A Cause-Specific Decomposition of the Seasonal Fluctuations in External Cause-of-Death Mortality in Spain Before and During the COVID-19 Pandemic (2016-2022)

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Extended Abstract - EPC 2026

Introduction

The COVID-19 pandemic profoundly disrupted social, economic, and health systems worldwide, with consequences extending beyond direct COVID-19 mortality patterns. While considerable attention has been paid to excess all-cause mortality and COVID-19 attributable deaths, less is known about the indirect impact of the pandemic on mortality. Indeed, specific COVID-19 measures and policy aimed to disrupt the ease of transmission by halting major economic activities and restricting population contact and mobility. These non-pharmaceutical interventions were essential responses to rising COVID-19 cases, hospitalisations, and deaths. However, these measures may have indirectly contributed to exacerbating the mortality trends of those causes most dependent on direct human behaviour. For instance, COVID-19 measures in Spain disrupted daily routines, occupational exposures, access to healthcare services and emergency care pathways, and enforced a level of social isolation unprecedented in modern Spanish history. Therefore, while the potential negative impact of such measures may be small relative to the mortality burden averted by pandemic control, understanding these indirect effects remains important for comprehensive pandemic impact assessment and future preparedness planning.

In this sense, considering external causes of death (including transport accidents, falls, suicides, accidental poisonings, and other injury-related deaths) offers a particularly informative lens for understanding these indirect pandemic effects, as these causes are highly sensitive to the behavioural changes, environmental exposures, healthcare access patterns, and non-pharmacological interventions (Lee et al., 2023) that were introduced and altered during the pandemic. Additionally, external causes constitute an important component of mortality among younger and working-age populations. Examining changes in these causes may provide complementary insights into pandemic mortality impacts that extend beyond the age groups most directly affected by COVID-19 itself.

While some studies have explored pandemic-related mortality changes through cause-specific decompositions of life expectancy (Spijker and Trias-Llimós 2023), research specifically examining external causes of death in Spain remains limited. Some existing Spanish studies have documented trends in suicide, overdose and external cause mortality counts and trends (de la Torre-Luque et al., 2024, López-Cuadrado et al., 2025, Llorca et al., 2025, & Giné et al., 2025), with some evidence pointing to recent increases (partly coinciding

with the onset of the COVID-19 pandemic). However, these analyses do not assess the relative contribution of specific external causes to overall mortality disturbances, nor do they systematically account for pre-pandemic trends and seasonal variation. Excess mortality decomposition approaches offer a complementary framework that directly quantify observed versus expected deaths, allow for transparent accounting of baseline trends and seasonal patterns, and provide intuitive measures of cause-specific contributions to total mortality disturbances during crises.

Building on evidence of substantial educational inequalities in external cause mortality in Spain (including strong gradients in suicide mortality and socioeconomic disparities in overdose and traffic deaths), the study will assess whether these inequalities widened or narrowed during the pandemic. Prior research reported educational inequalities in COVID-19 mortality in Spain (Trias-Llimós, Riffe, & Martín, 2025), and indicated that external causes showed educational patterning during 2020, with mortality declines concentrated among low-educated men (Spijker & Trias-Llimós, 2023). However, less is known about how educational gradients manifested differently across specific external causes (transport accidents, suicides, drug poisonings) or how these patterns evolved beyond 2020.

Accordingly, this study will examine how the short-term shocks induced by the COVID-19 pandemic (and the associated mitigating measures) affected external-cause mortality in Spain. The study builds conceptually and methodologically on the analysis presented by Acosta (2024a) at the European Population Conference 2024, where changes in external cause mortality patterns were explored yearly for 10 countries during the first wave of the COVID-19 pandemic. The analysis first characterizes pre-pandemic seasonal patterns in external-cause mortality by educational attainment and sex, establishing baseline trends. It will then estimate absolute and relative cause-specific excess deaths for major external-cause categories during and after the pandemic, and decompose overall mortality disturbances into cause-specific contributions. Finally, the study will assess how educational gradients in external-cause mortality evolved throughout the study period.

Analysis Strategy

Data

We use mortality data from the Spanish National Statistics Institute (INE) to examine mortality disturbances in external causes from 2016 to 2022. Monthly mortality counts for Spain were obtained for the entire study period, and yearly counts were extracted for 1980-2024. The monthly count dataset contains underlying and multiple cause of death information for each recorded death, disaggregated by year, month, sex, and educational attainment. Educational attainment is categorized into four levels following the ISCED-2011 framework: primary education or lower (levels 0–1), lower secondary education (level 2), upper secondary education (level 3), and higher education (levels 4 and above). The study examines external causes of death (ICD-10 codes V01-Y89), with particular focus on major subcategories: transport accidents (V01-V99), falls (W00-W19), accidental poisoning (X40-X49), suicide and intentional self-harm (X60-X84), and assault and homicide (X85-Y09).

Methodology

The present analysis extends Acosta's (2024) framework to Spain's complete pandemic period (2016-2022) with four key novelties enabling deeper investigation: (1) monthly temporal resolution permits examining mortality dynamics alongside specific non-pharmaceutical COVID-19 interventions; (2) multiple cause-of-death (MCOD) data can provide insights into changes in the etiological patterns underlying observed dynamics (e.g., co-occurring mental health conditions in suicide deaths, or comorbidities in injury deaths); (3) educational stratification enables the systematic assessment of socioeconomic inequalities in cause-specific mortality responses; and (4) an extended time coverage until 2022 captures post-acute pandemic dynamics beyond the initial wave. Following Acosta (2024a), expected monthly deaths are estimated via quasi-Poisson Generalised Additive Models (GAM) using pre-pandemic data (January 2016-March 2020), incorporating smooth temporal trends and cyclic seasonal patterns, and extrapolated to the pandemic and post-pandemic period. Absolute and relative excess deaths are calculated by subtracting the extrapolated predictions from the observed death counts.

Preliminary results

Preliminary analyses of external cause reveal a 5.7% increase in external cause mortality during March 2020-2022. This result masks dynamic temporal variation: a 2.4% decline in 2020, followed by a 3.4% increase in 2021 and a substantial 14.0% surge in 2022 (Figure S2). Figure 1 shows the extrapolation of pre-pandemic mortality counts starting on 14/03/2020. Accidental poisoning exhibited the largest relative increase (+18.9%), intensifying from +16.3% in 2020 to +28.8% in 2022. Intentional self-harm increased persistently (+5.8%), reaching a +10.0% increase in 2022 (Figure S2). Transport accidents (the only declining category) showed a -4.0% overall decrease, driven by 2020's sharp -15.8% drop during lockdowns. Other unintentional injuries, the largest absolute category, contributed +5.5% (1,342 excess deaths), surging to +15.4% in 2022.

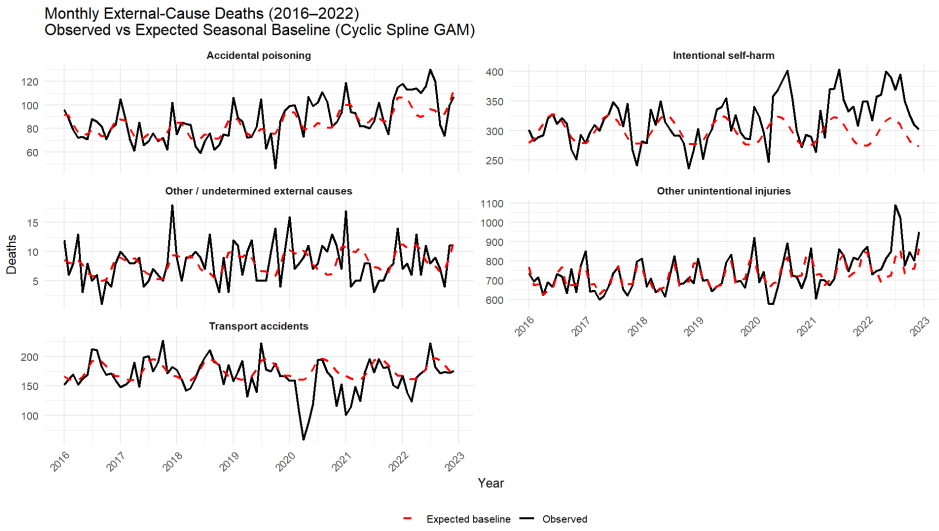

Figure 1: Monthly deaths from external CODs & expected monthly deaths from a seasonal baseline cyclic spline GAM and extrapolation by cause of death (beginning 14/03/2020).

Mortality disturbances varied markedly by education (Figure 2). Primary education showed a protective effect (-798 deaths), concentrated during the 2020-2021 lockdowns when reduced

mobility limited occupational and traffic exposures. First-stage secondary education experienced the largest burden (+1,947 excess deaths), driven primarily by other unintentional injuries and intentional self-harm. Higher education (+840 deaths) and upper secondary (+467 deaths) showed substantial contributions from accidental poisoning and intentional self-harm, suggesting different risk profiles across educational strata.

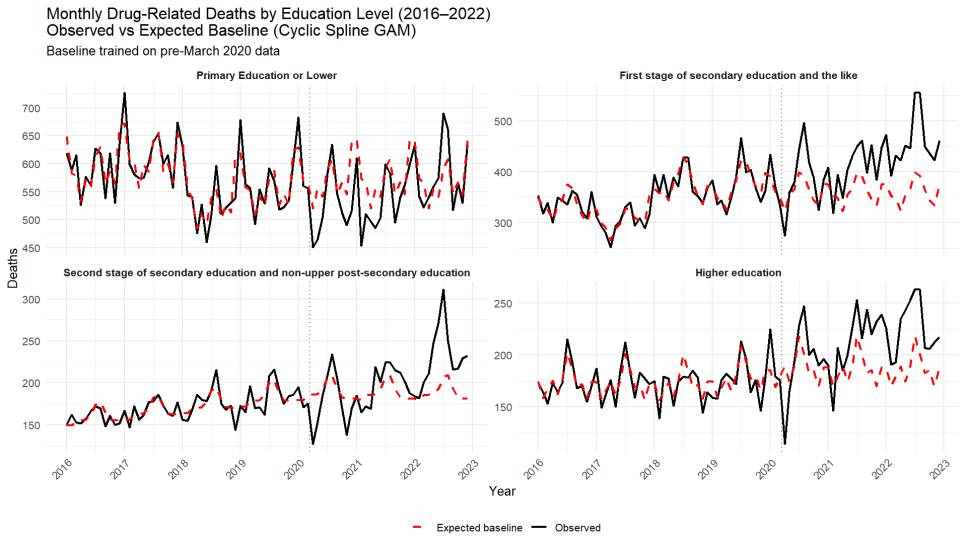

Figure 2: Monthly deaths from external CODs & expected monthly deaths from a seasonal baseline cyclic spline GAM and extrapolation by level of education (beginning 14/03/2020).

Next Steps

First, we will calculate proportional scores (p-scores) following the decomposition framework in Acosta (2024a). This decomposition will reveal which causes contributed towards the largest shares of monthly mortality change. P-scores will be calculated separately for each educational group and sex, enabling identification of which causes drove mortality disturbances most strongly within population subgroups. Importantly, p-scores will identify whether the same causes drove disturbances across all educational groups or whether different mechanisms operated in different socioeconomic strata.

We will also leverage MCOD data to investigate etiological shifts in external cause mortality composition. These MCOD analyses can distinguish whether observed mortality increases reflect changes in case volumes versus changes in the types of cases occurring, providing mechanistic insights into how pandemic conditions altered external cause mortality patterns.

Third, we will assess how educational gradients evolved across the pandemic period through systematic stratified analysis. We will quantify absolute differences and rate ratios in cause-specific excess mortality between educational groups, examining whether these inequalities widened, narrowed, or remained stable across pandemic phases. Additionally, we will examine cause-specific contributions to educational inequalities.

This analysis will contribute to understanding cause-specific external mortality patterns during the COVID-19 pandemic in Spain. By disaggregating mortality disturbances for specific external causes and socioeconomic strata, this study aims to provide insights into how pandemic-related disruptions differentially affected vulnerable populations.

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Supplementary materials

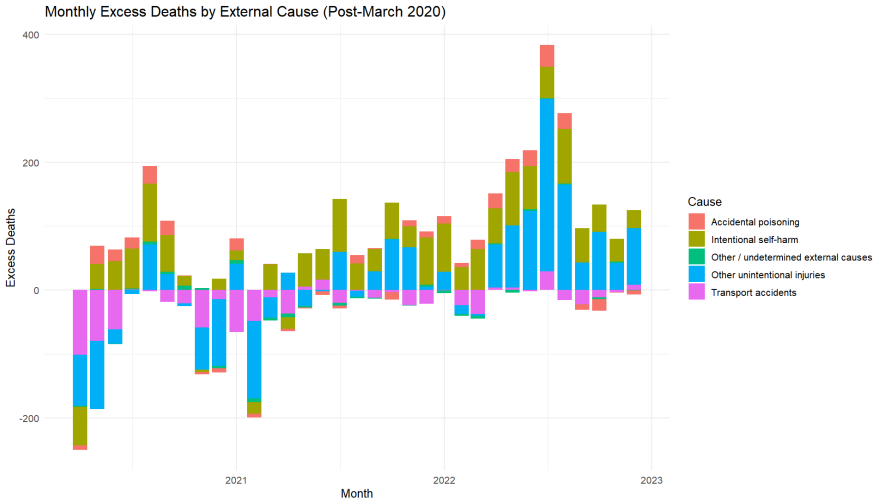

Figure S1: Contribution of external CODs to monthly excess deaths in Spain (2016-2022)

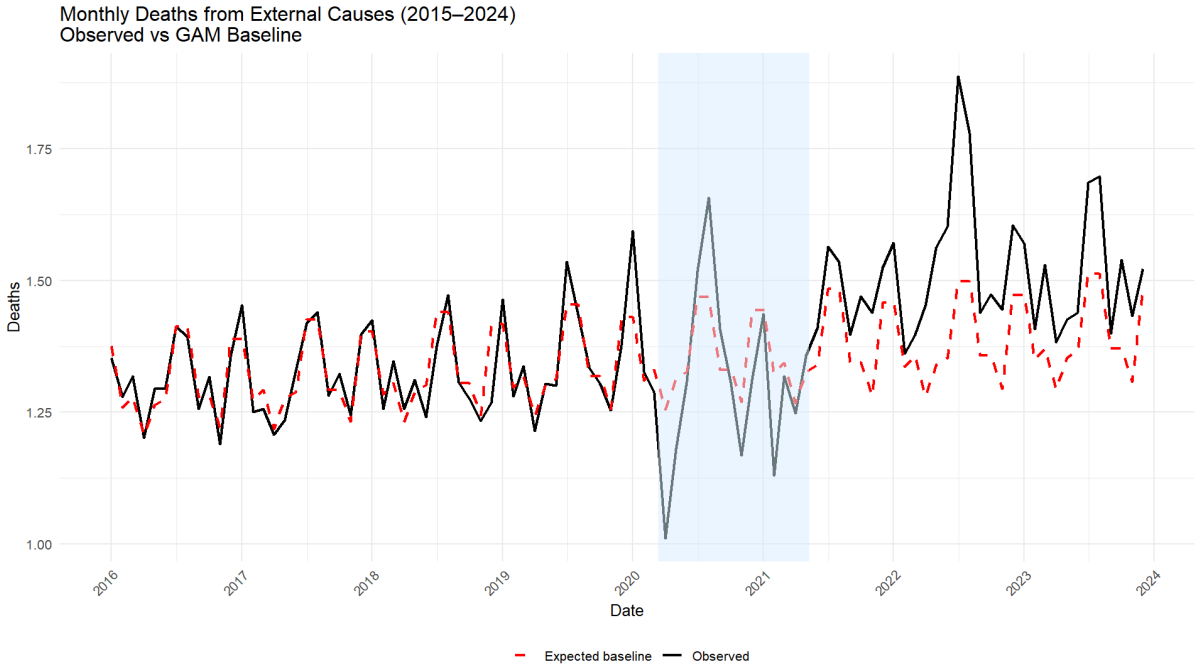

Figure S2: Total Monthly deaths from external causes & expected monthly deaths from a seasonal baseline cyclic spline GAM and extrapolation by level of education (beginning 14/03/2020). The shaded blue area represents the start and end of the first two states of alarm during the pandemic period.

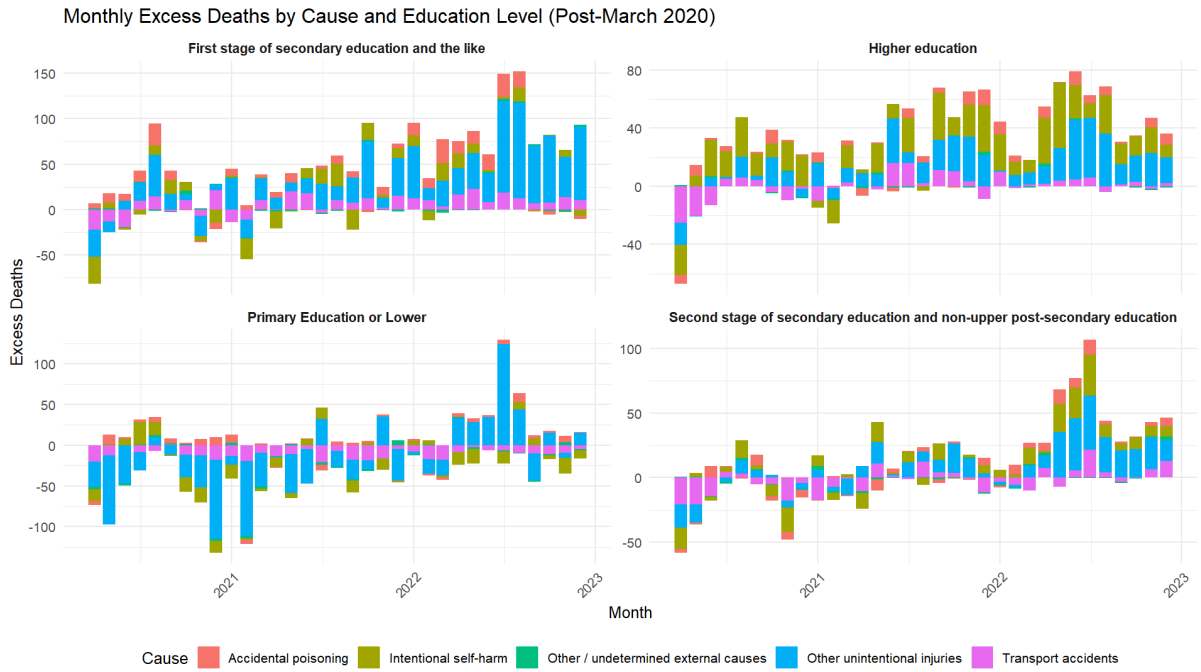

Figure S3: Contribution of external CODs to monthly excess deaths in Spain, disaggregated by education level (2016-2022)

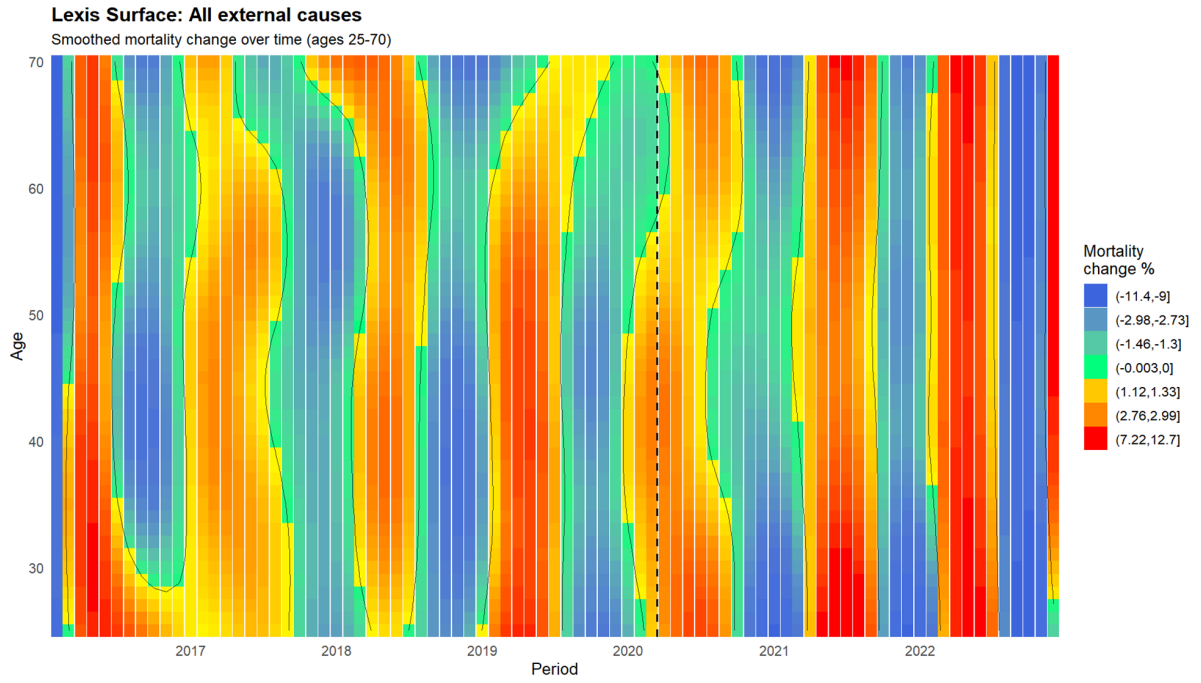

Figure S4. Lexis surface showing smoothed month-to-month mortality change for all external causes, ages 25-70, Spain 2016-2022. Colours represent percentage change in mortality rates compared to the previous month. The dashed vertical line marks the onset of COVID-19 measures (March 2020)

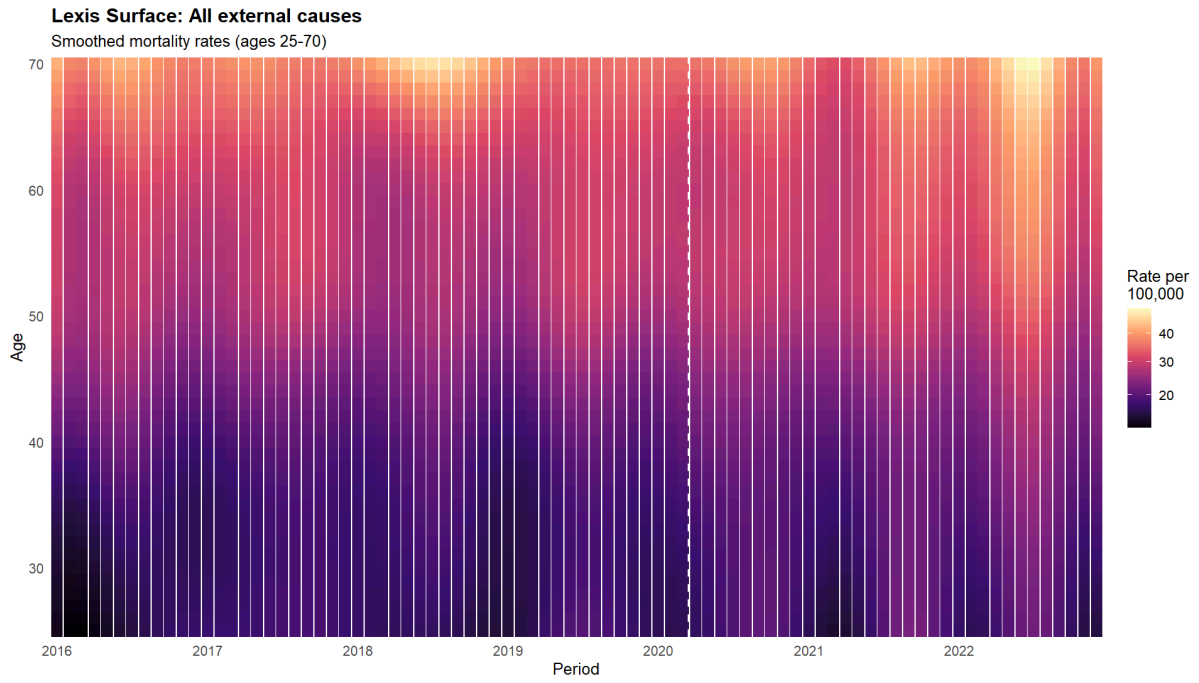

Figure S5: Lexis surface showing smoothed month-to-month mortality rates (per 100,000) for external causes in Spain (2016-2022)