and higher in April 2021. In Catalonia, Spain, compared to 2019, suicide counts decreased in April 2020 for an Incidence Rate Ratio (IRR) (95% CI) = 0.64 (0.41, 1.02) but increased between June and September 2020, with IRRs ranging between 1.14 and 1.31 (95% CIs not reported).[126] In the large study including 21 countries by Pirkis and colleagues, the initial analysis including April-July 2020 data did not reveal increases in any locale – however, inclusion of data up to October 2020 indicated increases in suicide in Vienna (Austria), Puerto Rico, and Japan – IRRs (95% CI) = 1.31 (1.08, 1.59), 1.29 (1.05, 1.58), and 1.05 (1.04, 1.07), respectively. In fact, the largest body of evidence indicating temporal variation in the impact of COVID-19 on population suicide comes from a series of Japanese studies. Two initial studies including data up to June 2020, indicated a downward trend in suicide in Japan.[110,120] Notwithstanding, subsequent studies revealed higher-than-expected suicide counts between July and November 2020,[117,123,124,137,142] with a peak excess 25.8% suicides in October 2020,[121] driving an overall 10% higher-than-expected suicide count in 2020 compared to 2019.[132]

Variation by sociodemographic variables

Several studies report heterogeneity in the effect of COVID-19 on suicide by sociodemographic characteristics. Variations by the most frequent variable of stratification, sex, are summarized in table 2.2. All other results stratified by sociodemographic variables, including groups defined by sex and age, are summarized in table 2.3. In most settings, effects were homogeneous across sex. However, there were exceptions. In Peru, initial decreases resulted in one fewer female suicide and two fewer male suicides per million residents per month.[113] In Japan, excess suicides between July and October 2020 were entirely driven by increases in female suicide;[117,139] with male suicide increasing only after October 2020.[123,142] In October 2020 in Japan, suicide went up by 61% among women, but only by 6% among men.[121] Between July 2020 and September 2021, the increase was of 31% among women but only 17% among men.[137]

Table 2.3 Variation in suicide across sociodemographic variables, systematic integrative review

Author, date	Setting	Sex and age groups	Racialized groups	Socioeconomic status (SES)	Other
Acharya et al., 2022	Nepal				Geographical variation: ↑↑ in Sudurpaschim and Karnali provinces
Anzai et al., 2021	Japan	↑ especially young females			
Arya et al., 2022	India			↑↑ males from low SES states	
Borges et al., 2022	Mexico				Geographical variation: e.g., ↑ in Mexico City and ↓ in Baja California
Bray et al., 2021	Maryland, USA		↑ Black but ↓ White residents		
Chen et al., 2021	Taiwan	↑only persons aged >64			
Eguchi et al., 2021	Japan	↑ especially females aged 40-49 and males aged 20-29			Occupation: ↑ in housewives, no change in self-employed persons
Garnett et al., 2022	United States	↑ only females aged 15-24; ↓ males aged 45-75			
Horita and Moriguchi, 2022	Japan	↑ in males aged 20-29 and females aged 20-79			
Kegler et al., 2022	USA		↑ in American Indian and Alaska Natives, Black Non-Hispanics, and Hispanics of any race		
Lin et al., 2021	Taiwan	↓ across groups except for ↑ in persons aged >64			
Mitchell and Li, 2021	Connecticut, USA		↑ Non-White, ↓ White persons		
Orellana and Ponte de Souza, 2022	Brazil	↑ in males aged >59 and females aged 30-59 (Northern region) and in females aged >59 (Northeastern region)			
Qin and Mehlum, 2020	Norway	Age groups assessed: no change found			

Rogalska and Syrkiewicz-Switala, 2022	Poland	Age groups and marital status assessed: no change found			
Sakamoto et al., 2021	Japan	↑ in females aged >30			
Schleihauf and Bowes, 2022	Nova Scotia, Canada	Age groups assessed: no change found			
Stene-Larsen et al., 2022	Norway	Age groups assessed: no change found			
Tanaka and Okamoto, 2021	Japan	↑ especially females and children and adolescents			
Watanabe and Tanaka, 2022	Japan	↑ males aged 20-29 and females of all ages			
Wollschlager et al., 2021	Rhineland-Palatinate (Germany) and Emilia-Romagna (Italy)	↑ males aged >69			
Zheng et al., 2021	Guandong, China	↑ males and females aged <15 and >70			

In terms of age, several studies reporting age group-stratified results found no relevant results to report. Notwithstanding, some interesting results indicate a marked impact of the pandemic on suicide risk among older adults. A study examining data from Rhineland-Palatinate, in Germany, and Emilia-Romagna, in Italy, revealed increases in suicide among men aged 70 and older.[133] Similarly in Guangdong, China, suicide rates during the COVID-19 period increased only among males and females aged 0-15 (increasing by 150% in males and 127% in females) and 70-79 (increasing by 21% in males and 12% in females).[152] Further, suicide rates went down in all age groups but older adults in Taiwan – in fact, older adults in Taiwan experienced 40% increases in suicide in August (RR, 95% CI = 1.41, 1.08-1.82) and October 2020 (RR, 95% CI = 1.44, 1.11-1.88).[136] In Japan, on the contrary, even though suicide increased across sex and age group after October, 2020, increases occurred earlier among females of all ages and young males[132] and were particularly salient among females aged 20-39 (i.e., suicide went up by 94% in June 2020 among females aged 20-29).[110,142] Tanaka and Okamoto, in addition, also detected suicide increases among Japanese adolescents.[143] In Brazil, increases affected especially men aged 60 and older and women aged 30-59 in the Northern region, and women aged >59 in the Northeastern region.[125]

Evidence is scarce regarding socioeconomic status: Only the study by Arya et al. in India reported that increases were 5-fold higher among males residing in low SES states.[145] Along these lines, Eguchi et al. reported results by job type – finding no variation in suicide among self-employed residents and increases in suicide throughout all pandemic periods among housewives (a specific category for females not employed outside of the home).[117]

Last, there is some evidence that suicide dynamics during the initial phases of the pandemic were affected by racial and ethnic minoritization in the United States: A study using state-wide data from Connecticut found that between March 10 and May 20, 2020 suicide increased by 60% among non-White individuals (a group that, in this study, included individuals of Black, Hispanic, Asian, and "Other" ethno-racial background), while it decreased to a 6-year low among White counterparts.[150] Likewise, in Maryland mean daily suicides increased by 94% among Black but decreased by 45% among White residents in 2020 compared to the 2017-2019 period, and after March 5, 2020 suicide had an increasing slope in Black residents (0.30, $p<0.01$) but a decreasing one in White counterparts (-0.19, $p<0.01$).[112]

2.4 Discussion

This systematic integrative literature review included all population-based estimates of changes in suicide during the months after the onset of the COVID-19 pandemic accessible using scientific databases and reported in English, Spanish, or French. I focused on describing heterogeneity in suicide variation across place and over time, as well as across population groups defined by sociodemographic characteristics. I did this for two reasons: first, the experience of the pandemic and of pandemic-related mental health stressors varied markedly across geographical and temporal contexts and persons – that is, "pandemic" as an exposure is ill-defined and, as such, of limited use to guide public health decision-making.[100,153] Focusing on differences across geographical or temporal contexts or population groups in suicide during the pandemic can guide identification of potential specific pandemic-related stressors (e.g., universal stay-at-home mandates without stimulus payments) or effect measure modifiers (e.g., level of uptake of remote work) that may function as actionable drivers of despair and suicide rates. Second, specific sociodemographic groups may have particularly high suicide risk during the pandemic and should be identified for prioritization of targeted interventions. The main finding was that, even though increases in suicide following the initial pandemic outbreak were not detected in most study locations, changes in suicide during the COVID-19 era varied geographically, temporally, and across population groups. To my knowledge, this is the first study to date to systematically examine variation across studies in suicide changes following onset of the pandemic.

I found that during the initial months of the pandemic, suicide decreased or remained unchanged in all locations with published data. This is in keeping with a previous systematic review including data up to July 2021.[39] Interpreting this finding is challenging, given that many experts expected increases in suicide driven by pandemic-related stressors,[36] and in light of increases in population prevalence of mental health symptoms[92–97] and suicidal thoughts[99] in several contexts. Not all studies suggested potential explanations for this finding. In many studies, reductions in suicide during the pandemic period were partially attributed to a temporal increase in social cohesion generated by the social disruption driven by the pandemic.[38,116,125,141] This phenomenon, sometimes referred to as "pulling together effect" and initially described in the work of Emile Durkheim,[154] has been previously reported in the aftermath of natural wars,[155] disasters,[156] pandemics,[154,157] and other major societal crises. Additional proposed explanations for lower-than-expected suicide rates included: a greater surveillance of youth due to extended stays at home with adult family members,[120,125] reduced access to means such as pesticides or medications,[114] crisis response strategies including bolstering mental health services to maintain access,[38,140] extended unemployment benefits and stimulus aids,[116,119] campaigns of mental health awareness bolstering videocall contact,[119] reductions in time living alone,[114] reductions in commuting time due to work-from-home policies,[110,143] reduction in stress among children and adolescents due to home schooling,[110,120,143] and in the particular case of Taiwan lack of need for physical distancing measures.[122,136]

As the pandemic evolved, however, subsequent increases in suicide were reported in specific locations: there were higher-than-expected suicide rates in Mexico, Puerto Rico, Japan, Vienna (Austria), Spain, Hungary, and Poland. In studies reporting monthly variation of suicide rates, higher-than-expected suicide rates started to be detected around 3-5 months after the initial outbreak.[114,121,123,126,139,142,143] For instance, several authors found suicide in Japan to have decreased between February and June 2020, with subsequent increases from July 2020 onwards.[139,142,143] Two observations stand out regarding suicide increases among specific population groups during the pandemic. First, increases were sex- and age-patterned in some locations. In Japan, increases in suicide took place earlier and were more marked among females (especially young females) than males.[117,121,123,139,142,143] In Guangdong (China),[152] Rhineland-Palatinate (Germany) and Emilia-Romagna (Italy),[133] and Taiwan,[136] on the contrary, suicides went up only among older adults (especially older men). Second, markers of minoritization and social disadvantage also played a role in suicide variation. For instance, in the United States, although suicide decreased after the initial outbreak in the general population, the decline was driven by decreases among White persons, with immediate increases reported among non-White residents in Connecticut[150] and Black residents in Maryland.[112]

Considering all available evidence, this review supports a potential role of (i) differences in risk of COVID-19 contagion and mortality and (ii) minoritization and socioeconomic disadvantage on suicide rates and trends during the pandemic. As mentioned, suicide rates increased disproportionately among older individuals and especially older males in some locations. COVID-19 incidence and mortality were also much higher in older adults than for the rest of the population during the initial phases of the pandemic,[158] likely contributing to increased fear of contagion and death, bereavement of partners and close friends, and loneliness due to isolation measures, stressors more acutely affecting older adults compared to their working-age counterparts. Death of a partner or close relative is a major risk factor for suicide in the short-term:[159] the increase in suicide risk following death of a spouse is highest in older adults[160] – especially among older males.[161] Importantly, while differences in risk of COVID-19 contagion and mortality may explain excess suicides among older adults, there are no clear differences between locations with and without increases in suicide among older individuals.

The potential role of minoritization and socioeconomic disadvantage as important actionable effect measure modifiers of the association between pandemic-related stressors and suicide is supported by observations from this review. First, suicide did not increase in countries where economic stimulus efforts were rapidly deployed (e.g., Australia,[138] United States[147]) but did increase in countries without such policies (e.g., Spain,[43] Mexico[111]). Moreover, in Japan, authors highlighted that economic relief policies implemented right after the initial pandemic outbreak were discontinued after June 2020 – which was followed by upward trends in suicide.[143] In fact, there is long-standing evidence that role of short- and long-term economic adversity (e.g., suicide) on suicide risk can be buffered by generous unemployment protection and overall expanded access to welfare.[75] Second, higher-than-expected suicide rates affected sociodemographic groups at higher economic vulnerability (i.e., at higher risk of unemployment, overrepresented in the hospitality and tourism industries, with lower access to remote job opportunities), such as young males and females of all ages in Japan.[117,132,142,143] Increases in caregiving burden[121,143] especially following school reopening[143] and in domestic violence[117,123,124] may also have played a role in increases in female suicide in Japan. All these factors are deeply intertwined, as overall increases in precarious and informal work typically re-establish women as an economically dependent flexible labor supply.[82] In the United States suicide increased only among ethno-racially minoritized residents,[112,150] the group with (i) the highest excess COVID-19 mortality,[162] (ii) the highest exposure to unemployment, and (iii) the lowest uptake of work-from-home policies.[163] In Mexico, researchers cited overcrowding as a potential cause for excess suicide mediated by excess COVID-19 incidence and mortality, as suicide increases were highest in Mexico City.[111] In Brazil, Orellana and de Souza emphasized that increases took place among older individuals in the Northern and Northeastern regions – the population groups with the lowest access to the Internet.[125]

There has been substantial debate regarding whether school closures may increase suicide risk among children and adolescents via reducing in-person social contact among youth. It is important to mention that, in general, adolescent suicide rates tend to be higher during school months than during vacation.[164] According to this review, it seems plausible that school closure was protective against suicide to some extent – data from Japan show that suicide among students decreased during the school closures of the first pandemic wave and subsequently increased after back-to-school mandates were passed.[143] Previous research has suggested that school closures may have a positive impact on students experiencing bullying at school – who can be at high risk for mental health disorders and suicide.[165,166]

The findings of this review have three important implications for public health decision-making. First, disproportionate increases in suicide among older individuals underscore the importance of targeting older individuals at high-risk for suicide (e.g., following loss of a partner of close friend), reducing social disconnectedness through early, proactive social care evaluation[167] and deploying older age-friendly suicide prevention strategies (e.g., within geriatric facilities). Also, this finding highlights the importance of further assessing differences in policies regulating safety nets for older adults between countries with and without suicide increases in this age group. Second, the enhancing role of minoritization and socioeconomic disadvantage for suicide risk during the pandemic suggests that additional protective socioeconomic measures (e.g., prolonged unemployment subsidies) should be put in place for individuals working low-wage, informal, and contingency jobs and those with reduced access to work-from-home positions. Third, suicide trends overall and by sociodemographic group should continue to be monitored across the globe, ideally reducing the lag between deaths take place and mortality data are available, given that suicide drivers can vary dramatically over time (e.g., firearm sales have recently gone up in the United States)[168] and to guide early identification of emerging high-risk groups.

This study has strengths worth noting. I based the review on an extensive search strategy that included multiple large databases. In addition, I used multiple reviewers to increase reliability of study selection and data extraction procedures, as well as of assessments of risk of bias. On the other hand, there were important methodological differences across studies (e.g., differences in the temporal definition of the COVID-19 or the control periods or in choice of statistical approach) that may account for part of the observed heterogeneity in results. Most studies, however, defined the COVID-19 period based on the date of the first confirmed case locally, used the previous 1-4 years as control period, and chose appropriate statistical methods for time-series analyses where an intervention (onset of the pandemic) is under consideration (i.e., interrupted time-series analysis using segmented regression or ARIMA models with appropriate adjustment for autocorrelation, seasonality, and non-stationarity). Moreover, the subset of studies examining suicide in Japan during the pandemic used a variety of designs but found overall similar results, suggesting relative robustness to choice of statistical approach.

In conclusion, this systematic integrative review including all population-based studies assessing changes in suicide following the onset of the pandemic found suicide trends during the pandemic to be heterogeneous across place and population subgroups and over time – though suicide rates remained unchanged or decreased in most locations. My findings support a relevant role of two factors modifying suicide risk among specific population groups during the pandemic. First, risk of COVID-19 contagion and mortality, as well as of bereavement and loss due to COVID-19, may explain the excess risk of suicide among older adults and especially males in several places – although explanations to why suicide among older adults only increased in some locations remain elusive. Second, socioeconomic vulnerability (e.g., vulnerability to unemployment, barriers to work-from-home jobs) may explain increases in suicide following interruption of stimulus aids and the excess risk of suicide among females and young males in Japan. Moreover, both factors affected ethno-racially minoritized persons in the United States, whose suicide risk also increased disproportionately. These findings highlight the importance of targeting social disconnectedness and deploying appropriate suicide prevention for older persons, ensuring access to labor market protection measures for socioeconomically vulnerable groups, and maintaining continued monitoring efforts to improve early detection of changes in suicide trends.

Chapter 3: The impact of the COVID-19 pandemic on suicide mortality in Spain: moderation by sex and age

3.1 Introduction

The initial COVID-19 pandemic outbreak profoundly impacted the mental health and wellbeing of the general population. A large body of evidence indicates increases in the overall population prevalence of mental health symptoms after April 2020 – especially for symptoms of depression and anxiety,[90,91] potentially due to stressors driven by the pandemic, such as fear of contagion, bereavement of loved ones, isolation and loneliness, negative economic effects, or disruption of mental healthcare delivery. At the same time, representative longitudinal surveys highlight remarkable variation in the mental health effects of the pandemic across population subgroups,[92–97] across place,[92,169] and over time.[94,95,97]

Initially, there was generalized concern that suicide mortality might also increase substantially,[36,170]. Surprisingly, an early interrupted time-series analysis found that suicide mortality remained stable or dropped in all 21 countries under study between April and July 2020.[38] Subsequent studies including up to December 2020, however, have highlighted substantial heterogeneity in suicide trends across place: Suicide rates dropped or remained unchanged in most study locations[138,140,141] but reports indicate increases in (i) suicide rates in Nepal between April 2020 and May 2021 (compared to 2019 as reference period and including month-fixed effects to account for seasonality and year-fixed effects to account for long-term trends),[135] (i) suicide counts in Puerto Rico, and Vienna, Austria between April and October 2020 (compared to expected counts using interrupted time-series analysis and accounting for seasonality),[38] (iii) suicide counts in Japan between July and October 2020 (compared to the corresponding period in the four prior years and accounting for underlying trends),[143] and (iv) additional preliminary evidence of crude increases in suicide counts in 2020 compared to 2019 in India[171] and compared to 2017 in Poland.[130] It is important to note that common limitations of most studies examining changes in suicide during the pandemic include use of short time periods (e.g., comparing suicide rates in 2020 vs. 2019) and suboptimal assessment and control for common threats to validity in time series analyses – e.g., autocorrelation, nonstationarity, and seasonality.[172]

Spain was initially one of the countries hardest hit by the pandemic – with the highest recorded COVID-19 incidence across Europe[40] during the spring of 2020 forcing a nation-wide stay-at-home order between March 15 and May 4.[54] Global Burden of Disease estimates suggest that Spain was among the top 5 European countries in terms of increase in prevalence of major depressive and anxiety disorders following onset of the pandemic.[41] However, whether Spain's suicide rate, traditionally one of the lowest among high-income countries,[47] increased following the onset of the pandemic remains unclear. Two studies have compared suicide risk in Spain between 2019 and 2020. First, a population-based study found no evidence of an increase in suicide mortality rates in 2020 in the Spanish region of Catalonia.[42] A subsequent nation-wide study also reported no annual differences but suggested slightly increased rates during the 2020 summer months[43] No studies have used longer study periods to assess changes on suicide mortality following the pandemic onset in Spain while accounting for pre-existing trends (i.e., non-stationarity) and seasonality, two common threats to validity in time-series analysis.[44]

In light of the heterogeneity of findings on suicide during the COVID-19 era, examining population subgroups can provide important insights to understand the dynamics of suicide risk during the pandemic: The impact of the pandemic on suicide should be heterogeneous across demographic groups due to differences in prevalence and vulnerability to stressors generated by the pandemic.

Further, investigating variations in suicide trends across population groups can help identify emerging high-risk groups and guide public health and clinical decision making.[173] Sex and age differences in variations in suicide mortality during the initial phases of the pandemic may exist based on sex- and age-specific effects of certain pandemic-specific stressors with potential impact on suicide risk. Predicting the direction of potential sex- and age-specific effects of the pandemic on suicide, however, is difficult as evidence regarding the sex- and age-specific distribution and impact of mental health stressors during the pandemic is mixed (i.e., heterogeneous across place and over time) and sometimes contradictory.[174–177]

Of a total 46 population-based studies assessing variations in suicide following the initial pandemic outbreak, the roles of sex and age on suicide trends were examined by 26 and 17 studies, respectively.[172] While most studies reported no evidence of effect moderation by sex or age group, two observations, the first one pertaining to several locations across the globe and the second one specific to Japan, stand out. First, during the summer and fall of 2020, the COVID-19 pandemic had a marked impact on suicide among men and women aged 65 years and older in Guangdong (China)[152] and Taiwan,[136] and specifically among males aged 65 years and older in Brazil[125] and the regions of Rhineland-Palatinate, in Germany, and Emilia-Romagna, in Italy.[133] These findings confirm early calls for specific suicide prevention efforts targeted towards older individuals.[178] Second, in Japan, early suicide increases were largely driven by increases among young males and females of all ages[132] – and especially females aged 20-39 years.[110] Reasons underlying these sex and age patterns in suicide mortality remain elusive at present time.

The roles of sex and age on suicide variations following the initial COVID-19 pandemic outbreak in Spain have not been studied. Here I used 2016-2020 suicide mortality data from Spain to investigate whether suicide mortality increased during the initial phases of the pandemic and to examine the potential moderation by sex and age.

3.2 Methods

Data source

I obtained 2016-2020 all-cause mortality data from Spain's National Institute of Statistics.[179] These publicly available and de-identified data consist of International Classification of Disease, Tenth Revision (ICD-10) codes indicating the underlying cause of death as recorded in death certificates by medical examiners and stored in Spain's single cause-of-death National Mortality Registry. For each death, I additionally retrieved information on sex (male/female) and age in years. Following previously implemented practices, I selected suicide deaths based on presence of ICD-10 codes X60-84 or Y87.0. Study procedures were approved by the Institutional Review Board of the Carlos III Health Institute, Madrid, Spain.

Analyses

COVID-19 transmission rates peaked in Spain towards the end of March 2020.[180] I used January 2016-March 2020 data to model trends of monthly suicide counts and forecast the expected monthly number of suicides between April and December 2020. I assumed constant denominators as Spain's population number and distribution remained roughly unchanged during the study period.[181] Then, to assess whether monthly suicide counts were higher than expected, I compared forecasted and observed monthly suicide counts between March and December 2020. All analyses were conducted for monthly suicides overall and by sex and age group.

Monthly suicide counts typically follow a seasonal pattern, with increases in late spring and summer and decreases in the winter, and autocorrelation across observations. Therefore, I implemented time series analysis.[44] I used seasonal autoregressive integrated moving averages (Seasonal ARIMA or SARIMA) models. SARIMA models are defined by the formula (p, d, q) x (P, D, Q, s), where p indicates the non-seasonal autoregression order, d indicates the non-seasonal differencing, and q indicates the non-seasonal moving average; while P indicates the seasonal autoregression order, D indicates the seasonal differencing, Q indicates the seasonal moving average, and s indicates the time span of the seasonal pattern. This procedure allowed me to model the data generating process while taking into account seasonality and trends.[44]

Each time series analysis was conducted following three steps.[44] I first assessed the mean, variance, and seasonality of suicide counts between January 2016 and March 2020 examining graphical representations of the temporal trends. Second, I obtained autocorrelation function (ACF) and partial autocorrelation function (PACF) plots to assess the presence of seasonality and trends. Third, I implemented the SARIMA models. For the main results, I selected model parameters using the auto.arima function in R, a variation of the Hyndman-Khandakar algorithm[182] – based on a combination of unit root tests, minimization of the Akaike Information Criterion (AIC), and maximum likelihood estimation to obtain the most parsimonious SARIMA model. Using the resulting SARIMA parameters, I modelled the observed number of suicides between January 2016 and March 2020 and forecasted the expected number of suicides and 95% Prediction Intervals (95% PI) between April and December 2020. For each model, I checked whether residuals deviated from white noise by examining the resulting residuals – including ACF plots of the residuals and p-values for the Ljung-Box statistic across different time lags.

I conducted four sets of sensitivity analyses. First, to assess the potential for model misspecification errors, I repeated all procedures selecting SARIMA model parameters manually instead of using the auto.arima command. To that end, I identified a set of potential combinations of parameters based on examination of ACF and PACF plots of the time series and selected the combination with the best fit as indicated by the lowest AIC and Bayesian Information Criterion (BIC).[44] Second, I examined the ability of SARIMA models to predict suicide outside of the period following the initial pandemic outbreak. To that end, I used January 2016-July 2019 data to predict monthly suicides and 95% PI for the August-December 2019 period and compared them to observed monthly suicide counts. Third, I repeated all procedures using the period between January 2010 and March 2020 for predictions – to examine the extent to which choice of the 2016-2020 period had impacted our results. Fourth, I repeated all models after excluding foreign-born individuals – given that in Spain foreign-born status is associated with suicide mortality and foreign-born individuals are disproportionately represented in younger age groups. All analyses were conducted using R version 4.1.1.

3.3 Results

Descriptive analyses

Between 2016 and 2020, there were 18,132 suicides in Spain – 13,481 among males and 4651 among females, 726 among individuals aged 15-24 years, 4385 among individuals aged 25-44, 7103 among individuals aged 45-64, and 5918 among individuals aged 65 years and older. The mean (standard deviation) monthly suicide counts were 302.2 (34.1) overall; 224.7 (27.8) among males and 77.5 (10.7) among females; and 73.1 (10.6) among individuals aged 25-44, 118.4 (14.4) among individuals aged 45-64, and 98.6 (16.6) among individuals aged 65 years and older.

Figure 3.1 Monthly suicides in Spain between January 2016 and December 2020

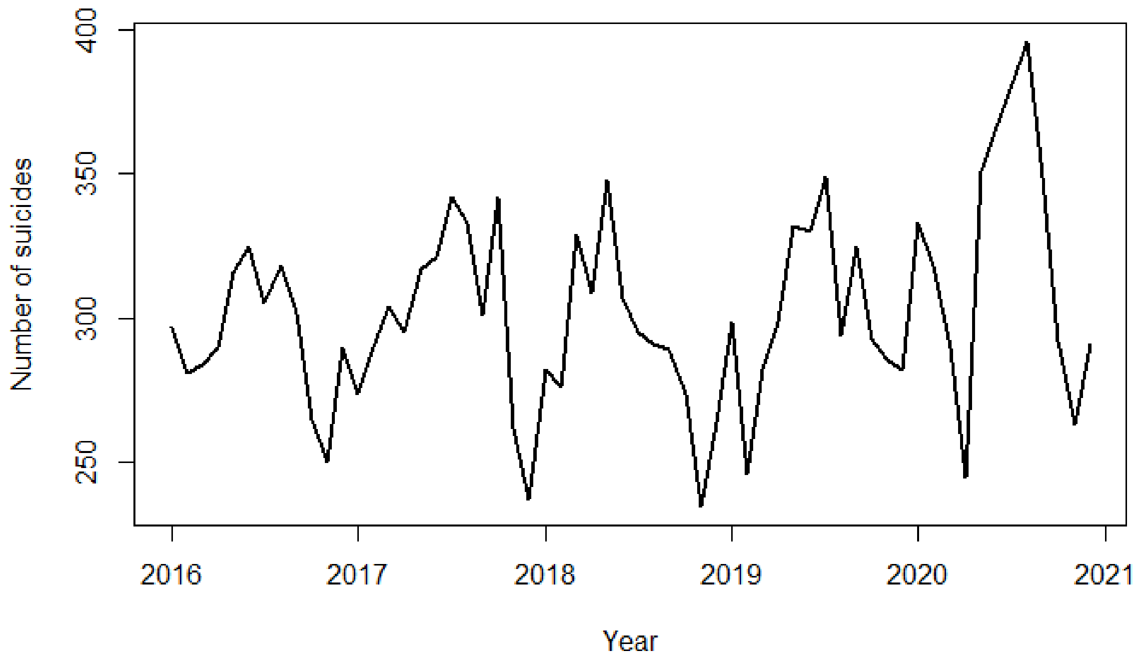


Figure 3.1 represents time trends in monthly suicides in Spain between January 2016 and December 2020. Overall, monthly suicides ranged between 235 suicides in November 2018 and 396 in August 2020. As expected, monthly suicide counts followed a robust seasonal pattern every year, peaking in spring and summer months and decreasing over the winter. Importantly, compared to previous years, in 2020 there was a marked increase in monthly suicides that extended between late spring and early fall (supplementary figure 10).

Forecasting models and excess suicide assessment

Supplementary table S3 summarizes the parameters used to specify SARIMA models for 2016-2020 monthly suicide counts in Spain, overall and across sex, age group, and foreign-born status. Of note, monthly suicide counts among individuals aged 15-24 were very low and relatively unstable – ranging between 5 and 18 monthly suicides in July and September 2020, respectively; and there was no seasonal component. I did not conduct further analyses in this age group.

Figure 3.2 represents observed and predicted monthly suicide counts for the 2016-2020 period in Spain. For forecasted months (April-December 2020), I also include 95% PI. Overall, suicide counts were 17% lower than predicted in April 2020 and higher than predicted between May and September 2020. Notably, the excess number of suicides was highest (over 30% higher than predicted) in July and August 2020. Supplementary figures S11 and S12 represent sex-specific 2016-2020 observed and predicted monthly suicide counts.

Figure 3.2 Observed and predicted suicides in Spain between January 2018 and December 2020, including 95% prediction intervals for the April-December 2020 period

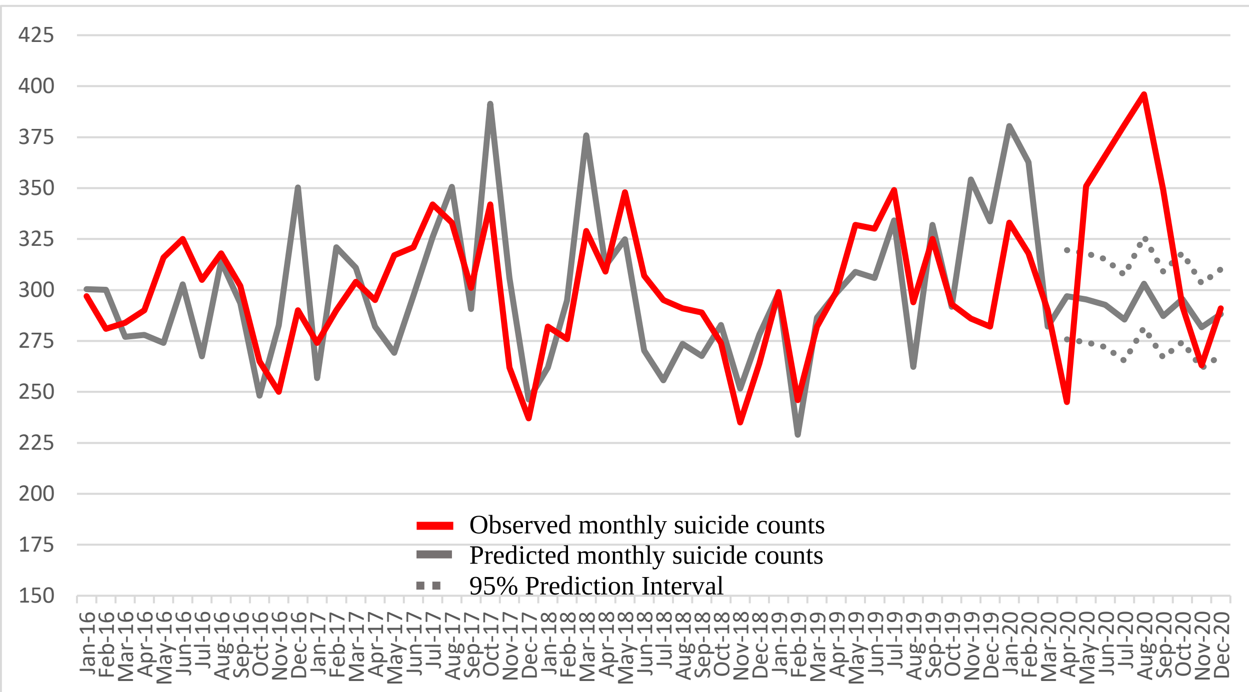


Figure 3.3 and supplementary table S4 summarize observed and predicted (95% PI) monthly suicide counts between April and December 2020 in Spain and the difference between predicted and observed suicides, overall and by sex. Figures 3.4 and 3.5 and supplementary tables S5 and S6 summarize observed and predicted (95% PI) sex-specific monthly suicide counts between April and December 2020 in Spain, presented by age group.

Figure 3.3 Observed and predicted monthly suicides between April and December 2020 in Spain, overall and by sex

Type	Months	Observed	Predicted	% Change
Overall	Apr−20	245	296.9	−17
	May−20	351	295.3	19
	Jun−20	366	292.8	25
	Jul−20	381	285.5	33
	Aug−20	396	303.1	31
	Sep−20	349	287.2	22
	Oct−20	292	295.5	−1
	Nov−20	263	281.7	−7
	Dec−20	291	288.2	1
Male	Apr−20	189	215.8	−12
	May−20	256	220.8	16
	Jun−20	288	218.8	32
	Jul−20	286	210.8	36
	Aug−20	300	221.7	35
	Sep−20	259	210.4	23
	Oct−20	213	219.2	−3
	Nov−20	200	212.8	−6
	Dec−20	212	214.9	−1
Female	Apr−20	56	84.5	−34
	May−20	95	73.9	29
	Jun−20	78	73.5	7
	Jul−20	95	76.6	24
	Aug−20	96	80.9	19
	Sep−20	90	79.3	14
	Oct−20	79	76.2	4
	Nov−20	63	69.5	−10
	Dec−20	79	73.6	8

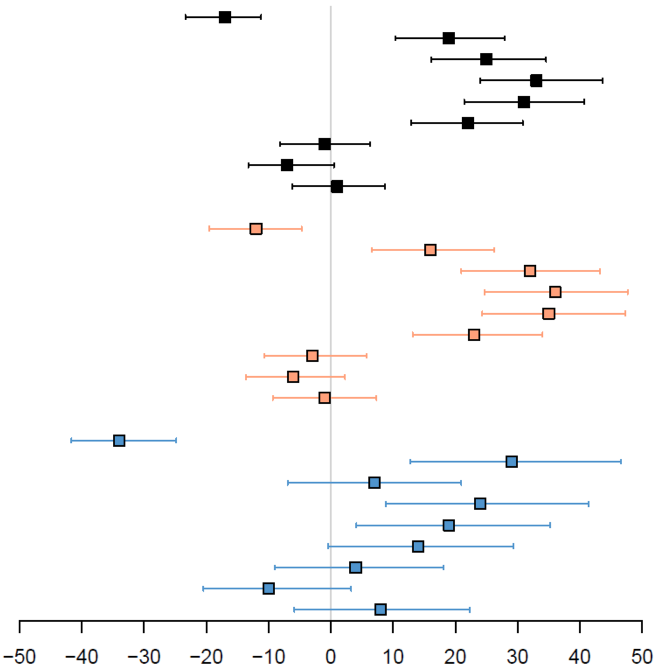


Figure 3.4 Observed and predicted monthly male suicides between April and December 2020 in Spain by age group

Age group	Month	Observed	Predicted	%Change
25−44 years	Apr−20	43	54.2	−21
	May−20	56	54	4
	Jun−20	72	59	22
	Jul−20	72	49.6	45
	Aug−20	59	50.1	18
	Sep−20	72	52.9	36
	Oct−20	51	52.4	−3
	Nov−20	46	52.9	−13
	Dec−20	55	55.1	0
45−64 years	Apr−20	74	84.8	−13
	May−20	96	87.3	10
	Jun−20	93	84.6	10
	Jul−20	104	85.3	22
	Aug−20	119	90.7	31
	Sep−20	99	83.1	19
	Oct−20	93	87.6	6
	Nov−20	77	86	−10
	Dec−20	87	85.1	2
>64 years	Apr−20	65	70.5	−8
	May−20	98	72	36
	Jun−20	112	72.1	55
	Jul−20	106	69.7	52
	Aug−20	112	73.9	52
	Sep−20	72	66.9	8
	Oct−20	58	71	−18
	Nov−20	64	67.1	−5
	Dec−20	62	66	−6

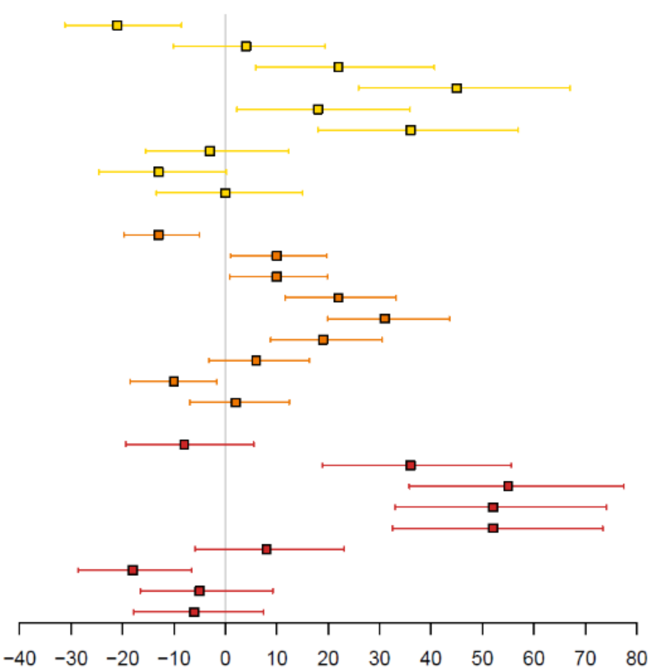
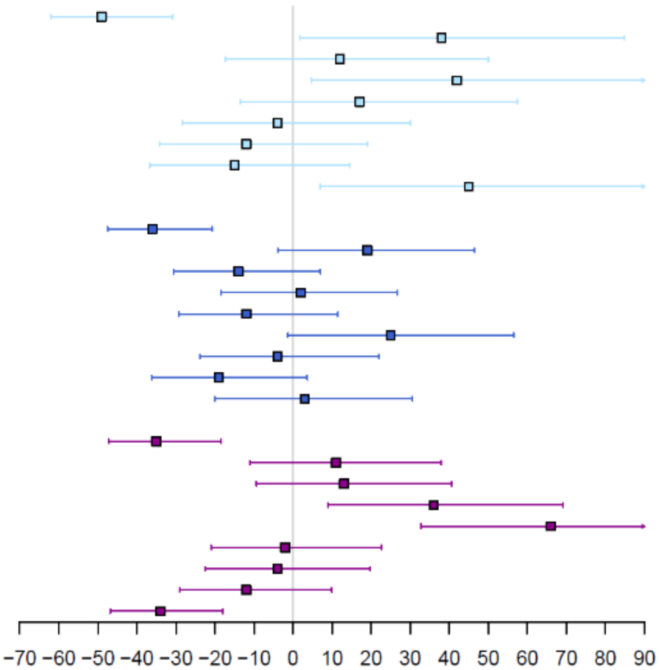


Figure 3.5 Observed and predicted monthly female suicides between April and December 2020 in Spain by age group

Age group	Month	Observed	Predicted	%Change
25−44 years	Apr−20	9	17.6	−49
	May−20	22	16	38
	Jun−20	18	16.2	12
	Jul−20	22	15.5	42
	Aug−20	20	17.1	17
	Sep−20	16	16.5	−4
	Oct−20	15	16.9	−12
	Nov−20	15	17.6	−15
	Dec−20	23	15.9	45
45−64 years	Apr−20	24	37.2	−36
	May−20	42	35.4	19
	Jun−20	32	37.1	−14
	Jul−20	38	37.4	2
	Aug−20	33	37.2	−12
	Sep−20	46	37	25
	Oct−20	34	35.3	−4
	Nov−20	26	32	−19
	Dec−20	38	37.2	3
>64 years	Apr−20	18	27.5	−35
	May−20	28	25.3	11
	Jun−20	27	23.9	13
	Jul−20	34	25	36
	Aug−20	43	26	66
	Sep−20	26	26.4	−2
	Oct−20	25	25.9	−4
	Nov−20	21	23.8	−12
	Dec−20	16	24.2	−34



While the period encompassing late spring, summer, and early fall of 2020 was characterized by excess suicide deaths in most sociodemographic groups, results suggest particularly salient suicide increases in older males. There were lower-than-predicted male suicide counts in April 2020 in all groups aged <65 years. Among males aged 65 and older, on the contrary, suicide counts in April 2020 remained roughly in line with predictions – that is, there was no discernible early phase of suicide risk decrease among older males. Between May and September 2020, male suicide counts were higher than predicted, peaking in June, July, and August 2020 (+32%, +36%, and +36%, respectively). Suicides were remarkably higher than predicted among males aged 65 years and older in June, July, and August 2020 (+56%, +53%, and +52%, respectively). Last, suicides among older males were 19% lower than predicted in October 2020.

Among females, suicide counts were lower than predicted across age groups in April 2020 (-34% overall). Female suicide counts were also higher than predicted over the summer, although to a lesser magnitude than among males – e.g., female suicide counts were 19% higher than predicted in August 2020. Between age group differences were less marked among females than in males, though female suicide in the 65 years and older group peaked in August 2020 with a striking 66% excess of suicide deaths. Suicides among older females were 34% lower than predicted in December 2020.

Results from the first sensitivity analysis, where I defined SARIMA parameters based on examination of ACF and PACF plots and comparison of AIC and BIC, did not differ from main results, suggesting robustness to potential model misspecifications. The second sensitivity analysis, examining the ability of SARIMA models to predict suicide during the late summer and fall of 2019, suggested good forecasting performance (supplementary figure 13). In the third sensitivity analysis, using January 2010-March 2020 instead of January 2016-March 2020 as reference period did not affect findings. In the fourth sensitivity analysis, results after exclusion of foreign-born individuals indicated even more salient higher-than-expected suicide counts among males aged 65 years and older in June and July 2020 (+71% and +70%, respectively) and no evidence of excess suicide counts among females aged 25-64 years during any recorded month. Results for males aged 25-64 years and females aged 65 years and older were roughly similar before and after exclusion of the foreign-born.

3.4 Discussion

I assessed the difference between observed and predicted monthly suicides in Spain following the initial COVID-19 pandemic outbreak. I found the number of monthly suicides in Spain to be lower than predicted in April 2020 and higher than predicted between May and

September 2020, overall and in virtually all sociodemographic groups as defined by sex and age. Suicide counts peaked in Spain between July and August 2020, with suicide counts over 30% higher suicide than predicted. Excess suicides during the summer of 2020 in Spain were largely driven by remarkably higher-than-predicted suicide counts among older males – with over 50% higher monthly suicide counts than predicted between June and August 2020. This study confirms that suicide increased during the initial phases of the pandemic in Spain by quantifying monthly differences between observed and predicted suicide counts – after accounting for autocorrelation, non-stationarity (i.e., underlying trends) and seasonality. In addition, I provide sociodemographic group-specific estimates of monthly variations in suicide following the onset of the pandemic, highlighting the importance of suicide among older individuals and especially older males. These results should enhance our understanding of the ways in which the pandemic impacted suicide risk in vulnerable population subgroups and help guide public health and clinical suicide prevention efforts.

The finding that suicide counts were overall lower than expected in April 2020, immediately following the initial pandemic outbreak in Spain, is in keeping with reports from countries and regions across the globe.[38,119,143] Interpreting these temporary decreases in suicide mortality is challenging, as suicide decreases were not expected[36,170] based on the socioeconomic stressors brought about by the pandemic and on increases in population-level prevalence of mental health symptoms[90,91] and suicidal thoughts.[99] On the one hand, suicide mortality can decrease in the early aftermath of certain major adverse societal events – including some natural disasters,[156] wars,[155] genocides,[183] terrorist attacks,[184] or pandemics.[154,157] Emile Durkheim's foundational work on suicide highlighted how wars and other major societal disruptors can result in temporary increases in social cohesion, sometimes referred to as "pulling together" effect,[154] that can lead to decreases in suicides.[9] On the other hand, not all major societal crises are followed by initial decreases in suicide: immediate suicide increases of variable magnitude are characteristic of large economic depressions (e.g., the great 1929-1939 depression in the US,[185] the post-soviet economic collapse,[186] or the 2008 economic recession in Europe[16,50,51] and the US[187]) and were also present after the 2003 Severe Acute Respiratory Syndrome (SARS) outbreak in Hong Kong – at least among older adults.[188]

Suicide counts, however, were higher than predicted throughout the summer and early fall of 2020. This finding, confirming prior reports that suggest increases in suicide in Spain in 2020 compared to 2019,[43] does not lend itself to easy interpretation – especially since suicide did not increase following the initial pandemic outbreak in the majority of countries and regions across the globe.[38] An explanation to why the initial lag between the pandemic outbreak and increases in suicide was seemingly shorter in Spain than in other regions (e.g., Japan[143]) also remains elusive at present time. Examining the impact of the pandemic on Spain's economy may help understand this finding. Spain's economy, with a -10.8% negative change of rate of gross domestic product (GDP) in 2020,[189] was the hardest hit across Europe. Reasons for the disproportionate economic impact of the pandemic in Spain remain under debate, but the large direct contribution of tourism to Spain's economy played an important role. In Spain, tourism provided 12.3% of GDP and 12.7% of employment in 2018[190] - leading the Organization for Economic Cooperation and Development in both metrics.[191] In 2020, in the context of travel restrictions, stay-at-home mandates, and other contagion containment measures, tourism in Spain fell by an unprecedented 72.4%.[192] Largely as a result of this, the unemployment rate increased progressively by 4% in March 2020, 11% in June 2020, and 18% in September 2020. There is long-standing evidence that economic downturns can increase suicide risk,[187,193] an effect partially mediated by increases in unemployment[16] and moderated by welfare systems and labor market protection.[75] Two observations may support a potential role of unemployment in excess suicide during the initial phases of the pandemic: First, suicide peaked in July and August 2020 – coinciding with (what should have been) peak tourism season in Spain. Second, our sensitivity analysis excluding foreign-born individuals suggests that excess suicides among females aged 25-44 years during summer 2020 were driven almost exclusively by suicides among foreign-born females. According to official registries, the March-June 2020 increase in unemployment rate among foreign-born women aged 35-44 years was more than two-fold greater than that of native-born counterparts (10.4% vs. 4.7% increases, respectively).[179] Because the association between unemployment and suicide is moderated by labor market protection, these results should generate debate regarding the role of welfare systems on suicide risk among socioeconomically vulnerable groups during major economic downturns.

Our main finding was that strikingly high suicide counts in individuals aged 65 and older, especially among older males, largely drove higher-than-predicted monthly suicide counts during summer 2020 in Spain – in line with what has been reported in Italy,[133] Germany,[133] and Brazil.[125] This finding may be related to older people's increased vulnerability to COVID-19 mortality as well as to certain pandemic-related social stressors. As mentioned, Spain was one of the hardest hit countries by the initial pandemic wave,[40] leading to the temporary collapse of the healthcare delivery[194,195] and resulting on the third largest reduction in life expectancy in 2020 across Europe (after Bulgaria and Lithuania).[196] Importantly, COVID-19 incidence and mortality were much higher among older adults than for the rest of the population during the initial outbreak in Spain, one the of the countries with the highest proportion of older adults:[197] Between January and May 2020, population mortality rates due to COVID-19 were 0.06% and

1.2% for people aged <65 and ≥ 65 years. Spain's 2020 reduction in life expectancy was almost entirely driven by increased mortality in the ≥ 80 years age groups.[198] Accordingly, several pandemic-related stressors were seemingly more intense among older than younger groups of the population – including but not limited to fear of contagion and death, loss and bereavement of partners and close friends, or isolation due to social distancing measures and erosion of the sense of community with loss of informal structures of emotional support.[199] There is long-standing evidence that self-reported mental health and perceptions of social support are strongly associated among older individuals.[200] In addition, and perhaps more importantly to explain our results, death of a close relative has long been considered an important risk factor for suicide, especially during the earliest phases of bereavement.[159] The association between death of a partner and suicide becomes stronger with older age and is particularly salient among older males,[160] which may explain the gendered pattern I observed in suicide risk among older people in Spain. A Danish population-based study found older males' suicide risk immediately following death of the spouse to be 15-fold higher the risk of middle-aged married counterparts.[161] Thwarted belongingness and perceived burdensomeness, key concepts within prevailing psychological theories of suicide,[201] may help understand the process through which risk of suicide among older males increases following widowhood – especially in the context of the COVID-19 pandemic, with social distancing limiting social and family contact. Importantly, even though increases in suicide among older men during the initial pandemic months have been reported in some locations, this has not been a generalized finding across the globe. Explanations to this phenomenon remain elusive at present time, and surveillance coupled with comparisons across contexts should help further understand why suicide rates among older males only increased in specific places. One potential explanation is economic stress: In Spain, where grandparents play a cornerstone role in family economy[202] and more than 35% of households are sustained by older people's retirement pensions, the downstream economic effects of the pandemic might have brought about unprecedented economic and psychological stress to older people. Importantly, widowhood also generates substantial economic stress: On average, survivor pensions in Spain amount to less than 52% of the deceased's retirement pension total.[203]

Preventing suicide among high-risk older individuals can be challenging because of age-specific risk factors that function as barriers for help-seeking – such as social disconnectedness and isolation[204] or disability (e.g., hearing impairment or walking difficulties).[205] Our findings should emphasize the importance of developing and implementing age-friendly suicide prevention strategies (e.g., strategies deployed within general medicine or geriatric facilities) and preventing social disconnectedness through early, proactive social care evaluation.[167]

This study raises more questions than it answers – there is still much to learn about the dynamics of suicide during the COVID-19 era. However, these findings may enhance understanding of the potential causal mechanisms underlying increases in suicide in Spain during the initial phases of the pandemic, underscoring the importance of acting upon the socioeconomic and political drivers of suicide following major societal crises. Additionally, these results highlight the importance of enhancing access to care during suicidal urges. There is indirect evidence that delivery of emergency psychiatric care was somewhat disrupted during the initial phases of the COVID-19 pandemic in Spain.[199] Barriers in access to social and clinical help during suicidal crises are particularly concerning among older adults due to reasons such as social disconnectedness[204] or physical impairment.[205] Development, deployment, and scale-up of easy to access, older age-friendly, and culturally adaptive mental healthcare and suicide-specific interventions is paramount for suicide prevention efforts during major adverse societal crises.

This study has limitations. First, suicide mortality data are subject to potential certification error.[206,207] Second, the validity of these results depends on the appropriateness of the modelling strategy. While our sensitivity analyses seemingly endorse choice of type of time series analysis and of SARIMA parameters, suggesting robustness to potential modelling decisions and model misspecification, I cannot rule out potential mistakes modelling the underlying data generating structure of our time series. Third, I did not examine separately different events taking place during the spring and summer of 2020 (i.e., onset of the pandemic, adoption of contagion control measures, etc.) – hence this study is not equipped to test the potential causal effect of each of these events on suicide increases. Fourth, I used monthly suicide counts, rather than rates, due to data availability. However, Spain's population has remained roughly stable in terms of number and age distribution between 2016 and 2020.[179] Moreover, considering the striking COVID-19 mortality experienced by older adults during spring 2020 in Spain, use of suicide counts instead of rates probably biased results towards the null hypothesis in this age group – that is, the monthly suicide rates probably were even more higher-than-expected than monthly suicide counts among older individuals during summer 2020 in Spain. Fifth, the data did not allow for examination of additional potentially vulnerable groups with important implications for public health decision making – such as low SES individuals, racial/ethnic minorities, frontline workers, or people living with mental disorders. Sixth, while I considered Spain as a whole unit of analysis, there were important differences across Spanish regions in terms of both COVID-19 incidence[208] and negative economic impact.[192] Future research should examine the geographical variation in suicide across regions in Spain in 2020.

In conclusion, I found higher-than-predicted suicide counts during the late spring, summer, and early fall of 2020 in Spain, revealing that the timing and patterns of suicide following the initial pandemic outbreak largely did not follow expectations. By identifying particularly salient periods and demographic groups, I enhance understanding of the potential drivers of puzzling suicide dynamics during the COVID-19 pandemic. In particular, I found that early increases in suicide in Spain were largely driven by striking increases in suicide among older individuals – especially older males. These findings have important implications for suicide prevention and should highlight the importance of (i) interpreting early declines in suicide following the initial pandemic outbreak with caution, (ii) acting upon the social drivers of suicide increases, and (iii) enhancing access to and quality of mental healthcare for suicide prevention during major adverse societal events.[209]

Conclusion

In this dissertation, I started by examining differences in suicide trends following the 2008 economic recession between native- and foreign-born individuals residing in Spain. I used an age-period-cohort analysis approach to enhance understanding of the potential mechanisms underlying such trends. I then synthesized the existing evidence concerning suicide trends following the initial phases of the COVID-19 pandemic through a systematic integrative review with a focus on geographical and temporal variation as well as on differences between sociodemographic groups as defined by potential markers of vulnerability. Finally, I assessed if monthly suicide counts following the initial pandemic outbreak in Spain were different than expected using SARIMA predictive models, an approach that correctly takes into account autoregression, non-stationarity, and seasonality – three common threats to time series analysis and forecasting that are often not controlled for in similar studies.

Summary of findings

In the first chapter, I found that, between 2000 and 2019 in Spain, suicide mortality rates were overall lower among foreign- than native-born residents. Age-period-cohort models revealed that, while suicide mortality remained roughly stable among native-born men over the study period, there were (i) marked increases after 2010 among foreign-born individuals, with a particularly salient peak among foreign-born women born around 1950; and (i) slight increases among cohorts of native-born women born after 1960.

These results underscore the importance of examining risk among vulnerable populations during major societal crises. Migrants residing in Spain experienced the starkest increases in unemployment rate and a slower economic recovery than native-born counterparts following the 2008 economic recession. In addition, irregular migrants' access to Spain's universal tax-funded healthcare system and welfare services was limited to emergency care due to austerity policies put in place to control expenditure during the aftermath of the recession. In fact, our sensitivity analysis examining foreign-born residents without Spanish citizenship (a proxy for lack of residency permit) indicated that increases in suicide among migrants were largely driven by this vulnerable groups. These findings from Spain can help understand the potential effects of austerity policies that reduce welfare in other contexts – as well as highlight the effects of welfare/safety net expansion policies, such as those undertaken in the United States during the initial months of the pandemic. Our result should guide further research examining the impact of austerity policies on social wellbeing and mental health of socioeconomically vulnerable population groups.

In the second chapter, my systematic integrative review revealed substantial heterogeneity in suicide rates and trends during the months following the initial COVID-19 pandemic outbreak – heterogeneity across place, over time, and across population subgroups. This heterogeneity was largely due to geographical and temporal variation in the intensity of pandemic-related stressors: under multiple versions of the exposure of interest (i.e., the COVID-19 pandemic), the consistency assumption of causal inference is violated[100,101] and one effect of the pandemic on suicide cannot be estimated. Variations in the distribution of potential effect measure modifiers are an additional source of heterogeneity in the effects of the pandemic on suicide. For example, in the absence of social welfare support, the potential negative mental health impact of stay-at-home mandates may be more intense among individuals unable to secure income working from home.

I aimed at examining potential factors that may explain the heterogeneity in results and be of help for public health and policy decision makers. Overall, three observations stand out in terms of potential implications for stakeholders. First, while in most locations suicide did not increase or even decreased during the initial months of the pandemic, subsequent delayed increases after a variable period were detected in several places – highlighting the importance of maintaining an appropriate monitoring of suicide trends, ideally with near real-time data sources. Second, increases in suicide risk were more common among sociodemographic groups exposed to the highest COVID-19 contagion and mortality risks – e.g., older adults in many locations, racially minoritized adults in the United States, etc. These groups seemingly faced a higher intensity of pandemic-related stressors such as fear of contagion and death, bereavement of loved ones, and loneliness. Third, increases were also more common in countries without strong early economic stimulus policies, where the economic impact of the pandemic was starker and earlier, and especially among sociodemographic groups at highest risk of unemployment – such as those without ability to work from home, especially females and minoritized persons who are overrepresented in the hospitality sector. This evidence underscores the importance of putting in place structurally competent early responses to socioeconomic despair among vulnerable groups.

In the third chapter, I found that observed monthly suicide counts after April 2020 in Spain were higher than predicted by an appropriate specification of SARIMA predictive models using data from the four prior years. This finding clarifies existing debate as to whether suicide in Spain, one of the initial global COVID-19 hotspots, increased during the initial phases of the pandemic. Further, I found that increases were largely present across demographic groups but particularly marked among older adults – especially in older males. This finding was robust across several sensitivity analysis and was found to be independent of inclusion of foreign-born individuals, a group with higher vulnerability to suicide during societal crises.

This finding ads to the evidence highlighted by chapter 2 in terms of potentially actionable social determinants of suicide during the COVID-19 pandemic, and can guide further research examining policy interventions

Strengths and limitations

This dissertation has general strengths and limitations that are important to consider. The main limitation, as is usually the case when working with suicide mortality data (especially if they come from single cause mortality registries), is the potential for certification errors.[206,207] Suicide certification is based on assessment of intentionality – sometimes intentionality is diffuse (e.g., drug poisonings, car crashes, falls from height). This limitation may be present in all three chapters. Another important limitation than impacts chapters 1 and 3 are potential errors in terms of modelling strategy (i.e., choice of age-period-cohort model specification in chapter 1, choice of SARIMA parameters in chapter 3). We tested robustness to potential model misspecifications implementing extensive sensitivity analyses that overall did not show such errors, but I cannot rule them out definitely. Also, we did not test the effect of well-defined interventions (e.g., withdrawal of access to specialized care for migrants without residency permit, stay-at-home mandates without supplementary welfare support) – which may be the most important limitation in terms of causal inference and potential implications for decision-making. Well-defined interventions enhance interpretability and applicability of results.

The main strength of this dissertation is the use of sophisticated methodological techniques coupled with strong theoretical rationale in the two empirical chapters that aim to address potential pitfalls of observational research with administrative data sources. For example, I used transparent, theoretical frameworks to guide selection of statistical approach: Stratified age-period-cohort modelling to examine the potential impact of the Great Recession on foreign- and native-born individuals allows for assessment of effects that are shared by individuals of all ages and birth cohorts – period effects and of effects that are shared by individuals born into a particular temporal context – cohort effects. Age- and sex-stratified SARIMA predictive models, which are appropriate for time series analysis where autocorrelation, non-stationarity, and seasonality are concerns for validity, allow for the examination of demographic groups at higher theoretical risk of suicide during the pandemic.

Next steps

These results should underscore the importance of taking the context into account when conceptualizing the potential impact of major societal crises on suicide mortality rates and trends. Public health decision-making needs to incorporate broad conceptual models that allow for the interrogation of multiple levels of organization to capture the socioeconomic and political settings where suicide unfolds across the life course and in response to major stressors. Incorporating causes beyond the proximal is critical to develop a socially conscious approach to suicide prevention efforts.

The population-level analyses employed in this dissertation have the benefit of measuring population-level negative consequences of major societal crises on suicide risk. As argued in the introduction section, population-level assessments are important to guide public health decision-making. However, these analyses need to be complemented with individual-level analyses focused on the deceased's particular circumstances to provide a complete understanding of suicide, a complex multi-causal and multi-level phenomenon, during societal crises. Future research should attempt to access individual-level information.

From a pragmatic standpoint, studies examining well-defined interventions are warranted as next step. While our results should be of use for public policy decision-makers, especially as our findings are intuitive within a social epidemiology theoretical framework, causal inference and decision-making would be greatly enhanced by studies examining the impact of specific versions of the exposures under consideration.

References

1. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*. 2020;396(10258):1204-1222. doi:10.1016/S0140-6736(20)30925-9

2. Rose GA. *The Strategy of Preventive Medicine / Geoffrey Rose.* Oxford University Press; 1992.

3. Linehan MM, Comtois KA, Murray AM, et al. Two-year randomized controlled trial and follow-up of dialectical behavior therapy vs therapy by experts for suicidal behaviors and borderline personality disorder. *Arch Gen Psychiatry*. 2006;63(7):757-766. doi:10.1001/archpsyc.63.7.757

4. Gunnell D, Knipe D, Chang SS, et al. Prevention of suicide with regulations aimed at restricting access to highly hazardous pesticides: a systematic review of the international evidence. *Lancet Glob Health*. 2017;5(10):e1026-e1037. doi:10.1016/S2214-109X(17)30299-1

5. Susser M. The logic in ecological: II. The logic of design. *Am J Public Health*. 1994;84(5):830-835. doi:10.2105/AJPH.84.5.830

6. Susser M, Susser E. Choosing a future for epidemiology: II. From black box to Chinese boxes and eco-epidemiology. *Am J Public Health*. 1996;86(5):674-677. doi:10.2105/AJPH.86.5.674

7. Susser MW. *Causal Thinking in the Health Sciences: Concepts and Strategies in Epidemiology*.; 1976.

8. Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 2001;30(3):427-432. doi:10.1093/ije/30.3.427

9. *Durkheim, E., Spaulding, J. A., & In Simpson, G. (1966). Suicide: A Study in Sociology*.

10. Naghavi M. Global, regional, and national burden of suicide mortality 1990 to 2016: systematic analysis for the Global Burden of Disease Study 2016. *BMJ*. 2019;364:l94. doi:10.1136/bmj.l94

11. Pettrone K, Curtin SC. Urban-rural Differences in Suicide Rates, by Sex and Three Leading Methods: United States, 2000-2018. *NCHS Data Brief*. 2020;(373):1-8.

12. Facebook, Twitter, options S more sharing, et al. Economic hardship tied to increase in U.S. suicide rates, especially in rural areas. Los Angeles Times. Published September 6, 2019. Accessed March 6, 2021. https://www.latimes.com/science/story/2019-09-06/economic-hardship-suicide-rates

13. Martínez-Alés G, Pamplin JR, Rutherford C, et al. Age, period, and cohort effects on suicide death in the United States from 1999 to 2018: moderation by sex, race, and firearm involvement. *Mol Psychiatry*. Published online April 7, 2021. doi:10.1038/s41380-021-01078-1

14. Martínez-Alés G, Gimbrone C, Rutherford C, et al. Role of Firearm Ownership on 2001-2016 Trends in U.S. Firearm Suicide Rates. *Am J Prev Med*. Published online August 19, 2021:S0749-3797(21)00357-3. doi:10.1016/j.amepre.2021.05.026

15. Ehlman DC, Yard E, Stone DM, Jones CM, Mack KA. Changes in Suicide Rates - United States, 2019 and 2020. *MMWR Morb Mortal Wkly Rep*. 2022;71(8):306-312. doi:10.15585/mmwr.mm7108a5

16. Stuckler D, Basu S, Suhrcke M, Coutts A, McKee M. Effects of the 2008 recession on health: a first look at European data. *Lancet Lond Engl*. 2011;378(9786):124-125. doi:10.1016/S0140-6736(11)61079-9

17. Lopez Bernal JA, Gasparrini A, Artundo CM, McKee M. The effect of the late 2000s financial crisis on suicides in Spain: an interrupted time-series analysis. *Eur J Public Health*. 2013;23(5):732-736. doi:10.1093/eurpub/ckt083

18. Salmerón D, Cirera L, Ballesta M, Navarro-Mateu F. Time trends and geographical variations in mortality due to suicide and causes of undetermined intent in Spain, 1991-2008. *J Public Health Oxf Engl*. 2013;35(2):237-245. doi:10.1093/pubmed/fds103

19. Karanikolos M, Mladovsky P, Cylus J, et al. Financial crisis, austerity, and health in Europe. *The Lancet*. 2013;381(9874):1323-1331. doi:10.1016/S0140-6736(13)60102-6

20. Ayuso-Mateos JL, Barros PP, Gusmão R. Financial crisis, austerity, and health in Europe. *Lancet Lond Engl*. 2013;382(9890):391-392. doi:10.1016/S0140-6736(13)61663-3

21. Cayuela A, Cayuela L, Sánchez Gayango A, Rodríguez-Domínguez S, Pilo Uceda FJ, Velasco Quiles AA. Suicide mortality trends in Spain, 1980-2016. *Rev Psiquiatr Salud Ment*. 2020;13(2):57-62. doi:10.1016/j.rpsm.2018.07.002

22. Alfonso-Sánchez JL, Martin-Moreno JM, Martinez IM, Martinez AA. Epidemiological Study and Cost Analysis of Suicide in Spain: Over 100 Years of Evolution. *Arch Suicide Res Off J Int Acad Suicide Res*. 2020;24(sup2):S356-S369. doi:10.1080/13811118.2019.1612802

23. Cayuela L, Sánchez Gayango A, Sánchez-Trincado PA, Rodríguez-Domínguez S, Velasco Quiles AA, Cayuela A. Suicide mortality in Spain (1984-2018): age-period-cohort analysis. *Rev Psiquiatr Salud Ment*. Published online July 13, 2020:S1888-9891(20)30068-9. doi:10.1016/j.rpsm.2020.05.010

24. Tasas de paro por nacionalidad, sexo y comunidad autónoma https://www.ine.es/jaxiT3/Datos.htm?t=4249#!tabs-grafico.

25. Harper S, Riddell CA, King NB. Declining Life Expectancy in the United States: Missing the Trees for the Forest. *Annu Rev Public Health*. 2021;42(1):null. doi:10.1146/annurev-publhealth-082619-104231

26. López-Cuadrado T, Hernández-Calle D, Martínez-Alés G. Trends in suicide mortality in Spain, 2000–2019: Moderation by foreign-born status. *J Affect Disord*. 2022;300:532-539. doi:10.1016/j.jad.2022.01.031

27. Ajdacic-Gross V, Bopp M, Gostynski M, Lauber C, Gutzwiller F, Rössler W. Age-period-cohort analysis of Swiss suicide data, 1881-2000. *Eur Arch Psychiatry Clin Neurosci*. 2006;256(4):207-214. doi:10.1007/s00406-005-0627-1

28. Park S, Song YJ, Kim J, et al. Age, Period, and Cohort Effects on Suicide Mortality in South Korea, 1992–2015. *Int J Environ Res Public Health*. 2018;15(8):1580. doi:10.3390/ijerph15081580

29. Cha ES, Chang SS, Choi Y, Lee WJ. Trends in pesticide suicide in South Korea, 1983–2014. *Epidemiol Psychiatr Sci*. 2020;29. doi:10.1017/S2045796019000118

30. Chen X, Sun Y, Li Z, Yu B, Gao G, Wang P. Historical trends in suicide risk for the residents of mainland China: APC modeling of the archived national suicide mortality rates during 1987-2012. *Soc Psychiatry Psychiatr Epidemiol*. 2019;54(1):99-110. doi:10.1007/s00127-018-1593-z

31. Chung RY, Yip BHK, Chan SSM, Wong SYS. COHORT EFFECTS OF SUICIDE MORTALITY ARE SEX SPECIFIC IN THE RAPIDLY DEVELOPED HONG KONG CHINESE POPULATION, 1976-2010. *Depress Anxiety*. 2016;33(6):558-566. doi:10.1002/da.22431

32. Gunnell D, Middleton N, Whitley E, Dorling D, Frankel S. Influence of cohort effects on patterns of suicide in England and Wales, 1950-1999. *Br J Psychiatry J Ment Sci*. 2003;182:164-170. doi:10.1192/bjp.182.2.164

33. Odagiri Y, Uchida H, Nakano M. Gender differences in age, period, and birth-cohort effects on the suicide mortality rate in Japan, 1985-2006. *Asia Pac J Public Health*. 2011;23(4):581-587. doi:10.1177/1010539509348242

34. Yu B, Chen X. Age and Birth Cohort-Adjusted Rates of Suicide Mortality Among US Male and Female Youths Aged 10 to 19 Years From 1999 to 2017. *JAMA Netw Open*. 2019;2(9):e1911383. doi:10.1001/jamanetworkopen.2019.11383

35. Wang Z, Yu C, Wang J, Bao J, Gao X, Xiang H. Age-period-cohort analysis of suicide mortality by gender among white and black Americans, 1983–2012. *Int J Equity Health*. 2016;15(1):107. doi:10.1186/s12939-016-0400-2

36. Reger MA, Stanley IH, Joiner TE. Suicide Mortality and Coronavirus Disease 2019-A Perfect Storm? *JAMA Psychiatry*. 2020;77(11):1093-1094. doi:10.1001/jamapsychiatry.2020.1060

37. Santomauro DF, Herrera AMM, Shadid J, et al. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *The Lancet*. 2021;398(10312):1700-1712. doi:10.1016/S0140-6736(21)02143-7

38. Pirkis J, John A, Shin S, et al. Suicide trends in the early months of the COVID-19 pandemic: an interrupted time-series analysis of preliminary data from 21 countries. *Lancet Psychiatry*. 2021;8(7):579-588. doi:10.1016/S2215-0366(21)00091-2

39. John A, Eyles E, Webb RT, et al. The impact of the COVID-19 pandemic on self-harm and suicidal behaviour: update of living systematic review. Published online June 17, 2021. doi:10.12688/f1000research.25522.2

40. Rapid Risk Assessment: Coronavirus disease 2019 (COVID-19) in the EU/EEA and the UK– ninth update. European Centre for Disease Prevention and Control. Published April 23, 2020. Accessed May 30, 2022. https://www.ecdc.europa.eu/en/publications-data/rapid-risk-assessment-coronavirus-disease-2019-covid-19-pandemic-ninth-update

41. COVID-19 Mental Disorders Collaborators. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *Lancet Lond Engl*. 2021;398(10312):1700-1712. doi:10.1016/S0140-6736(21)02143-7

42. Pérez V, Elices M, Vilagut G, et al. Suicide-related thoughts and behavior and suicide death trends during the COVID-19 in the general population of Catalonia, Spain. *Eur Neuropsychopharmacol J Eur Coll Neuropsychopharmacol*. 2021;56:4-12. doi:10.1016/j.euroneuro.2021.11.006

43. de la Torre-Luque A, Pemau A, Perez-Sola V, Ayuso-Mateos JL. [Suicide mortality in Spain in 2020: The impact of the COVID-19 pandemic]. *Rev Psiquiatr Salud Ment*. Published online February 2, 2022. doi:10.1016/j.rpsm.2022.01.003

44. Shumway RH, Stoffer DS. *Time Series Analysis and Its Applications*. Springer New York; 2011. doi:10.1007/978-1-4419-7865-3

45. Turecki G, Brent DA, Gunnell D, et al. Suicide and suicide risk. *Nat Rev Dis Primer*. 2019;5(1):1-22. doi:10.1038/s41572-019-0121-0

46. Hedegaard H. Increase in Suicide Mortality in the United States, 1999–2018. 2020;(362):8.

47. OECD. Suicide rates (indicator). OECD Data. Published 2021. Accessed February 11, 2021. http://data.oecd.org/healthstat/suicide-rates.htm

48. Oyesanya M, Lopez-Morinigo J, Dutta R. Systematic review of suicide in economic recession. *World J Psychiatry*. 2015;5(2):243-254. doi:10.5498/wjp.v5.i2.243

49. Chang SS, Stuckler D, Yip P, Gunnell D. Impact of 2008 global economic crisis on suicide: time trend study in 54 countries. *BMJ*. 2013;347:f5239. doi:10.1136/bmj.f5239

50. Barr B, Taylor-Robinson D, Scott-Samuel A, McKee M, Stuckler D. Suicides associated with the 2008-10 economic recession in England: time trend analysis. *BMJ*. 2012;345:e5142. doi:10.1136/bmj.e5142

51. De Vogli R, Marmot M, Stuckler D. Excess suicides and attempted suicides in Italy attributable to the great recession. *J Epidemiol Community Health*. 2013;67(4):378-379. doi:10.1136/jech-2012-201607

52. Keyes KM, Li G. Age–Period–Cohort Modeling. In: Li G, Baker SP, eds. *Injury Research: Theories, Methods, and Approaches*. Springer US; 2012:409-426. doi:10.1007/978-1-4614-1599-2_22

53. Valero-Matas JA, Coca JR, Valero-Oteo I. Análisis de la inmigración en España y la crisis económica. *Papeles Poblac*. 2014;20(80):9-45.

54. BOE.es - BOE-A-2012-5403 Real Decreto-ley 16/2012, de 20 de abril, de medidas urgentes para garantizar la sostenibilidad del Sistema Nacional de Salud y mejorar la calidad y seguridad de sus prestaciones. Accessed August 29, 2021. https://www.boe.es/buscar/act.php?id=BOE-A-2012-5403

55. Agudelo-Suárez AA, Ronda E, Vázquez-Navarrete ML, García AM, Martínez JM, Benavides FG. Impact of economic crisis on mental health of migrant workers: what happened with migrants who came to Spain to work? *Int J Public Health*. 2013;58(4):627-631. doi:10.1007/s00038-013-0475-0

56. National Institute of Statistics [Instituto Nacional de Estadística] https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176780&menu=resultados&idp=1254735573175#!tabs-1254736194710.

57. National Institute of Statistics [Instituto Nacional de Estadística] - Ongoing Register of Residents https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177012&menu=resultados&idp=1254734710990#!tabs-1254736195461.

58. Keyes KM, Li G. A multi-phase method for estimating cohort effects in age-period contingency table data. *Ann Epidemiol*. 2010;20(10):779-785. doi:10.1016/j.annepidem.2010.03.006

59. Jalal H, Burke DS. Hexamaps for age–period–cohort data visualization and implementation in R. *Epidemiology*. Published online 2020.

60. Keyes KM, Utz RL, Robinson W, Li G. What is a cohort effect? Comparison of three statistical methods for modeling cohort effects in obesity prevalence in the United States, 1971-2006. *Soc Sci Med 1982*. 2010;70(7):1100-1108. doi:10.1016/j.socscimed.2009.12.018

61. Susser M. Commentary: the longitudinal perspective and cohort analysis. *Int J Epidemiol*. 2001;30(4):684-687. doi:10.1093/ije/30.4.684

62. Susser E, Neugebauer R, Hoek HW, et al. Schizophrenia after prenatal famine. Further evidence. *Arch Gen Psychiatry*. 1996;53(1):25-31. doi:10.1001/archpsyc.1996.01830010027005

63. Holford TR. Understanding the effects of age, period, and cohort on incidence and mortality rates. *Annu Rev Public Health*. 1991;12:425-457. doi:10.1146/annurev.pu.12.050191.002233

64. Yang Y, Schulhofer-Wohl S, Fu WJ, Land KC. The Intrinsic Estimator for Age-Period-Cohort Analysis: What It Is and How to Use It. *Am J Sociol*. 2008;113(6):1697-1736. doi:10.1086/587154

65. Reither EN, Land KC, Jeon SY, et al. Clarifying hierarchical age-period-cohort models: A rejoinder to Bell and Jones. *Soc Sci Med 1982*. 2015;145:125-128. doi:10.1016/j.socscimed.2015.07.013

66. Yang YC, Land KC. Misunderstandings, Mischaracterizations, and the Problematic Choice of a Specific Instance in Which the IE Should Never Be Applied. *Demography*. 2013;50(6):1969-1971. doi:10.1007/s13524-013-0254-9

67. Pelzer B, te Grotenhuis M, Eisinga R, Schmidt-Catran AW. The Non-uniqueness Property of the Intrinsic Estimator in APC Models. *Demography*. 2015;52(1):315-327. doi:10.1007/s13524-014-0360-3

68. Bell A, Jones K. The hierarchical age–period–cohort model: Why does it find the results that it finds? *Qual Quant*. 2018;52(2):783-799. doi:10.1007/s11135-017-0488-5

69. Clayton D, Schifflers E. Models for temporal variation in cancer rates. I: Age-period and age-cohort models. *Stat Med*. 1987;6(4):449-467. doi:10.1002/sim.4780060405

70. Clayton D, Schifflers E. Models for temporal variation in cancer rates. II: Age-period-cohort models. *Stat Med*. 1987;6(4):469-481. doi:10.1002/sim.4780060406

71. Real Decreto de 24 de julio de 1889, texto de la edición del. Accessed August 25, 2021. https://noticias.juridicas.com/base_datos/Privado/cc.l1t1.html

72. Rogers A. Recession, Vulnerable Workers and Immigration: :76.

73. Blakely T, Collings S, Atkinson J. Unemployment and suicide. Evidence for a causal association? *J Epidemiol Community Health*. 2003;57(8):594-600. doi:10.1136/jech.57.8.594

74. Lewis G, Sloggett A. Suicide, deprivation, and unemployment: record linkage study. *BMJ*. 1998;317(7168):1283-1286.

75. Norström T, Grönqvist H. The Great Recession, unemployment and suicide. *J Epidemiol Community Health*. 2015;69(2):110-116. doi:10.1136/jech-2014-204602

76. Milner A, Page A, LaMontagne AD. Long-Term Unemployment and Suicide: A Systematic Review and Meta-Analysis. *PLoS ONE*. 2013;8(1):e51333. doi:10.1371/journal.pone.0051333

77. Fortuna LR, Álvarez K, Ramos Ortiz Z, et al. Mental health, migration stressors and suicidal ideation among Latino immigrants in Spain and the United States. *Eur Psychiatry J Assoc Eur Psychiatr*. 2016;36:15-22. doi:10.1016/j.eurpsy.2016.03.001

78. Metzl JM, Hansen H. Structural Competency and Psychiatry. *JAMA Psychiatry*. 2018;75(2):115-116. doi:10.1001/jamapsychiatry.2017.3891

79. Beller J, Regidor E, Lostao L, et al. Decline of depressive symptoms in Europe: differential trends across the lifespan. *Soc Psychiatry Psychiatr Epidemiol*. 2021;56(7):1249-1262. doi:10.1007/s00127-020-01979-6

80. Gabilondo A, Alonso J, Pinto-Meza A, et al. Prevalencia y factores de riesgo de las ideas, planes e intentos de suicidio en la población general española. Resultados del estudio ESEMeD. *Med Clínica*. 2007;129(13):494-500. doi:10.1157/13111370

81. Gili M, Roca M, Basu S, McKee M, Stuckler D. The mental health risks of economic crisis in Spain: evidence from primary care centres, 2006 and 2010. *Eur J Public Health*. 2013;23(1):103-108. doi:10.1093/eurpub/cks035

82. Insarauto V. Women's Vulnerability to the Economic Crisis through the Lens of Part-time Work in Spain. *Work Employ Soc*. 2021;35(4):621-639. doi:10.1177/09500170211001271

83. Martín-María N, Caballero FF, Lara E, et al. Effects of transient and chronic loneliness on major depression in older adults: A longitudinal study. *Int J Geriatr Psychiatry*. 2021;36(1):76-85. doi:https://doi.org/10.1002/gps.5397

84. Koo YW, Kõlves K, De Leo D. Suicide in older adults: a comparison with middle-aged adults using the Queensland Suicide Register. *Int Psychogeriatr*. 2017;29(3):419-430. doi:10.1017/S1041610216001848

85. Conwell Y. Suicide Later in Life. *Am J Prev Med*. 2014;47(3):S244-S250. doi:10.1016/j.amepre.2014.05.040

86. Blazer D. Social Isolation and Loneliness in Older Adults—A Mental Health/Public Health Challenge. *JAMA Psychiatry*. 2020;77(10):990. doi:10.1001/jamapsychiatry.2020.1054

87. Bakst SS, Braun T, Zucker I, Amitai Z, Shohat T. The accuracy of suicide statistics: are true suicide deaths misclassified? *Soc Psychiatry Psychiatr Epidemiol*. 2016;51(1):115-123. doi:10.1007/s00127-015-1119-x

88. De Leo D. Can we rely on suicide mortality data? *Crisis J Crisis Interv Suicide Prev*. 2015;36(1):1-3. doi:10.1027/0227-5910/a000315

89. Gunnell D, Bennewith O, Simkin S, et al. Time trends in coroners' use of different verdicts for possible suicides and their impact on officially reported incidence of suicide in England: 1990-2005. *Psychol Med*. 2013;43(7):1415-1422. doi:10.1017/S0033291712002401

90. Robinson E, Sutin AR, Daly M, Jones A. A systematic review and meta-analysis of longitudinal cohort studies comparing mental health before versus during the COVID-19 pandemic in 2020. *J Affect Disord*. 2022;296:567-576. doi:10.1016/j.jad.2021.09.098

91. Prati G, Mancini AD. The psychological impact of COVID-19 pandemic lockdowns: a review and meta-analysis of longitudinal studies and natural experiments. *Psychol Med*. 2021;51(2):201-211. doi:10.1017/S0033291721000015

92. Budimir S, Pieh C, Dale R, Probst T. Severe Mental Health Symptoms during COVID-19: A Comparison of the United Kingdom and Austria. *Healthcare*. 2021;9(2):191. doi:10.3390/healthcare9020191

93. Pieh C, Budimir S, Delgadillo J, Barkham M, Fontaine JRJ, Probst T. Mental Health During COVID-19 Lockdown in the United Kingdom. *Psychosom Med*. 2021;83(4):328-337. doi:10.1097/PSY.0000000000000871

94. Brunoni AR, Suen PJC, Bacchi PS, et al. Prevalence and risk factors of psychiatric symptoms and diagnoses before and during the COVID-19 pandemic: findings from the ELSA-Brasil COVID-19 mental health cohort. *Psychol Med*. Published online April 21, 2021:1-12. doi:10.1017/S0033291721001719

95. Daly M, Robinson E. Anxiety reported by US adults in 2019 and during the 2020 COVID-19 pandemic: Population-based evidence from two nationally representative samples. *J Affect Disord*. 2021;286:296-300. doi:10.1016/j.jad.2021.02.054

96. Hyland P, Shevlin M, McBride O, et al. Anxiety and depression in the Republic of Ireland during the COVID-19 pandemic. *Acta Psychiatr Scand*. 2020;142(3):249-256. doi:10.1111/acps.13219

97. Wang C, Pan R, Wan X, et al. A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. *Brain Behav Immun*. 2020;87:40-48. doi:10.1016/j.bbi.2020.04.028

98. Mortier P, Vilagut G, Ferrer M, et al. Thirty-day suicidal thoughts and behaviours in the Spanish adult general population during the first wave of the Spain COVID-19 pandemic. *Epidemiol Psychiatr Sci*. 2021;30:e19. doi:10.1017/S2045796021000093

99. Czeisler MÉ. Mental Health, Substance Use, and Suicidal Ideation During the COVID-19 Pandemic — United States, June 24–30, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69. doi:10.15585/mmwr.mm6932a1

100. Cole SR, Frangakis CE. The consistency statement in causal inference: a definition or an assumption? *Epidemiol Camb Mass*. 2009;20(1):3-5. doi:10.1097/EDE.0b013e31818ef366

101. VanderWeele TJ, Hernán MA. Causal Inference Under Multiple Versions of Treatment. *J Causal Inference*. 2013;1(1):1-20. doi:10.1515/jci-2012-0002

102. Hernán MA, VanderWeele TJ. Compound Treatments and Transportability of Causal Inference. *Epidemiol Camb Mass*. 2011;22(3):368-377. doi:10.1097/EDE.0b013e3182109296

103. Alegria M, Atkins M, Farmer E, Slaton E, Stelk W. One Size Does Not Fit All: Taking Diversity, Culture and Context Seriously. *Adm Policy Ment Health*. 2010;37(1-2):48-60. doi:10.1007/s10488-010-0283-2

104. Torraco RJ. Writing Integrative Literature Reviews: Guidelines and Examples. *Hum Resour Dev Rev*. 2005;4(3):356-367. doi:10.1177/1534484305278283

105. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi:10.1136/bmj.n71

106. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther*. 2002;27(4):299-309. doi:10.1046/j.1365-2710.2002.00430.x

107. Bhaskaran K, Gasparrini A, Hajat S, Smeeth L, Armstrong B. Time series regression studies in environmental epidemiology. *Int J Epidemiol*. 2013;42(4):1187-1195. doi:10.1093/ije/dyt092

108. Hategeka C, Ruton H, Karamouzian M, Lynd LD, Law MR. Use of interrupted time series methods in the evaluation of health system quality improvement interventions: a methodological systematic review. *BMJ Glob Health*. 2020;5(10):e003567. doi:10.1136/bmjgh-2020-003567

109. Acharya SR, Shin YC, Moon DH. COVID-19 outbreak and suicides in Nepal: Urgency of immediate action. *Int J Soc Psychiatry*. 2021;67(5):606-608. doi:10.1177/0020764020963150

110. Anzai T, Fukui K, Ito T, Ito Y, Takahashi K. Excess Mortality From Suicide During the Early COVID-19 Pandemic Period in Japan: A Time-Series Modeling Before the Pandemic. *J Epidemiol*. 2021;31(2):152-156. doi:10.2188/jea.JE20200443

111. Borges G, Garcia JA, Pirkis J, et al. A state level analyses of suicide and the COVID-19 pandemic in Mexico. *BMC Psychiatry*. 2022;22(1):460. doi:10.1186/s12888-022-04095-8

112. Bray MJC, Daneshvari NO, Radhakrishnan I, et al. Racial Differences in Statewide Suicide Mortality Trends in Maryland During the Coronavirus Disease 2019 (COVID-19) Pandemic. *JAMA Psychiatry*. 2021;78(4):444-447. doi:10.1001/jamapsychiatry.2020.3938

113. Calderon-Anyosa RJC, Kaufman JS. Impact of COVID-19 lockdown policy on homicide, suicide, and motor vehicle deaths in Peru. *Prev Med*. 2021;143:106331. doi:10.1016/j.ypmed.2020.106331

114. Calderon-Anyosa RJC, Bilal U, Kaufman JS. Variation in Non-external and External Causes of Death in Peru in Relation to the COVID-19 Lockdown. :18.

115. Deisenhammer EA, Kemmler G. Decreased suicide numbers during the first 6 months of the COVID-19 pandemic. *Psychiatry Res*. 2021;295:113623. doi:10.1016/j.psychres.2020.113623

116. Dwyer J, Dwyer J, Hiscock R, et al. COVID-19 as a context in suicide: early insights from Victoria, Australia. *Aust N Z J Public Health*. 2021;45(5):517-522. doi:10.1111/1753-6405.13132

117. Eguchi A, Nomura S, Gilmour S, et al. Suicide by gender and 10-year age groups during the COVID-19 pandemic vs previous five years in Japan: An analysis of national vital statistics. *Psychiatry Res*. 2021;305:114173. doi:10.1016/j.psychres.2021.114173

118. Faust JS, Du C, Mayes KD, et al. Mortality From Drug Overdoses, Homicides, Unintentional Injuries, Motor Vehicle Crashes, and Suicides During the Pandemic, March-August 2020. *JAMA*. 2021;326(1):84-86. doi:10.1001/jama.2021.8012

119. Faust JS, Shah SB, Du C, Li SX, Lin Z, Krumholz HM. Suicide Deaths During the COVID-19 Stay-at-Home Advisory in Massachusetts, March to May 2020. *JAMA Netw Open*. 2021;4(1). doi:10.1001/jamanetworkopen.2020.34273

120. Isumi A, Doi S, Yamaoka Y, Takahashi K, Fujiwara T. Do suicide rates in children and adolescents change during school closure in Japan? The acute effect of the first wave of COVID-19 pandemic on child and adolescent mental health. *Child Abuse Negl*. 2020;110:104680. doi:10.1016/j.chiabu.2020.104680

121. Koda M, Harada N, Eguchi A, Nomura S, Ishida Y. Reasons for Suicide During the COVID-19 Pandemic in Japan. *JAMA Netw Open*. 2022;5(1):e2145870. doi:10.1001/jamanetworkopen.2021.45870

122. Lin CY, Chang SS, Shen LJ. Decrease in Suicide During the First Year of the COVID-19 Pandemic in Taiwan. *J Clin Psychiatry*. 2021;82(6):21br14137. doi:10.4088/JCP.21br14137

123. Nomura S, Kawashima T, Harada N, et al. Trends in suicide in Japan by gender during the COVID-19 pandemic, through December 2020. *Psychiatry Res*. 2021;300:113913. doi:10.1016/j.psychres.2021.113913

124. Nomura S, Kawashima T, Yoneoka D, et al. Trends in suicide in Japan by gender during the COVID-19 pandemic, up to September 2020. *Psychiatry Res*. 2021;295:113622. doi:10.1016/j.psychres.2020.113622

125. Orellana JDY, de Souza MLP. Excess suicides in Brazil: Inequalities according to age groups and regions during the COVID-19 pandemic. *Int J Soc Psychiatry*. Published online May 27, 2022:002076402210978. doi:10.1177/00207640221097826

126. Pérez V, Elices M, Vilagut G, et al. Suicide-related thoughts and behavior and suicide death trends during the COVID-19 in the general population of Catalonia, Spain. *Eur Neuropsychopharmacol J Eur Coll Neuropsychopharmacol*. 2022;56:4-12. doi:10.1016/j.euroneuro.2021.11.006

127. Osváth P, Bálint L, Németh A, Kapitány B, Rihmer Z, Döme P. Changes in suicide mortality of Hungary during the first year of the COVID-19 pandemic. *Orv Hetil*. 2021;162(41):1631-1636. doi:10.1556/650.2021.32346

128. Pokhrel S, Sedhai YR, Atreya A. An increase in suicides amidst the coronavirus disease 2019 pandemic in Nepal. *Med Sci Law*. 2021;61(2):161-162. doi:10.1177/0025802420966501

129. Qin P, Mehlum L. National observation of death by suicide in the first 3 months under COVID-19 pandemic. *Acta Psychiatr Scand*. 2021;143(1):92-93. doi:10.1111/acps.13246

130. Rogalska A, Syrkiewicz-Świtała M. COVID-19 and Mortality, Depression, and Suicide in the Polish Population. *Front Public Health*. 2022;10:854028. doi:10.3389/fpubh.2022.854028

131. Schleihauf E, Bowes MJ. Suicide and drug toxicity mortality in the first year of the COVID-19 pandemic: use of medical examiner data for public health in Nova Scotia. *Health Promot Chronic Dis Prev Can*. 2021;42(2):60-67. doi:10.24095/hpcdp.42.2.02

132. Watanabe M, Tanaka H. Increased suicide mortality in Japan during the COVID-19 pandemic in 2020. *Psychiatry Res*. 2022;309:114422. doi:10.1016/j.psychres.2022.114422

133. Wollschläger D, Schmidtmann I, Blettner M, et al. Suicides During the COVID-19 Pandemic 2020 Compared to the Years 2011–2019 in Rhineland–Palatinate (Germany) and Emilia–Romagna (Italy). *Dtsch Ärztebl Int*. 2021;118(47):814-815. doi:10.3238/arztebl.m2021.0365

134. Calati R, Gentile G, Fornaro M, Tambuzzi S, Zoja R. Preliminary suicide trends during the COVID-19 pandemic in Milan, Italy. *J Psychiatr Res*. 2021;143:21-22. doi:10.1016/j.jpsychires.2021.08.029

135. Acharya B, Subedi K, Acharya P, Ghimire S. Association between COVID-19 pandemic and the suicide rates in Nepal. *PLOS ONE*. 2022;17(1):e0262958. doi:10.1371/journal.pone.0262958

136. Chen YY, Yang CT, Pinkney E, Yip PSF. Suicide trends varied by age-subgroups during the COVID-19 pandemic in 2020 in Taiwan. *J Formos Med Assoc*. 2022;121(6):1174-1177. doi:10.1016/j.jfma.2021.09.021

137. Horita N, Moriguchi S. Trends in Suicide in Japan Following the 2019 Coronavirus Pandemic. *JAMA Netw Open*. 2022;5(3):e224739. doi:10.1001/jamanetworkopen.2022.4739

138. Leske S, Kõlves K, Crompton D, Arensman E, de Leo D. Real-time suicide mortality data from police reports in Queensland, Australia, during the COVID-19 pandemic: an interrupted time-series analysis. *Lancet Psychiatry*. 2021;8(1):58-63. doi:10.1016/S2215-0366(20)30435-1

139. Osaki Y, Otsuki H, Imamoto A, et al. Suicide rates during social crises: Changes in the suicide rate in Japan after the Great East Japan earthquake and during the COVID-19 pandemic. *J Psychiatr Res*. 2021;140:39-44. doi:10.1016/j.jpsychires.2021.05.035

140. Partonen T, Kiviruusu O, Grainger M, et al. Suicides from 2016 to 2020 in Finland and the effect of the COVID-19 pandemic. *Br J Psychiatry J Ment Sci*. 2022;220(1):38-40. doi:10.1192/bjp.2021.136

141. Radeloff D, Papsdorf R, Uhlig K, Vasilache A, Putnam K, von Klitzing K. Trends in suicide rates during the COVID-19 pandemic restrictions in a major German city. *Epidemiol Psychiatr Sci*. 2021;30:e16. doi:10.1017/S2045796021000019

142. Sakamoto H, Ishikane M, Ghaznavi C, Ueda P. Assessment of Suicide in Japan During the COVID-19 Pandemic vs Previous Years. *JAMA Netw Open*. 2021;4(2):e2037378. doi:10.1001/jamanetworkopen.2020.37378

143. Tanaka T, Okamoto S. Increase in suicide following an initial decline during the COVID-19 pandemic in Japan. *Nat Hum Behav*. 2021;5(2):229-238. doi:10.1038/s41562-020-01042-z

144. Rossom RC, Penfold RB, Owen-Smith AA, Simon GE, Ahmedani BK. Suicide Deaths Before and During the Coronavirus Disease 2019 Pandemic: An Interrupted Time-series Study. *Med Care*. 2022;60(5):357-360. doi:10.1097/MLR.0000000000001700

145. Arya V, Page A, Spittal MJ, et al. Suicide in India during the first year of the COVID-19 pandemic. *J Affect Disord*. 2022;307:215-220. doi:10.1016/j.jad.2022.03.066

146. Garnett MF. Suicide Mortality in the United States, 2000–2020. 2022;(433):8.

147. Kegler SR, Simon TR, Zwald ML, et al. *Vital Signs* : Changes in Firearm Homicide and Suicide Rates — United States, 2019–2020. *MMWR Morb Mortal Wkly Rep*. 2022;71(19). doi:10.15585/mmwr.mm7119e1

148. McIntyre RS, Lui LM, Rosenblat JD, et al. Suicide reduction in Canada during the COVID-19 pandemic: lessons informing national prevention strategies for suicide reduction. *J R Soc Med*. 2021;114(10):473-479. doi:10.1177/01410768211043186

149. Barbic D, Scheuermeyer FX, Barbic SP, Honer WG. Suicide Deaths in British Columbia during the First Wave of the COVID-19 Pandemic. *Can J Psychiatry*. 2021;66(9):830-831. doi:10.1177/07067437211018398

150. Mitchell TO, Li L. State-Level Data on Suicide Mortality During COVID-19 Quarantine: Early Evidence of a Disproportionate Impact on Racial Minorities. *Psychiatry Res*. 2021;295:113629. doi:10.1016/j.psychres.2020.113629

151. Stene-Larsen K, Raknes G, Engdahl B, et al. Suicide trends in Norway during the first year of the COVID-19 pandemic: A register-based cohort study. *Eur Psychiatry*. 2022;65(1):e26. doi:10.1192/j.eurpsy.2022.17

152. Zheng XY, Tang SL, Ma SL, et al. Trends of injury mortality during the COVID-19 period in Guangdong, China: a population-based retrospective analysis. *BMJ Open*. 2021;11(6):e045317. doi:10.1136/bmjopen-2020-045317

153. Hernán MA, Taubman SL. Does obesity shorten life? The importance of well-defined interventions to answer causal questions. *Int J Obes 2005*. 2008;32 Suppl 3:S8-14. doi:10.1038/ijo.2008.82

154. Bastiampillai T, Allison S, Brailey J, Ma M, Wa SK, Looi JCL. Pandemics and Social Cohesion: 1918-1920 Influenza Pandemic and the Reduction in US Suicide Rates. *Prim Care Companion CNS Disord*. 2021;23(3):20com02882. doi:10.4088/PCC.20com02882

155. Thomas K, Gunnell D. Suicide in England and Wales 1861–2007: a time-trends analysis. *Int J Epidemiol*. 2010;39(6):1464-1475. doi:10.1093/ije/dyq094

156. Matsubayashi T, Sawada Y, Ueda M. Natural disasters and suicide: evidence from Japan. *Soc Sci Med 1982*. 2013;82:126-133. doi:10.1016/j.socscimed.2012.12.021

157. Gaddy HG. Social distancing and influenza mortality in 1918 did not increase suicide rates in the United States. *SSM - Popul Health*. 2021;16:100944. doi:10.1016/j.ssmph.2021.100944

158. Goldstein JR, Lee RD. Demographic perspectives on the mortality of COVID-19 and other epidemics. *Proc Natl Acad Sci*. 2020;117(36):22035-22041. doi:10.1073/pnas.2006392117

159. Ajdacic-Gross V, Ring M, Gadola E, et al. Suicide after bereavement: an overlooked problem. *Psychol Med*. 2008;38(5):673-676. doi:10.1017/S0033291708002754

160. Mogensen H, Möller J, Hultin H, Mittendorfer-Rutz E. Death of a Close Relative and the Risk of Suicide in Sweden-A Large Scale Register-Based Case-Crossover Study. *PloS One*. 2016;11(10):e0164274. doi:10.1371/journal.pone.0164274

161. Erlangsen A. Loss of partner and suicide risks among oldest old: a population-based register study. *Age Ageing*. 2004;33(4):378-383. doi:10.1093/ageing/afh128

162. Yancy CW. COVID-19 and African Americans. *JAMA*. 2020;323(19):1891-1892. doi:10.1001/jama.2020.6548

163. St-Denis X. Sociodemographic Determinants of Occupational Risks of Exposure to COVID-19 in Canada. *Can Rev Sociol Rev Can Sociol*. 2020;57(3):399-452. doi:10.1111/cars.12288

164. Hansen B, Lang M. Back to school blues: Seasonality of youth suicide and the academic calendar. *Econ Educ Rev*. 2011;30(5):850-861. doi:10.1016/j.econedurev.2011.04.012

165. Young Shin Kim, Bennett Leventhal. Bullying and suicide. A review. *Int J Adolesc Med Health*. 2008;20(2):133-154. doi:10.1515/IJAMH.2008.20.2.133

166. Holt MK, Vivolo-Kantor AM, Polanin JR, et al. Bullying and Suicidal Ideation and Behaviors: A Meta-Analysis. *Pediatrics*. 2015;135(2):e496-e509. doi:10.1542/peds.2014-1864

167. Van Orden K, Conwell Y. Suicides in Late Life. *Curr Psychiatry Rep*. 2011;13(3):234-241. doi:10.1007/s11920-011-0193-3

168. McKnight PBL and R. Three million more guns: The Spring 2020 spike in firearm sales. Brookings. Published July 13, 2020. Accessed February 1, 2021. https://www.brookings.edu/blog/up-front/2020/07/13/three-million-more-guns-the-spring-2020-spike-in-firearm-sales/

169. Czeisler MÉ, Howard ME, Robbins R, et al. Early public adherence with and support for stay-at-home COVID-19 mitigation strategies despite adverse life impact: a transnational cross-sectional survey study in the United States and Australia. *BMC Public Health*. 2021;21(1):503. doi:10.1186/s12889-021-10410-x

170. Sher L. The impact of the COVID-19 pandemic on suicide rates. *QJM Mon J Assoc Physicians*. 2020;113(10):707-712. doi:10.1093/qjmed/hcaa202

171. Menon V, Cherian AV, Vijayakumar L. Rising incidence and changing demographics of suicide in India: Time to recalibrate prevention policies? *Asian J Psychiatry*. 2022;69:102983. doi:10.1016/j.ajp.2021.102983

172. Martinez-Ales et al. Suicide COVID-19 systematic review (in elaboration).

173. Martínez-Alés G, Jiang T, Keyes KM, Gradus JL. The Recent Rise of Suicide Mortality in the United States. *Annu Rev Public Health*. 2022;43(1):99-116. doi:10.1146/annurev-publhealth-051920-123206

174. Sojli E, Tham WW, Bryant R, McAleer M. COVID-19 restrictions and age-specific mental health—U.S. probability-based panel evidence. *Transl Psychiatry*. 2021;11(1):1-7. doi:10.1038/s41398-021-01537-x

175. Patel K, Robertson E, Kwong ASF, et al. Psychological Distress Before and During the COVID-19 Pandemic Among Adults in the United Kingdom Based on Coordinated Analyses of 11 Longitudinal Studies. *JAMA Netw Open*. 2022;5(4):e227629. doi:10.1001/jamanetworkopen.2022.7629

176. Zaninotto P, Iob E, Demakakos P, Steptoe A. Immediate and Longer-Term Changes in the Mental Health and Well-being of Older Adults in England During the COVID-19 Pandemic. *JAMA Psychiatry*. 2022;79(2):151-159. doi:10.1001/jamapsychiatry.2021.3749

177. Hajek A, Sabat I, Neumann-Böhme S, et al. Prevalence and determinants of probable depression and anxiety during the COVID-19 pandemic in seven countries: Longitudinal evidence from the European COvid Survey (ECOS). *J Affect Disord*. 2022;299:517-524. doi:10.1016/j.jad.2021.12.029

178. Wand APF, Zhong BL, Chiu HFK, Draper B, De Leo D. COVID-19: the implications for suicide in older adults. *Int Psychogeriatr*. 2020;32(10):1225-1230. doi:10.1017/S1041610220000770

179. Instituto Nacional de Estadística. (National Statistics Institute). Accessed January 31, 2022. https://www.ine.es/dynt3/inebase/es/index.htm?padre=1928&capsel=1932

180. Working group for the surveillance and control of COVID-19 in Spain, Members of the Working group for the surveillance and control of COVID-19 in Spain. The first wave of the COVID-19 pandemic in Spain: characterisation of cases and risk factors for severe outcomes, as at 27 April 2020. *Euro Surveill Bull Eur Sur Mal Transm Eur Commun Dis Bull*. 2020;25(50). doi:10.2807/1560-7917.ES.2020.25.50.2001431

181. Instituto Nacional de Estadística. (National Statistics Institute). Accessed August 11, 2022. https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176951&menu=ultiDatos&idp=1254735572981

182. Hyndman RJ, Khandakar Y. Automatic Time Series Forecasting: The forecast Package for R. *J Stat Softw*. 2008;27:1-22. doi:10.18637/jss.v027.i03

183. Lester D. *Suicide during War and Genocide*. Oxford University Press; :215-218. Accessed June 7, 2022. https://oxfordmedicine.com/view/10.1093/med/9780198570059.001.0001/med-9780198570059-chapter-31

184. Claassen CA, Carmody T, Stewart SM, et al. Effect of 11 September 2001 terrorist attacks in the USA on suicide in areas surrounding the crash sites. *Br J Psychiatry J Ment Sci*. 2010;196(5):359-364. doi:10.1192/bjp.bp.109.071928

185. Luo F, Florence CS, Quispe-Agnoli M, Ouyang L, Crosby AE. Impact of Business Cycles on US Suicide Rates, 1928–2007. *Am J Public Health*. 2011;101(6):1139-1146. doi:10.2105/AJPH.2010.300010

186. Brainerd E. Economic reform and mortality in the former Soviet Union: A study of the suicide epidemic in the 1990s. *Eur Econ Rev*. 2001;45(4):1007-1019. doi:10.1016/S0014-2921(01)00108-8

187. Reeves A, Stuckler D, McKee M, Gunnell D, Chang SS, Basu S. Increase in state suicide rates in the USA during economic recession. *The Lancet*. 2012;380(9856):1813-1814. doi:10.1016/S0140-6736(12)61910-2

188. Cheung YT, Chau PH, Yip PSF. A revisit on older adults suicides and Severe Acute Respiratory Syndrome (SARS) epidemic in Hong Kong. *Int J Geriatr Psychiatry*. 2008;23(12):1231-1238. doi:10.1002/gps.2056

189. National accounts and GDP. Accessed June 9, 2022. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=National_accounts_and_GDP

190. Ministry of industry, trade and tourism - COVID-19 news. Accessed June 9, 2022. https://www.mincotur.gob.es/en-us/covid-19/Paginas/COVID-19.aspx

191. OECD. *OECD Tourism Trends and Policies 2020*. OECD; 2020. doi:10.1787/6b47b985-en

192. Moreno-Luna L, Robina-Ramírez R, Sánchez MSO, Castro-Serrano J. Tourism and Sustainability in Times of COVID-19: The Case of Spain. *Int J Environ Res Public Health*. 2021;18(4):1859. doi:10.3390/ijerph18041859

193. Tapia Granados JA, Diez Roux AV. Life and death during the Great Depression. *Proc Natl Acad Sci U S A*. 2009;106(41):17290-17295. doi:10.1073/pnas.0904491106

194. Condes E, Arribas JR, COVID19 MADRID-S.P.P.M. group. Impact of COVID-19 on Madrid hospital system. *Enfermedades Infecc Microbiol Clin Engl Ed*. 2021;39(5):256-257. doi:10.1016/j.eimc.2020.06.005

195. Martínez-Alés G, Domingo-Relloso A, Arribas JR, Quintana-Díaz M, Hernán MA, COVID@HULP Group. Critical Care Requirements Under Uncontrolled Transmission of SARS-CoV-2. *Am J Public Health*. 2021;111(5):923-926. doi:10.2105/AJPH.2020.306151

196. Islam N, Jdanov DA, Shkolnikov VM, et al. Effects of covid-19 pandemic on life expectancy and premature mortality in 2020: time series analysis in 37 countries. *BMJ*. 2021;375:e066768. doi:10.1136/bmj-2021-066768

197. Countries With the Oldest Populations in the World. PRB. Accessed October 7, 2022. https://www.prb.org/resources/countries-with-the-oldest-populations-in-the-world/

198. Aburto JM, Schöley J, Kashnitsky I, et al. Quantifying impacts of the COVID-19 pandemic through life-expectancy losses: a population-level study of 29 countries. *Int J Epidemiol*. 2022;51(1):63-74. doi:10.1093/ije/dyab207

199. Hernández-Calle D, Martínez-Alés G, Mediavilla R, Aguirre P, Rodríguez-Vega B, Bravo-Ortiz MF. Trends in Psychiatric Emergency Department Visits Due to Suicidal Ideation and Suicide Attempts During the COVID-19 Pandemic in Madrid, Spain. *J Clin Psychiatry*. 2020;81(5). doi:10.4088/JCP.20l13419

200. White AM, Philogene GS, Fine L, Sinha S. Social support and self-reported health status of older adults in the United States. *Am J Public Health*. 2009;99(10):1872-1878. doi:10.2105/AJPH.2008.146894

201. Van Orden KA, Witte TK, Cukrowicz KC, Braithwaite S, Selby EA, Joiner TE. The Interpersonal Theory of Suicide. *Psychol Rev*. 2010;117(2):575-600. doi:10.1037/a0018697

202. Meil G, Rogero-García J, Romero-Balsas P. Grandparents' Role in Spanish Families' Work/Life Balance Strategies. *J Comp Fam Stud*. 2018;49(2):163-177. doi:10.3138/jcfs.49.2.163

203. Spain - Employment, Social Affairs & Inclusion - European Commission. Accessed October 7, 2022. https://ec.europa.eu/social/main.jsp?catId=1129&langId=en&intPageId=4796

204. Martín-María N, Caballero FF, Lara E, et al. Effects of transient and chronic loneliness on major depression in older adults: A longitudinal study. *Int J Geriatr Psychiatry*. 2021;36(1):76-85. doi:10.1002/gps.5397

205. Koo YW, Kõlves K, Leo D de. Profiles by suicide methods: an analysis of older adults. *Aging Ment Health*. 2019;23(3):385-391. doi:10.1080/13607863.2017.1411884

206. De Leo D. Can we rely on suicide mortality data? *Crisis*. 2015;36(1):1-3. doi:10.1027/0227-5910/a000315

207. Bakst SS, Braun T, Zucker I, Amitai Z, Shohat T. The accuracy of suicide statistics: are true suicide deaths misclassified? *Soc Psychiatry Psychiatr Epidemiol*. 2016;51(1):115-123. doi:10.1007/s00127-015-1119-x

208. Trias-Llimós S, Riffe T, Bilal U. Monitoring life expectancy levels during the COVID-19 pandemic: Example of the unequal impact of the first wave on Spanish regions. *PLOS ONE*. 2020;15(11):e0241952. doi:10.1371/journal.pone.0241952

209. Cook BL, Hou SSY, Lee-Tauler SY, Progovac AM, Samson F, Sanchez MJ. A Review of Mental Health and Mental Health Care Disparities Research: 2011-2014. *Med Care Res Rev MCRR*. 2019;76(6):683-710. doi:10.1177/1077558718780592

Appendix A

A.1 Supplementary Tables

Supplementary Table S1 Model fit statistics for age-period-cohort model for suicide rates among native-born individuals in Spain from 2000 to 2019 (Ref Cohort: 1960)

Model parameter	Change in deviance (degrees of freedom)		
	All	Male	Female
Age	-	-	-
Age-drift	55,5 (1)***	89,1 (1)***	1,3 (1)*
Age-cohort	519,2 (3)***	477,3 (3)***	103,9 (3)***
Age-period-cohort	24 (2)***	11,8 (2)***	25,3 (2)***
Age-period	-513,1 (-3)***	-475,5 (-3)***	-96,1 (-3)***
Age-drift	-30,1 (-2)***	-13,6 (-2)***	-33,1 (-2)***
*** p < .001, ** p < .01, * p < .05			

Supplementary Table S2 Model fit statistics for age-period-cohort model for suicide rates among foreign-born individuals in Spain from 2000 to 2019 (Ref Cohort: 1960)

Model parameter	Change in deviance (degrees of freedom)		
	All	Male	Female
Age	-	-	-
Age-drift	51,3 (1)***	40,5 (1)***	3,4 (1)
Age-cohort	32,5 (3)***	22,8 (3)***	7,1 (3)
Age-period-cohort	120,7 (2)***	80 (2)***	19,3 (2)***
Age-period	-60,7 (-3)***	-20,5 (-3)***	-7,1 (-3)
Age-drift	-92,5 (-2)***	-82,4 (-2)***	-19,4 (-2)***
*** p < .001, ** p < .01, * p < .05			

Supplementary Table S3 Parameters used to specify SARIMA models for monthly suicide counts 2016-2020 in Spain, overall and across sex and age group

Population	*p*	*d*	*q*	*P*	*D*	*Q*	*s*	AIC	BIC	Log-Likelihood
Overall	0	0	0	1	0	0	12	-139.75	-133.95	72.87
25-44 years	0	0	0	1	0	0	12	-74.4	-73.89	40.2
45-64 years	4	1	0	0	0	1	12	-109.33	-107.38	60.67
>64 years	0	0	0	1	0	0	12	-88.1	-87.59	47.05
Males	0	0	0	1	0	0	12	-126.71	-120.92	66.36
25-44 years	0	0	0	1	0	0	12	-72.29	-66.49	39.14
45-64 years	0	1	1	0	0	1	12	-116.11	-110.38	61.06
>64 years	0	0	0	1	0	0	12	-80.22	-74.42	43.11
Females	1	0	0	1	0	0	12	-82.33	-74.61	45.17
25-44 years	0	0	0	1	0	0	12	0.83	1.34	2.59
45-64 years	0	1	1	1	0	0	12	-35.9	-28.26	21.95
>64 years	0	0	0	1	0	0	12	-30.68	-24.89	18.34

Supplementary Table S4 Observed and predicted monthly suicides between April and December 2020 in Spain, overall and by sex

	Month	Observed suicides	Predicted suicides	95% PI		% Change
Overall	Apr-20	245	296.9	275.8	319.6	-17%
	May-20	351	295.3	274.4	317.9	+19%
	Jun-20	366	292.8	272	315.2	+25%
	Jul-20	381	285.5	265.3	307.4	+33%
	Aug-20	396	303.1	281.5	326.2	+31%
	Sep-20	349	287.2	266.8	309.1	+22%
	Oct-20	292	295.5	274.6	318.1	-1%
	Nov-20	263	281.7	261.7	303.2	-7%
	Dec-20	291	288.2	267.7	310.2	+1%
Males	Apr-20	189	215.8	198.3	234.8	-13%
	May-20	256	220.8	202.9	240.2	+16%
	Jun-20	288	218.8	201.1	238.1	+32%
	Jul-20	286	210.8	193.7	229.4	+36%
	Aug-20	300	221.7	203.7	241.3	+36%
	Sep-20	259	210.4	193.3	228.9	+24%
	Oct-20	213	219.2	201.4	238.5	-3%
	Nov-20	200	212.8	195.5	231.5	-7%
	Dec-20	212	214.9	197.5	233.8	-2%
Females	Apr-20	56	84.5	74.5	96.0	-34%
	May-20	95	73.9	64.8	84.2	+29%
	Jun-20	78	73.5	64.5	83.8	+7%
	Jul-20	95	76.6	67.2	87.3	+24%
	Aug-20	96	80.9	71	92.2	+19%
	Sep-20	90	79.3	69.6	90.4	+14%
	Oct-20	79	76.2	66.9	86.8	+4%
	Nov-20	63	69.5	61	79.2	-10%
	Dec-20	79	73.6	64.6	83.9	+8%

95% PI = 95% Predicted Interval. Observed monthly suicide counts that fall beyond the 95% PI are highlighted in gray.

Supplementary Table S5 Observed and predicted monthly male suicides between April and December 2020 in Spain by age group

	Month	Observed suicides	Predicted suicides	95% PI		% Change
25-44 years	Apr-20	43	54.2	47	62.5	-21%
	May-20	56	54	46.9	62.3	+4%
	Jun-20	72	59	51.2	68	+23%
	Jul-20	72	49.6	43.1	57.2	+46%
	Aug-20	59	50.1	43.4	57.7	+18%
	Sep-20	72	52.9	45.9	61	+37%
	Oct-20	51	52.4	45.4	60.4	-3%
	Nov-20	46	52.9	45.9	61	-14%
	Dec-20	55	55.1	47.8	63.5	-1%
45-64 years	Apr-20	74	84.8	78	92.2	-13%
	May-20	96	87.3	80.2	95.1	+10%
	Jun-20	93	84.6	77.6	92.2	+10%
	Jul-20	104	85.3	78.1	93.2	+22%
	Aug-20	119	90.7	82.9	99.2	+32%
	Sep-20	99	83.1	75.9	91	+20%
	Oct-20	93	87.6	79.9	96	+7%
	Nov-20	77	86	78.3	94.4	-11%
	Dec-20	87	85.1	77.4	93.5	+3%
>64 years	Apr-20	65	70.5	61.6	80.6	-8%
	May-20	98	72	63	82.4	+37%
	Jun-20	112	72.1	63.1	82.5	+56%
	Jul-20	106	69.7	60.9	79.7	+53%
	Aug-20	112	73.9	64.6	84.5	+52%
	Sep-20	72	66.9	58.5	76.5	+8%
	Oct-20	58	71	62.1	81.2	-19%
	Nov-20	64	67.1	58.6	76.7	-5%
	Dec-20	62	66	57.7	75.5	-7%

95% PI = 95% Predicted Interval. Observed monthly suicide counts that fall beyond the 95% PI are highlighted in gray.

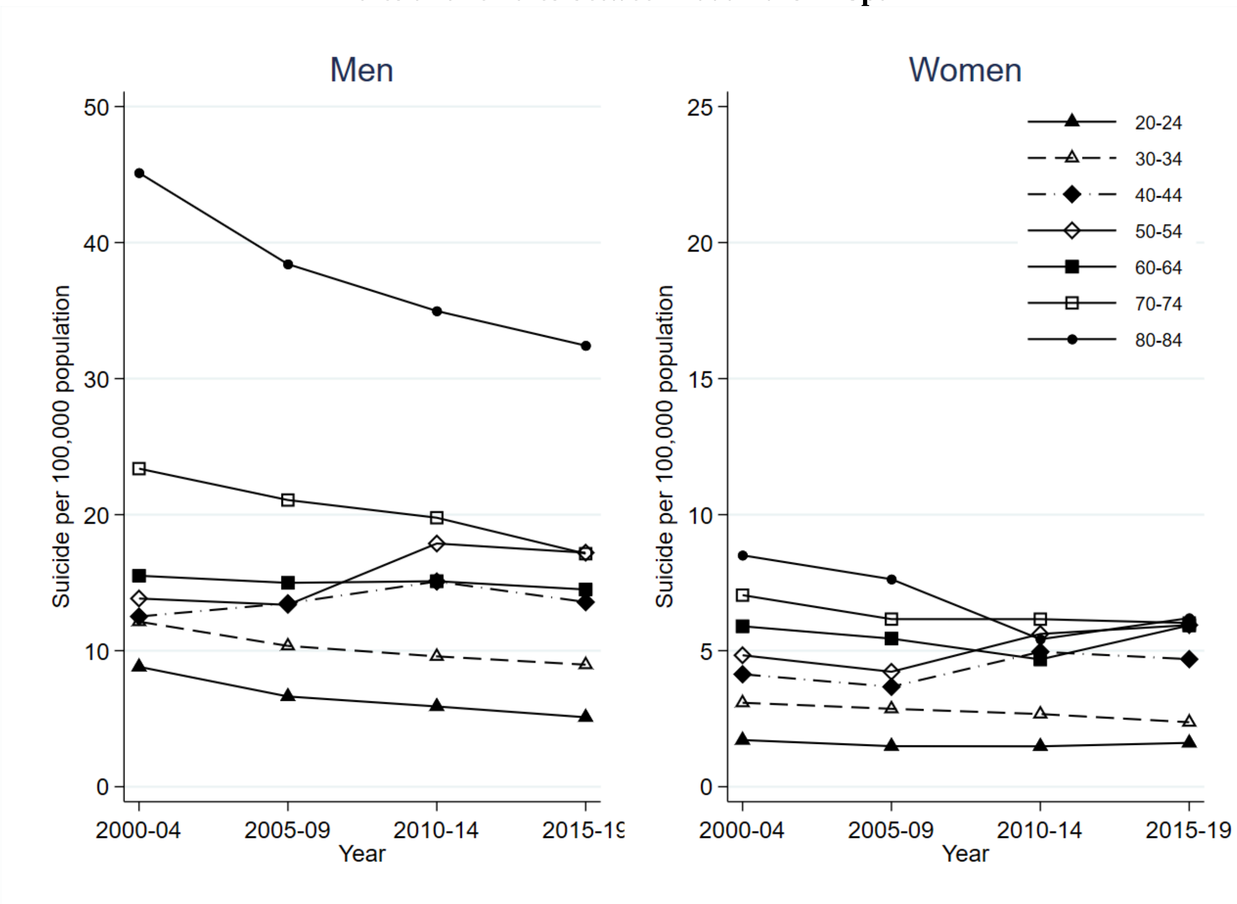
Supplementary Table S6 Observed and predicted monthly female suicides between April and December 2020 in Spain by age group

	Month	Observed suicides	Predicted suicides	95% PI		% Change
25-44 years	Apr-20	9	17.6	13	23.7	-49%
	May-20	22	16	11.9	21.6	+38%
	Jun-20	18	16.2	12	21.8	+12%
	Jul-20	22	15.5	11.5	21	+42%
	Aug-20	20	17.1	12.7	23.1	+17%
	Sep-20	16	16.5	12.3	22.3	-4%
	Oct-20	15	16.9	12.6	22.8	-12%
	Nov-20	15	17.6	13.1	23.7	-15%
	Dec-20	23	15.9	11.8	21.5	+45%
45-64 years	Apr-20	24	37.2	30.3	45.7	-36%
	May-20	42	35.4	28.7	43.7	+19%
	Jun-20	32	37.1	29.9	46.1	-14%
	Jul-20	38	37.4	30	46.6	+2%
	Aug-20	33	37.2	29.6	46.6	-12%
	Sep-20	46	37	29.4	46.6	+25%
	Oct-20	34	35.3	27.9	44.7	-4%
	Nov-20	26	32	25.1	40.7	-19%
	Dec-20	38	37.2	29.1	47.5	+3%
>64 years	Apr-20	18	27.5	22.1	34.1	-35%
	May-20	28	25.3	20.3	31.5	+11%
	Jun-20	27	23.9	19.2	29.8	+13%
	Jul-20	34	25	20.1	31.2	+36%
	Aug-20	43	26	20.9	32.4	+66%
	Sep-20	26	26.4	21.2	32.9	-2%
	Oct-20	25	25.9	20.9	32.3	-4%
	Nov-20	21	23.8	19.1	29.6	-12%
	Dec-20	16	24.2	19.5	30.1	-34%

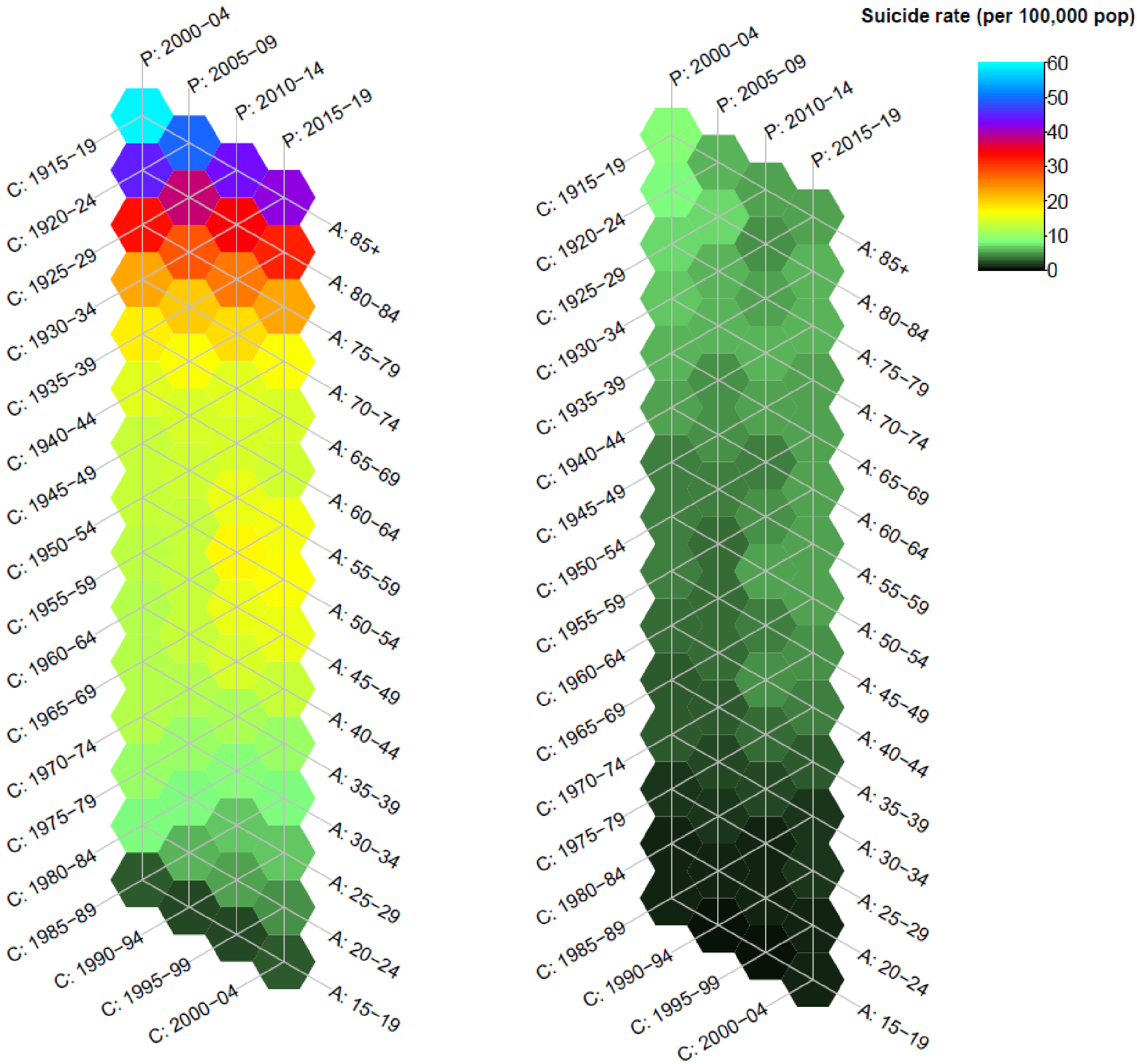
95% PI = 95% Predicted Interval. Observed monthly suicide counts that fall beyond the 95% PI are highlighted in gray.

A.2 Supplementary Figures

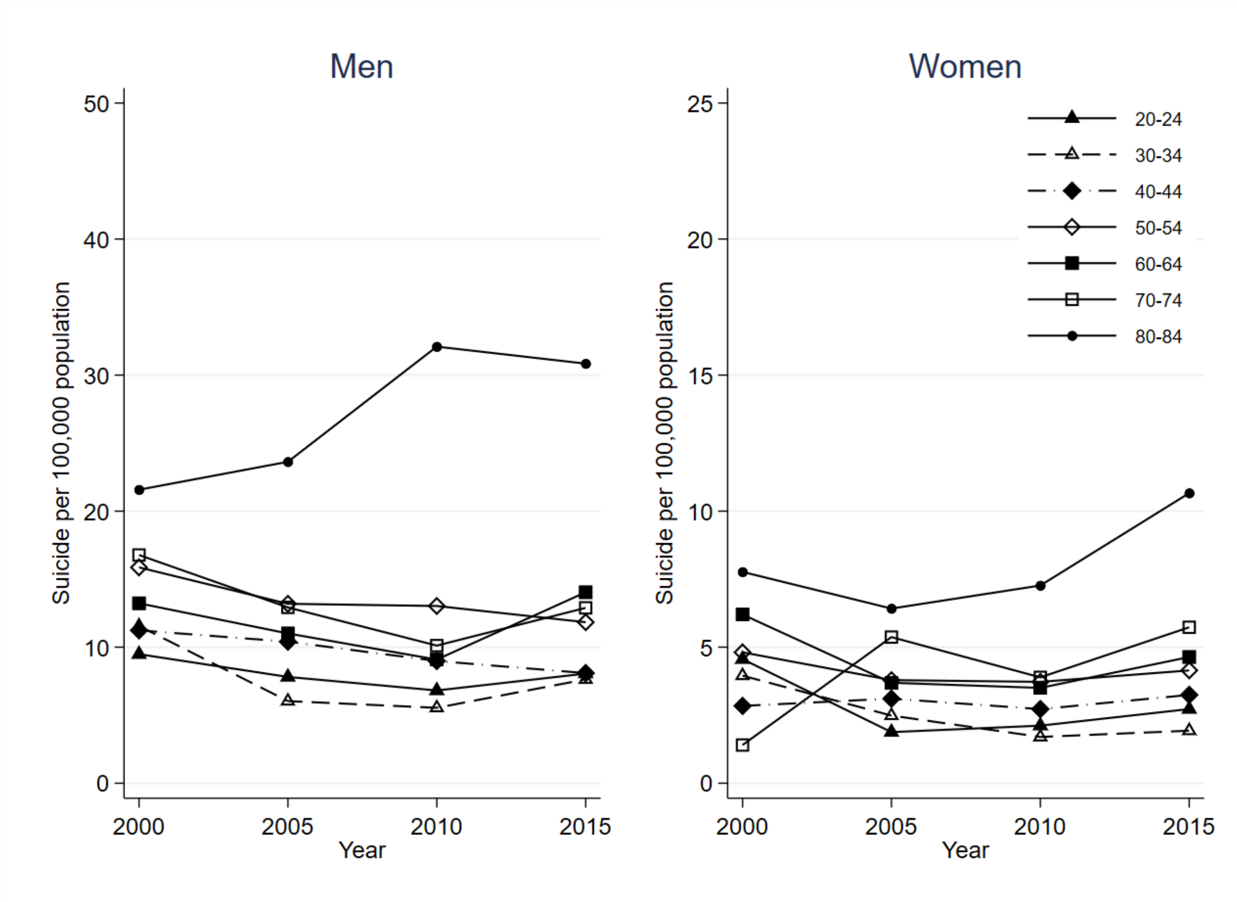
Supplementary Figure S1 Age group-specific suicide mortality rates over time among native-born males and females between 2000-2019 in Spain



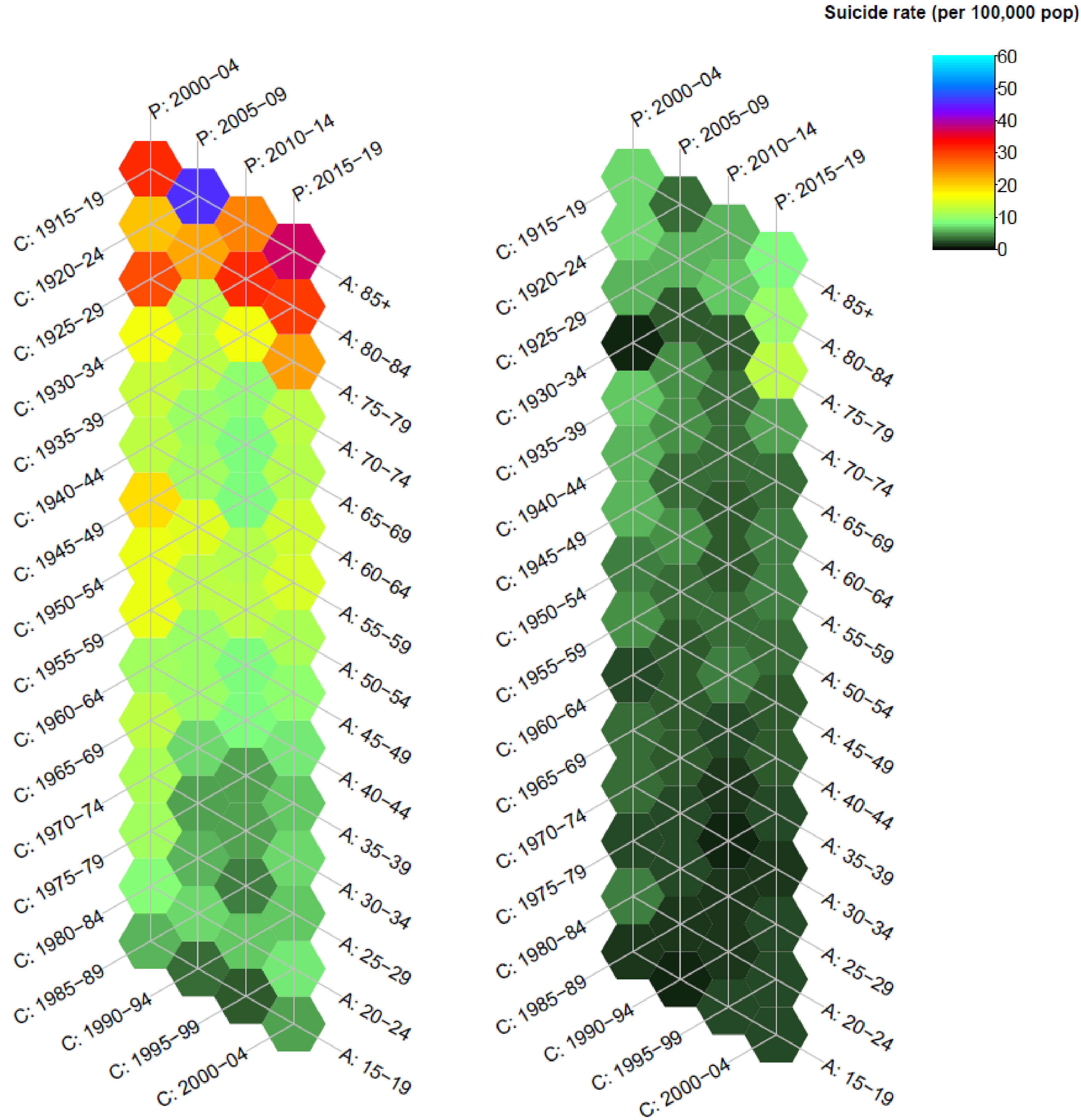
Supplementary Figure S2 Suicide mortality rates among native-born males and females between 2000-2019 in Spain across age, period, and cohort



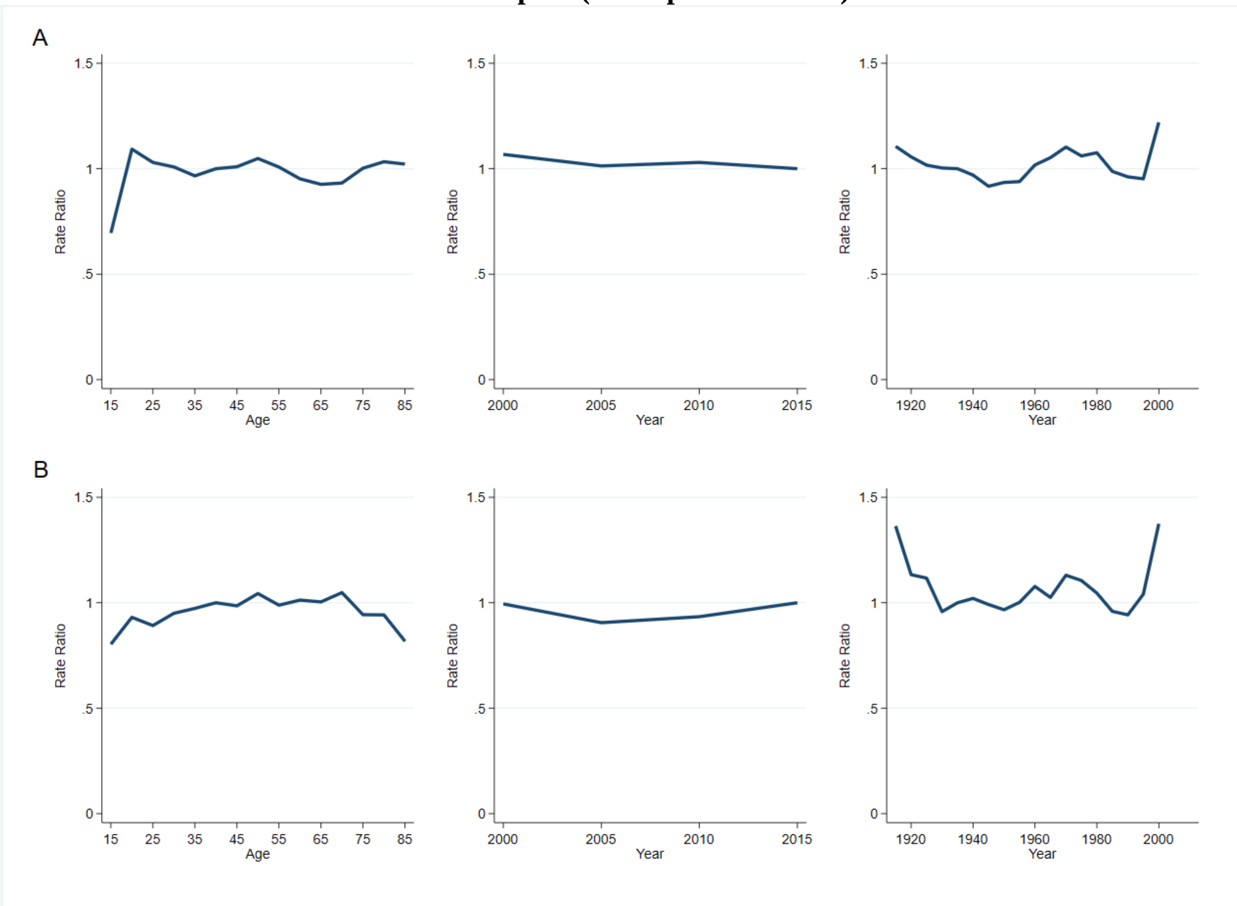
Supplementary Figure S3 Age group-specific suicide mortality rates over time among foreign-born males and females between 2000-2019 in Spain



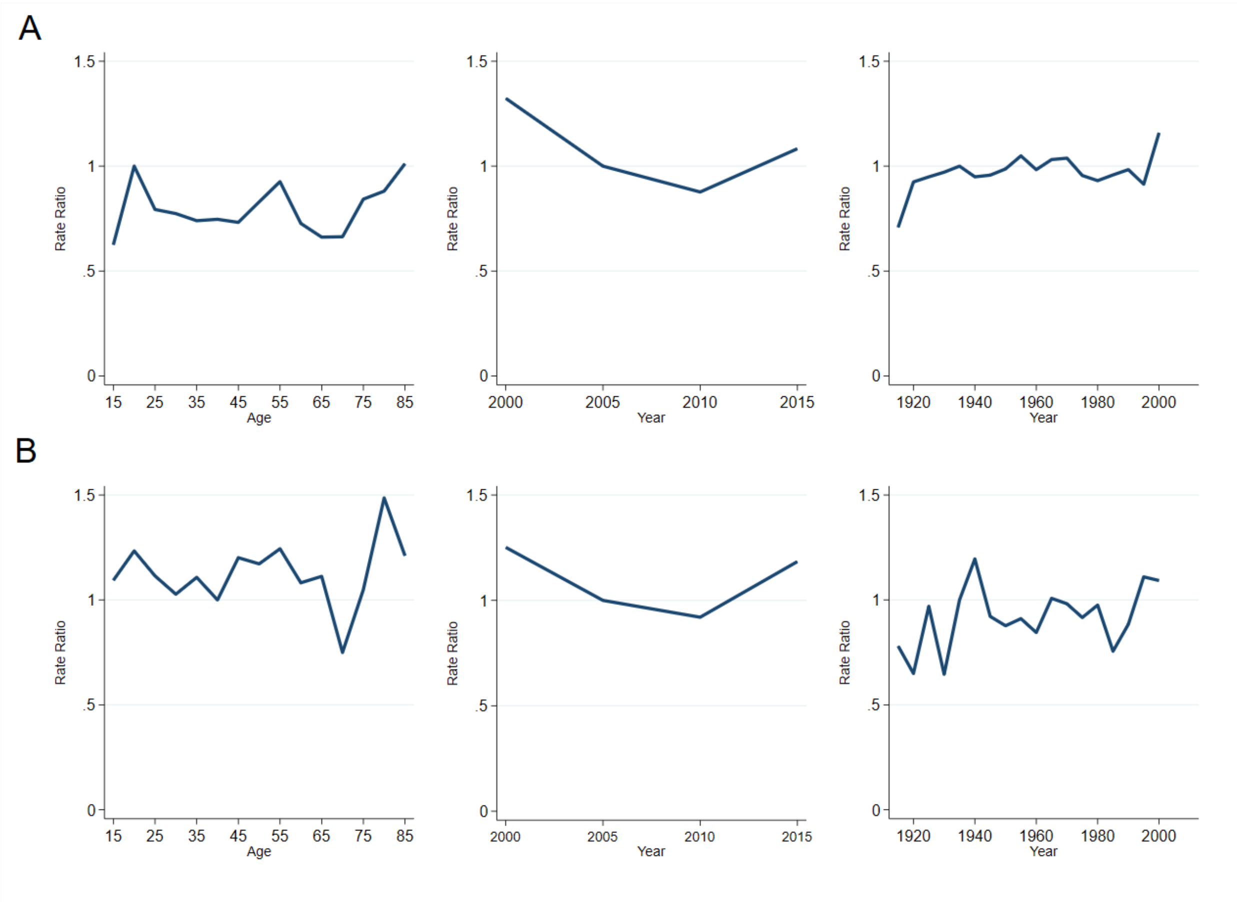
Supplementary Figure S4 Suicide mortality rates among foreign-born males and females between 2000-2019 in Spain across age, period, and cohort



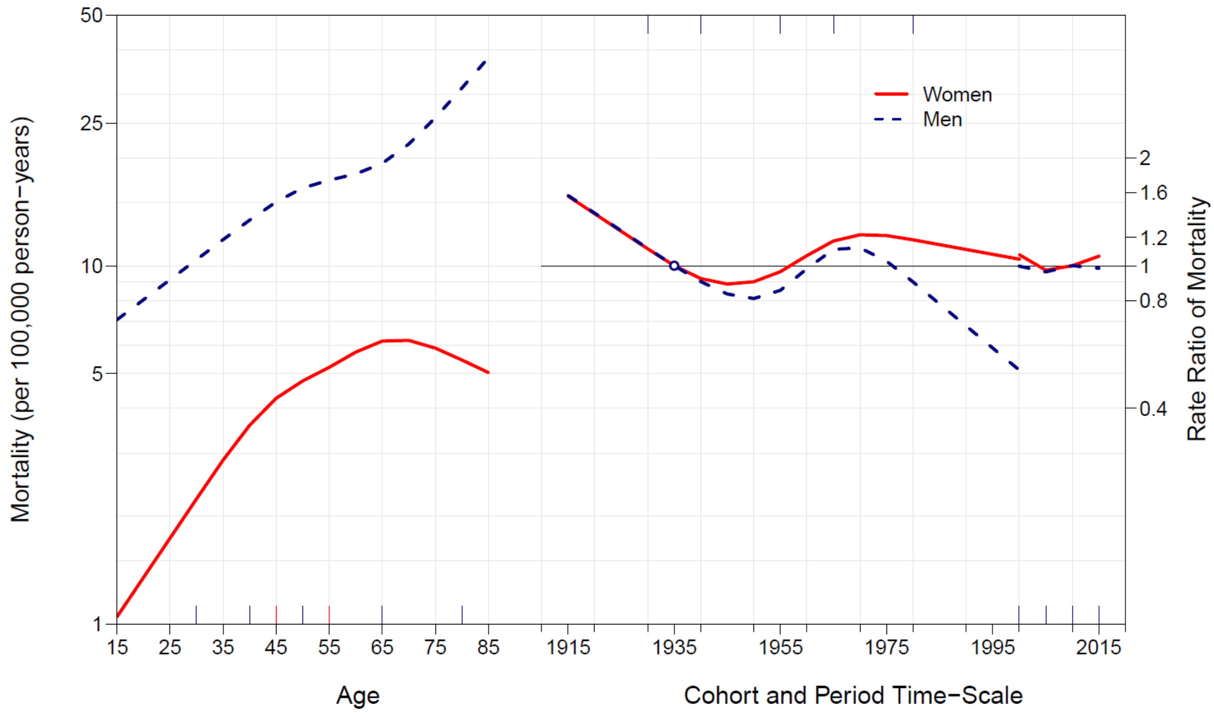
Supplementary Figure S5 Age, period, and cohort effects on suicide among native-born males and females between 2000-2019 in Spain (multi-phase method) - A: Men. B: Women.



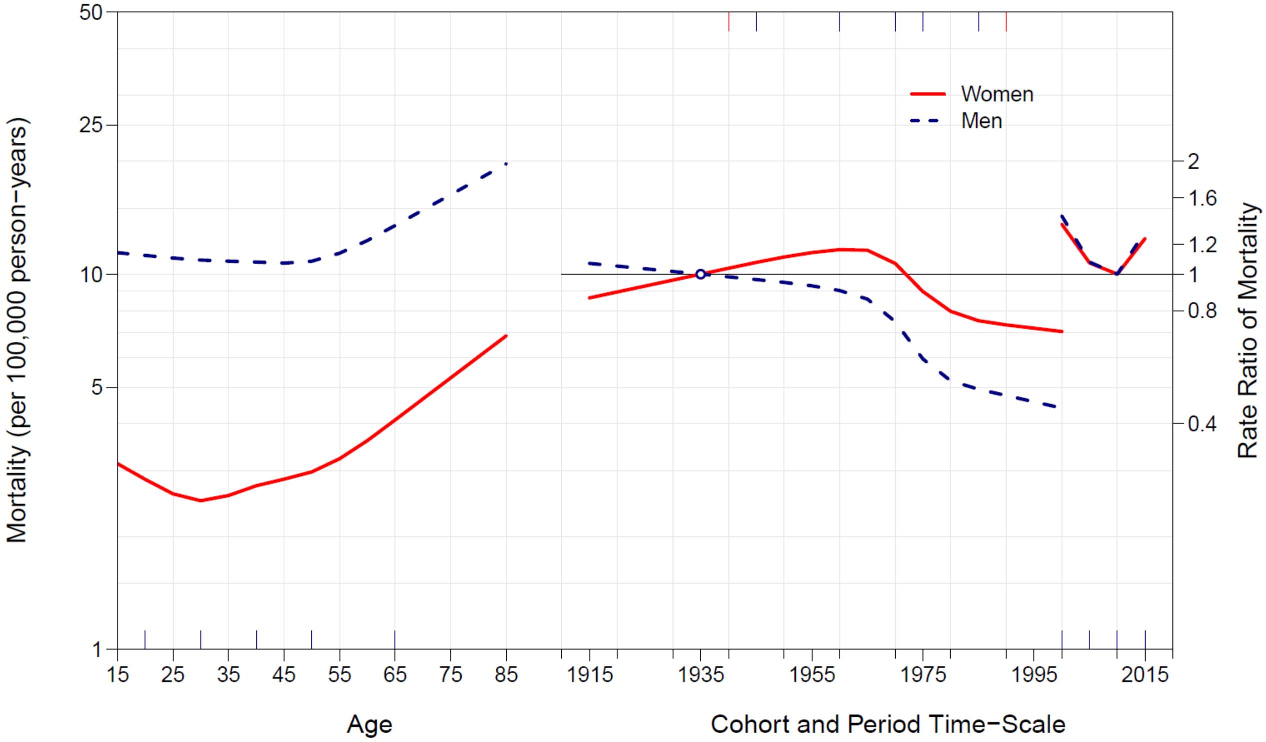
Supplementary Figure S6 Age, period, and cohort effects on suicide among foreign-born males and females between 2000-2019 in Spain (multi-phase method) - A: Men. B: Women.



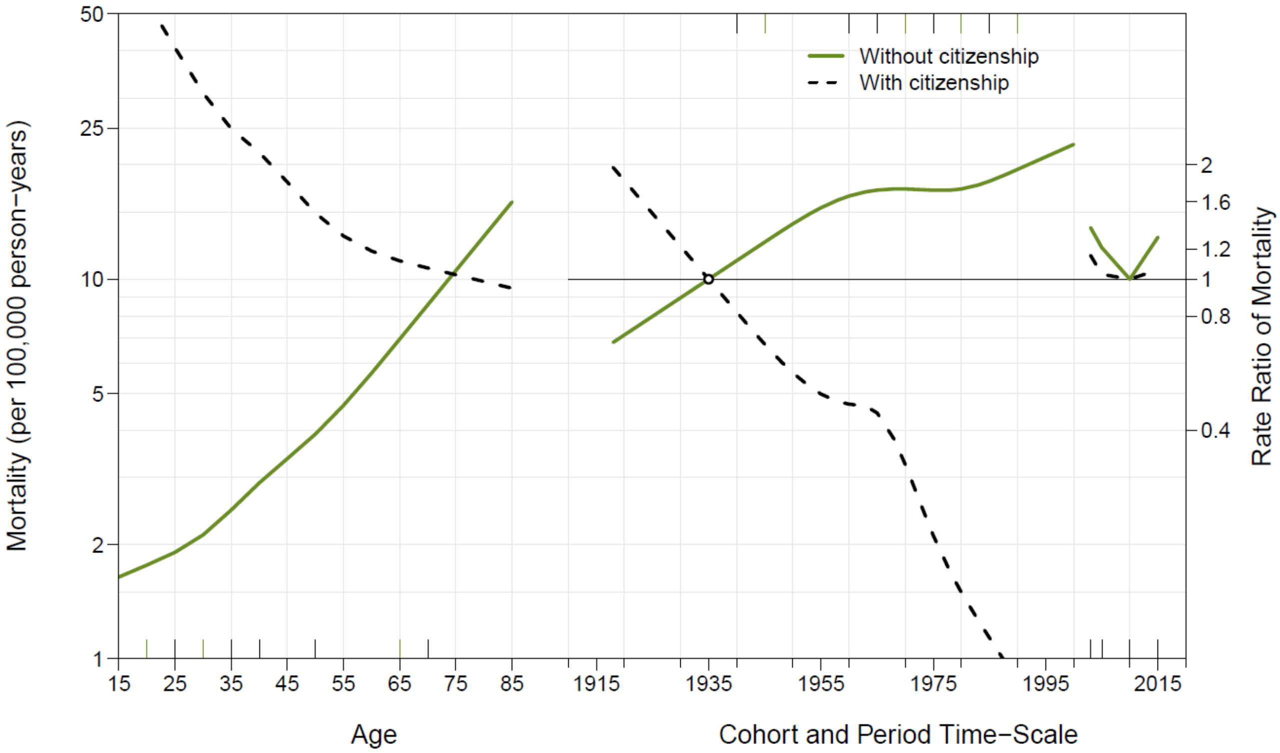
Supplementary Figure S7 Age, period, and cohort effects on suicide among native-born males and females between 2000-2019 in Spain (reference year: 1935)



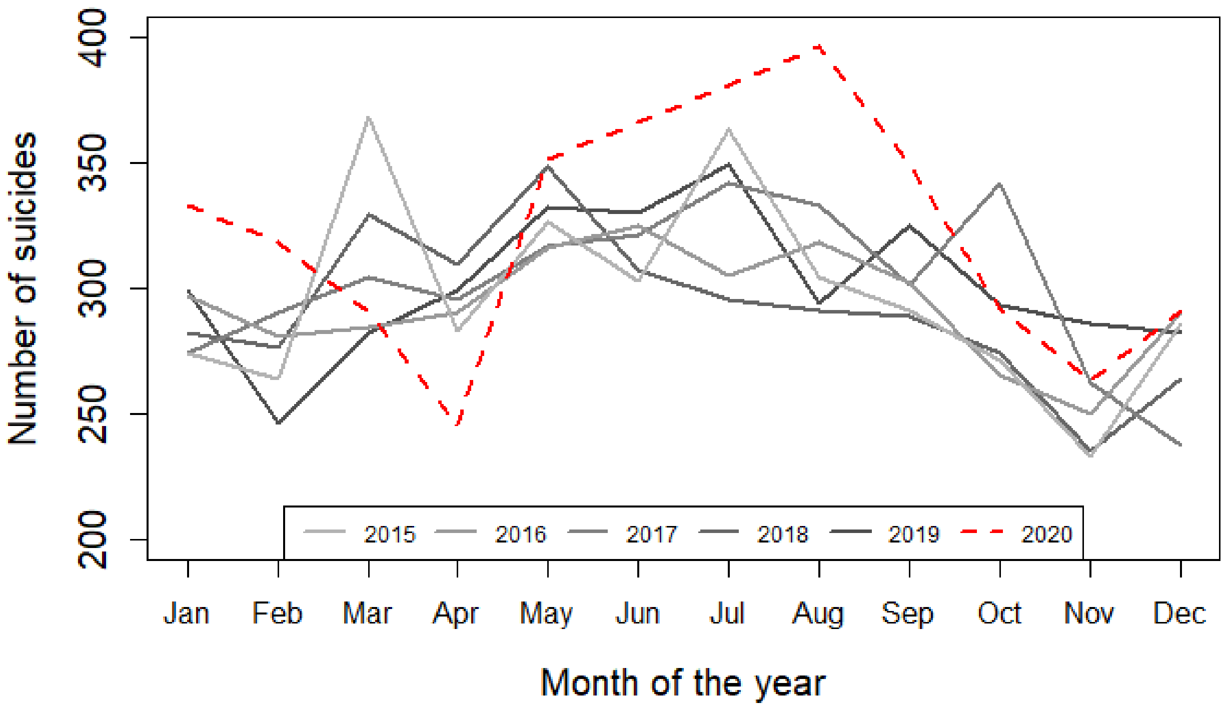
Supplementary Figure S8 Age, period, and cohort effects on suicide among foreign-born males and females between 2000-2019 in Spain (reference year: 1935)



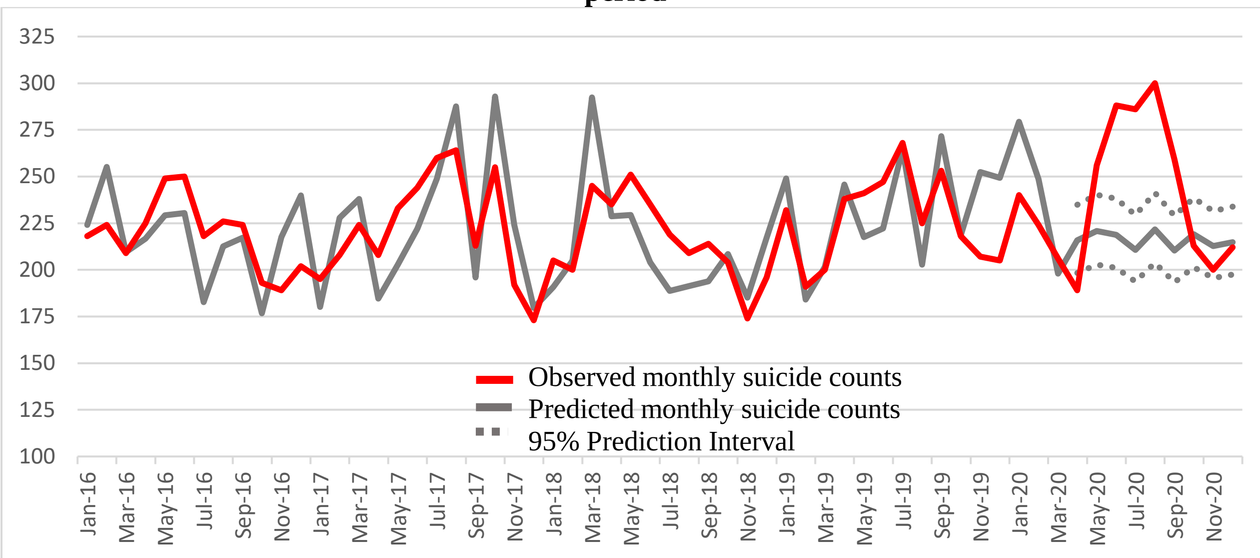
Supplementary Figure S9 Age, period, and cohort effects on suicide among foreign-born individuals between 2000-2019 in Spain, stratified by Spanish citizenship (reference year: 1935)



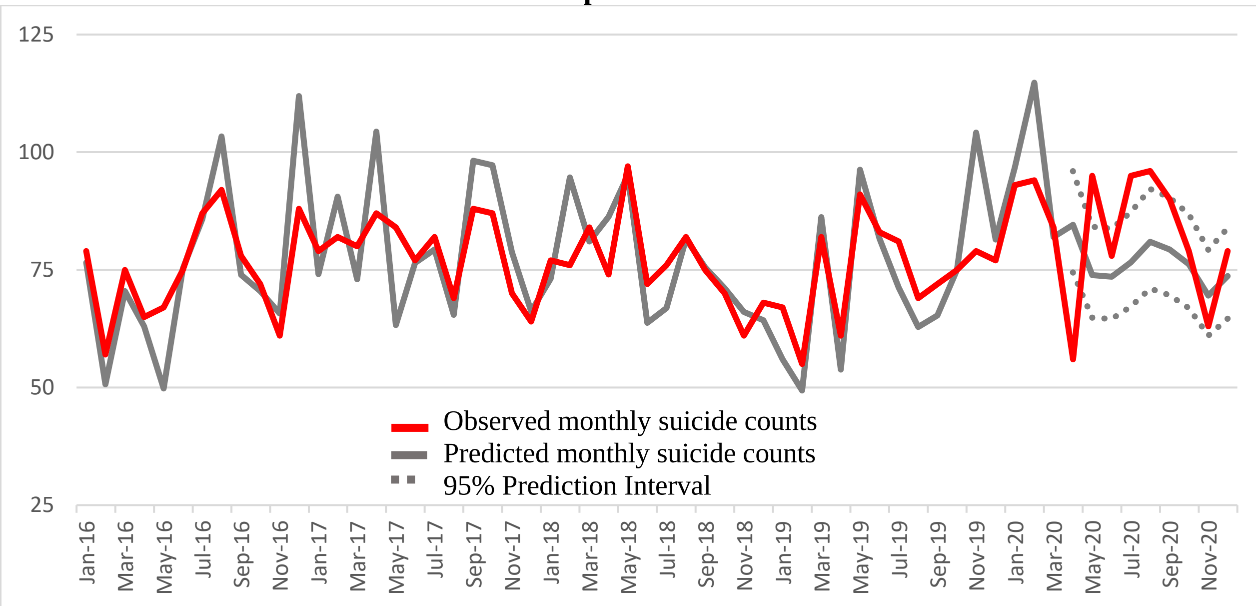
Supplementary Figure S10 Monthly suicides in Spain between January 2016 and December 2020



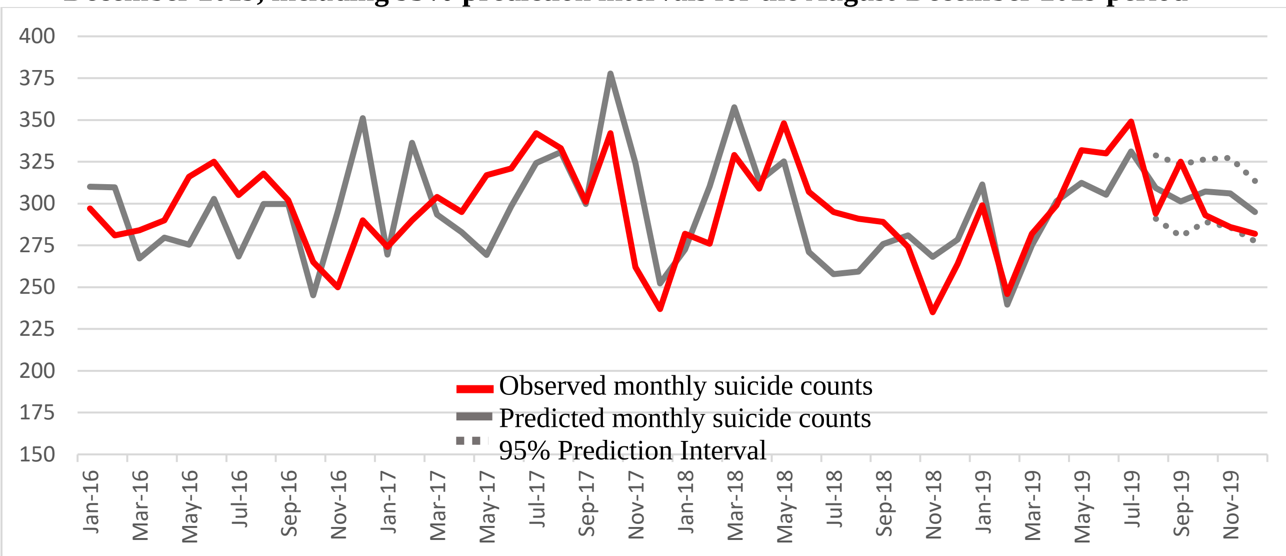
Supplementary Figure S11 Observed and predicted suicides among males in Spain between January 2016 and December 2020, including 95% prediction intervals for the April-December 2020 period



Supplementary Figure S12 Observed and predicted suicides among females in Spain between January 2016 and December 2020, including 95% prediction intervals for the April-December 2020 period



Supplementary Figure S13 Observed and predicted suicides in Spain between January 2016 and December 2019, including 95% prediction intervals for the August-December 2019 period



Appendix B

Supplementary Table S7 Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Checklist for Chapter 2

Section and Topic	Item #	Checklist item	Page where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	40
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	X
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	38-40
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	40
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	58
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	40
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	40
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	41
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	59
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	59
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	43
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	43
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	59

Section and Topic	Item #	Checklist item	Page where item is reported
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	59
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	NA
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	42
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	NA
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	41-43, 63
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	42
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	59
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	65
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	65
Study characteristics	17	Cite each included study and present its characteristics.	59
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	59
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	59
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	59
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	NA
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA

Section and Topic	Item #	Checklist item	Page where item is reported
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	50-54
	23b	Discuss any limitations of the evidence included in the review.	55
	23c	Discuss any limitations of the review processes used.	55
	23d	Discuss implications of the results for practice, policy, and future research.	55
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	NA
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	NA
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	NA
Competing interests	26	Declare any competing interests of review authors.	NA
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	42

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/