**Title: How the COVID-19 pandemic hit crime rates in Barcelona: Analysis of variation in crime trends**

**Abstract**

**Objectives:** This study compares the observed and forecasted crime trends in Barcelona, using crime statistics from January 2018 to March 2021.

**Methods:** We trained (seasonal) auto-regressive integrated moving average (ARIMASARIMA) modeling (95% confidence intervals) using daily recorded crimes from January 2018 to February 2020. These models were then used to forecast crime data from March 2020 to March 2021 across four periods (lockdown, summer, fall, and winter). Crime data were organized into two categories: property crime (burglary, theft) and violent crime (robbery, assault, domestic violence, and sexual offenses [rape, assault, or abuse]).

**Results:** Overall, crime rates for property and violent crimes during lockdown declined sharply from the forecasted levels. Theft, burglary, assault, robbery, and sexual offenses also exhibited general decreases throughout the study period, with the same sharp declines during lockdown, progressive recovery in the summer, and steady or slight reductions from fall to March 2021. Only the pattern for domestic violence differed, reaching the forecasted rates for all periods and surpassing the forecasted rate for summer 2020.

**Conclusions:** Our findings show how the pandemic has affected mid-term crime trends. They help to place the measures applied in the last year into context and to determining the most suitable policies to reduce violence and crime during societal change.

**Keywords:** *COVID-19, crime trends, time series, ARIMA, lockdown, Barcelona, property crime, violent crime, domestic violence, sexual violence*

## Introduction

Human behaviors, interactions, and movements are highly intertwined with the spread of infectious disease (Haug et al., 2020). The global spread of SARS-CoV-2 since December 2019 has led to governments imposing various measures to prevent virus transmission. These measures have deeply affected social structures and systems, disrupted the different segments of society, modified human activity, and changed multiple aspects of everyday life (Leach et al., 2021). Our understanding of these processes continues to progress slowly through the ongoing COVID-19 pandemic (Perra, 2021).

Once the World Health Organization (WHO) declared COVID-19 a global pandemic, governments and other actors deployed a cascade of preventive and reactive public health and social measures to curb the virus' transmission and relieve pressures on health care systems and nursing homes. These non-pharmacological interventions, which included social distancing, quarantine, isolation, lockdown, and other mobility restrictions (e.g., curfew), proved effective in reducing the incidence of the virus (Haug et al., 2020). Equally, however, they have resulted in multiple side effects on people's health, the environment, culture, the economy, labor markets and employment, equality, social interactions, and crime (Bambra et al., 2021; Bell & Blanchflower, 2020; Nivette et al., 2021). Research has shown that the most stringent measures (e.g., lockdown) are inconvenient and that it is often more suitable to use a progressive combination of less drastic containment measures, government help, and financial programs tailored to the specific context and stage of the pandemic. Such an approach seems to offer the best way to mitigate curb the spread, reduce the costs, and mitigate the side effects of interventions (Haug et al., 2020).

The consequences of the pandemic provide an opportunity to reflect, transform, test, and

advance criminological knowledge. Indeed, it can be seen as an externality, offering a natural social experiment, or also as an internality in terms of a chance to make visible the critical and alternative approaches beyond the dominant basis, assumptions, and epistemologies (Walklate, 2021). Criminology literature suggests various pathways whereby social and movement restrictions and policies related to shock events or emergencies can lead to a decrease in certain crimes and an increase in others, resulting in a temporary change to the crime landscape in urban areas. As a result, urban crime patterns have temporarily changed in different grades associated with the restrictions (Nivette et al., 2021).

Criminal opportunity, which is explained by the crime pattern, lifestyle, routine activities, and environmental design theories, is related to socio-environmental changes and structural and situational opportunities (Wilcox & Cullen, 2018). This framework explains how stay-at-home orders and social distancing measures can cause crime rates to fall due to the changes in urban mobility patterns and the disruption in convergence of potential targets, perpetrators, and guardians. It is particularly noticeable in crime hotspots, reducing the density of daily encounters in the city where robbery, theft, assault, or nightlife-related incidents occur. There is also consideration of how rational choice mechanisms influence antisocial behavior through hierarchical decision-making processes, with criminals choosing specific areas and targets linked to daily routines that are modified during the pandemic. This can be seen from a propensity-situational approach through the lens of situational action theory (Wikström, 2019), considering the divergent social conditions influencing the likelihood that individuals will engage in antisocial behaviors and, therefore, the possible differential impact on specific urban areas and communities. Reduced peer influence, increased monitoring, and formal social control to ensure compliance with containment measures can also drive or influence the individuals' willingness to

take part in informal social control, which may contribute to reducing opportunities by fostering collective efficacy in a neighborhood (Sargeant et al., 2021).

Shock events like the COVID-19 pandemic may increase social disorganization and social deprivation, weaken social cohesion, and exacerbate inequalities and disadvantages depending on the population and community characteristics (Wenger, 2021). Multilevel stressors (i.e., psychological, economic, political, and financial), clustering, and/or intensifying previous burden (i.e., populations with structural inequalities and deprivation have also accompanied this context). For some populations, this has resulted in a syndemic (Singer et al., 2017), in which adverse conditions co-occur interact to generate an integrated effect. As explained by the general theory of stress (Agnew, 1992), this scenario can be a trigger for, or can aggravate, negative emotions, which in turn, may affect the likelihood of antisocial behavior and hinder adaptive behavior in both the short and long term. The COVID-19 outbreak may also have triggered uncertainty and insecurity that may lead to anomie, given the inability of society to regulate social changes satisfactorily (Merton, 1938), mainly for individuals who experience difficulties. Governmental public health and communication policies have not always been adequately deployed and conveyed in situations where norms and scientific evidence change rapidly.

Consequently, the pandemic could have increased factors that affect criminal propensity (individual and social problems and related stressors) depending on an individual's background, situational characteristics, and emotional regulation strategies (Sampson & Smith, 2021; Vertsberger et al., 2021). This can drive offending behavior within a temporarily disrupted socio-ecological system where criminal opportunity and motivation may have changed. This has occurred at a time when opportunities have been displaced to residential facilities and online environments, especially during periods of lockdown. People have also spent more time at home,

experiencing social isolation, emotional, economic, and financial stress, with reduced access to support because of the imposed restrictions, potentially increasing domestic and intimate partner violence, child abuse, and substance use and abuse (Pereda & Díaz-Faes, 2020; Piquero et al., 2021; Taylor et al., 2021).

Empirically, a growing number of studies have explored the variations in crime related to the COVID-19 pandemic in specific regions, countries, or cities. The first globally informed analysis was conducted by Nivette et al. (2021) using police-recorded crime mostly from Europe, Asia, and the Americas between January 2018 and May–June 2020. Their results revealed that crime rates fell worldwide in 27 major cities across 23 countries in association with stay-at-home orders, finding an average overall decline of -37% (overall effect size, 0.63). This study showed that crime declined substantially in most categories in each city from the beginning of the restrictions, especially in the theft and robbery domains (-47% and -46%, respectively), followed by motor vehicle theft (-39%), assault (-35%), burglary (-28%), and homicide (-14%). Nonetheless, their analysis unveiled important heterogeneity by city and crime type regarding both the direction and size of the crime trends. To address these differences, they contrasted a set of containment response policies as predictors of variation in crime rates, finding a negative association between the stringency of measures and the levels of crime. In other words, the most restrictive measures were associated with the greatest declines in crime. Nivette et al. (2021), as with other research (Abrams, 2021; Balmori de la Miyar et al., 2021; Chen et al., 2021; Langton et al., 2021; Perez-Vincent et al., 2021; Shen et al. 2021), reported that the fall in crime in other countries or cities was short-lived, reaching its nadir after a few weeks and recovering to previous levels as restrictions eased. Extending the pandemic period, Lopez and Rosenfeld (2021) used police data from 31 US cities for the period from January 2017 to December 2020.

There was a mean of 20 cities for all crimes—ranging from a minimum of 13 for domestic violence to a maximum of 28 for robbery—and found that property crimes decreased in all cities during the pandemic, except for motor vehicle crimes, which showed an upward trend after the stay-at-home orders of March 2020. Violent crime peaked in summer 2020 and declined thereafter.

On domestic and intimate partner violence, Piquero et al.'s (2021) meta-analysis first provided evidence suggesting that this type of incident increased by 7.9% (medium effect size, 0.66) after the stay-at-home orders based on official administrative pre–post records drawn from 18 studies. The trend for sexual violence is difficult to estimate and emerging evidence on this issue is mixed because several of its forms fall under other criminal typologies in official data sources. Studies covering these data during and after lockdown periods are scarce, Payne et al. (2020) in Australia, Abrams (2021) in the US, and Shen et al. (2021) in Japan have all reported marked declines in sexual assault, while Hoehn-Velasco et al. (2021) noticed a U-shape trend of sexual crimes against women (including sexual assault and rape) in Mexico. At the same time, Ceccato et al. (2021) showed different patterns for rape in New York (V-shape trend), São Paulo (L-shape trend), and Stockholm (no sign of impact). Finally, Muldoon et al. (2021) noticed an increase in sexual assault in Ottawa based on emergency department admissions.

### *COVID-19 restrictions in Barcelona*

The first case of COVID-19 was detected in Barcelona on February 25th, 2020, and the evolution of confirmed cases in Barcelona since the onset of the pandemic is shown in Figure 1. Educational institutions closed on March 13th and a stay-at-home order was implemented on March 15th and extended to June 21st, 2020, under the state of alarm declared by the Spanish central government. Commonly known as lockdown, this period also entailed the closure of the

borders, non-essential activity in retail businesses, bars and restaurants, and entertainment and leisure facilities (e.g., parks, cinemas, theaters, museums, night-time), as well as the prohibition of large gatherings outside and inside people's homes. Two weeks later, restrictions were tightened, ordering non-essential workers to stay at home from March 30th to April 9th. However, a portion of the workforce in sectors that did not work from home (e.g., industry, construction) were allowed to return to work on April 13th. On May 2nd, a progressive period of easing of restrictions began, structured in four distinct de-escalation phases.

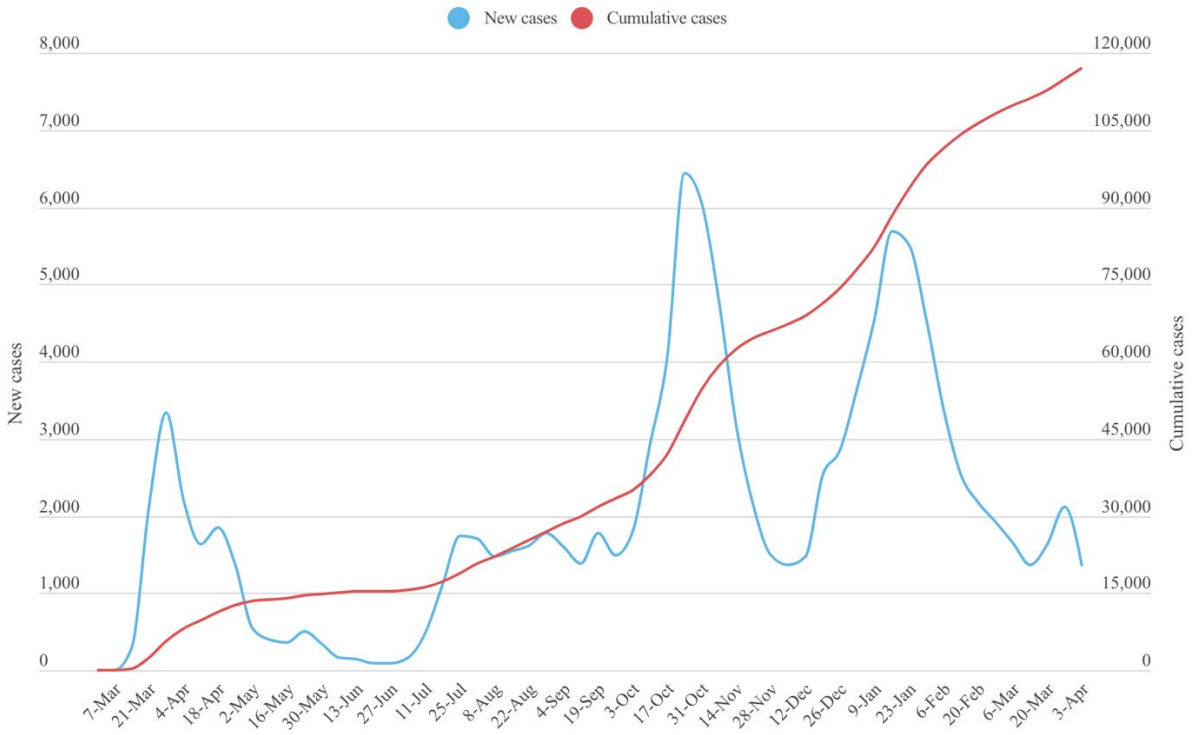


**Figure 1.** New and cumulative confirmed COVID-19 cases in Barcelona from March 2020 to March 2021 inclusive. Source: Agència de Salut Pública de Barcelona (2021).

De-escalation Phase 0 was implemented until May 24th, allowing the opening of certain commercial premises and the practice of individual sports out of the home. Phase 1, from May 25th to June 7th, expanded the lifting of measures to allow family or friends to gather in groups of up to ten people, bars and restaurant's terraces to open at half capacity, hotels to reopen with

common areas closed, and commercial premises <400 $m^2$ to reopen. In Barcelona, citizens were still not allowed to leave the city. During this phase (on May 21st), the Ministry of Health imposed the mandatory use of masks in enclosed spaces and in public spaces where a minimum safety distance of 2 m could not be guaranteed. Phase 2 was in effect from June 8th to June 17th and allowed, among other things, mobility within the Barcelona metropolitan area (5,627,638 inhabitants), malls to reopen with limited seating capacity, consumption to resume within bars and restaurants, and flea markets to reopen. On June 18th, Phase 3 began and significantly lifted previous restrictions, allowing activities in commercial premises and nightlife venues, and mobility within the Catalan territory for the first time since the lockdown began. The next day, on June 19th, Catalonia entered a new stage called "new normality," and two days later, the state of alarm finally expired. Coinciding with the summer period, this marked a 4 months period of less restrictive measures, albeit with some oscillations. For example, on July 9th, the use of face masks in public spaces became compulsory again, with a new safety distance of 1.5 meters, after being lifted on June 26th. Eventually, due to the rise in cases, more restriction measures were ordered (e.g., closure of bars and restaurants on October 16th), and a new state of alarm was finally imposed on October 25th, 2020, that would last for several months. This mainly included a night curfew, restrictions on mobility within Catalonia, and gatherings in public spaces, but falling short of a full lockdown. The government started vaccination campaigns on December 27th, 2020, and extended the second state of the alarm to May 9th, 2021.

The changes in containment policies affected mobility, highlighting the potential shift and displacement effect on criminal opportunity. As shown in Figure 2, mobility data reveal how people moved around and used public and private spaces. The trends in mobility shifted markedly during lockdown, with time spent in residential facilities increasing and time spent in

all other settings plummeting. By contrast, mobility came closer to the baseline value in the summer before falling off again in October 2020 due to the re-entry of some restrictions. Finally, mobility exhibited an upswing from baseline in November, with a further fall in December and a subsequent recovery toward baseline.

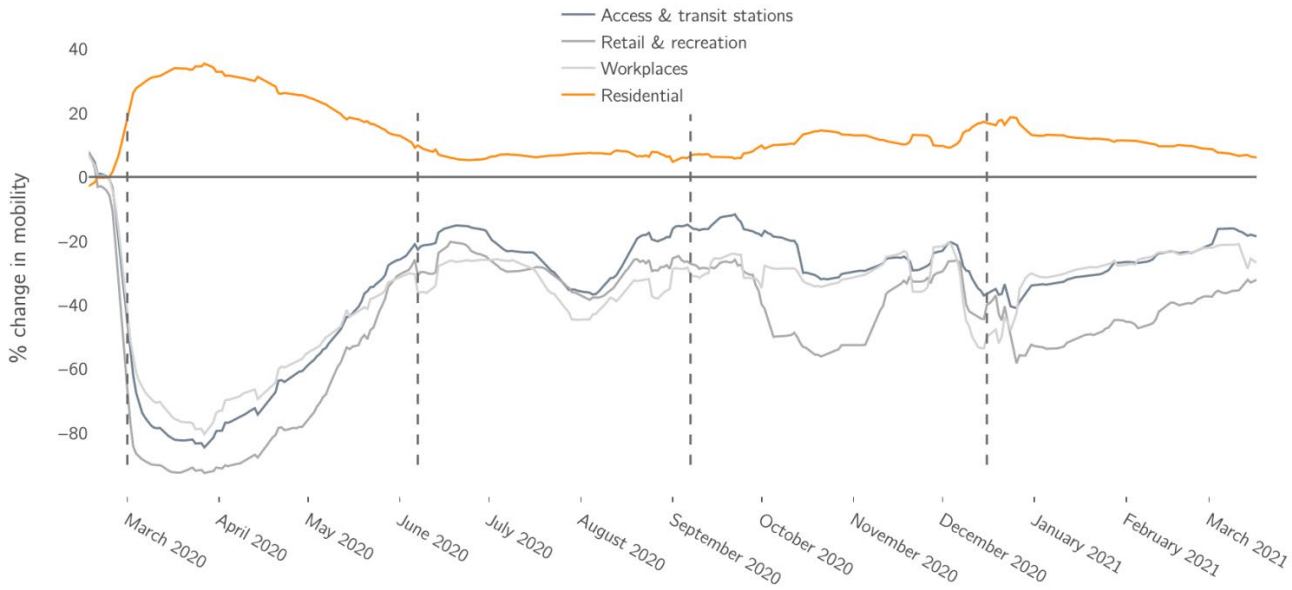


**Figure 2**. Median percentage change in mobility from baseline in Barcelona between March 2020 and March 2021. Source: Google (2021), and Agència de Salut Pública de Barcelona (2021). Note: An additive seasonal decomposition was applied to the raw time series data.

**The current study**

This study aims to analyze whether the trend of daily recorded crime by Catalonia's police force (*Mossos d'Esquadra*) in the city of Barcelona changed due to the containment policies (during lockdown; i.e., March 15$^{th}$ to June 21$^{st}$ 2020) and during the rest of the COVID-19 pandemic (post-lockdown; including summer, fall, and winter). We plan to test the following six hypotheses. First, there will be a general decline in property and violent crimes during the lockdown period, followed by a steady or slight reduction in the fall and winter, but without full recovery of previous crimes rates throughout the period. Second, the downward trend will be

particularly noticeable for burglary, theft, assault, and robbery. Third, domestic violence will increase, but this effect will not appear immediately following the lockdown. Fourth, sexual offenses will decrease, especially during lockdown, and will show a slight upturn in onset by summer 2020, followed by steady levels. Fifth, homicide will exhibit little or no change. Sixth, and finally, we expect a sudden and temporary increase in crime levels during the post-lockdown period, with steady levels or a slight reduction from the introduction of new restrictions on October 25th, 2020. We anticipate that crime levels will not recover to pre-pandemic at any point during the pandemic and that the forecasted and observed crime levels will diverge, except for domestic violence and homicide.

## Method

### Data

Data are drawn from the *Mossos d'Esquadra* police records, which comprises the daily recorded crime rates in Barcelona (1,664,182 inhabitants). The first data point for the current database was January 1st, 2018, and the most recent addition was on March 31st, 2021. These data therefore covered a year after the COVID-19 pandemic was declared by the WHO on 11 March 2020 and a period after the 3-month lockdown period from March 15th to June 21st, 2020.

We focused on daily offense records for 15 types of crime: assault, intentional homicide, residential theft, commercial theft, theft in other places, residential burglary, commercial burglary, burglary in other places, residential robbery, commercial robbery, robbery in other places, motor vehicle theft, domestic violence, sexual abuse, and rape/sexual assault. The official data provided by the police included both consummated crime (e.g., killing a person with a knife) and attempted crime (e.g., sticking a knife in a vital area with an intention to kill, but where the victim survived). However, they do not include crimes committed through imprudence

(e.g., if a flowerpot is thrown from a balcony and kills someone or if the facts do not show a clear intent to kill).

**Analytical approach**

To assess changes in daily police-recorded crime due to the pandemic restrictions and to draw conclusions at the macro level, we first grouped the 15 individual offenses into two main categories depending on the nature of the crime: a) property crime, which includes thefts (i.e., residential theft, commercial theft, theft in other places, motor vehicle theft) and burglaries (i.e., residential burglary, commercial burglary, burglary in other places); and b) violent crimes, which includes intentional homicide, assault, robberies (i.e., residential robbery, commercial robbery, robbery in other places), domestic violence, and sexual offenses (including sexual abuse and rape/assault). Furthermore, we selected four different periods of interest: the lockdown period (March 15$^{th}$ to June 21$^{st}$, 2020) and the three post-lockdown periods, which we split into summer (June 22$^{nd}$ to September 21$^{st}$, 2020), fall (September 22$^{nd}$ to December 31$^{st}$, 2020), and winter (January 1$^{st}$ to March 14$^{th}$, 2021). Then, we visually inspected the daily rates of property and violent recorded crimes for the three full calendar years with available data (2018–2020). Instead of visualizing the raw data, we performed an additive seasonal decomposition (i.e., trend, seasonality, and residual) of time series for both property and violent crime. That is, we decomposed each time series as a sum of the trend, seasonality, and residual components, which we repeated for both crime categories and for each calendar year, and depicted only the trend component, see Figure 3. The trend helped to visualize and assess quantitatively how the observed variable changed over a given period (e.g., summer or fall) in different years.

We computed forecasts for each aggregated category (property and violent crimes) and offense (thefts, burglaries, intentional homicide, assault, robberies, domestic violence, and sexual

offenses) by training separate auto-regressive integrated moving average (ARIMA) models on the weekly number of offenses recorded from January 1st, 2018, to February 29th, 2020. ARIMA models have been extensively used to forecast time series for crime data during the COVID-19 restrictions when assessing changes in crime trends (Ashby 2020; Payne et al., 2020; Payne et al., 2021). For a given offense category, these models leverage the trend, seasonality, and lagged autocorrelation (i.e., the correlation of observations separated by time within a given time series) of the observed time series to produce forecasts with confidence intervals for unobserved periods. A key assumption of this process is that there is an underlying relationship between past and future data, whereby the ARIMA model learns the key aspects of the observed time series to produce accurate predictions. Once forecasts have been computed for each crime category, we can quantitatively assess the significance of the difference between the observed and predicted crime rates based on past data (e.g., what would have happened if COVID-19 had not occurred).

First, for each crime category, we ascertained whether the time series exhibited trend and/or seasonal effects, also known as non-stationarity or presence of a unit-root. If a series contains a unit-root, then a shift in time causes a change in the distribution of the series, and thus needs to be de-seasonalized before fitting an ARIMA model. We performed the augmented Dickey–Fuller test, which is the most common statistical tool to check for stationarity, setting the null hypothesis as the time series being non-stationary and exhibiting a time-dependent structure. Among the categories considered, the null hypothesis could be rejected at the 0.05 significance level for burglaries ($p$ = 3e-5), domestic violence ($p$ = 4e-16), intentional homicide ($p$ = 1e-14), and sexual offenses ($p$ = 1e-4), but could not be rejected for thefts ($p$ = 0.06), robberies ($p$ = 0.78), assault ($p$ = 0.34), aggregated property crime ($p$ = 0.06), and violent categories ($p$ = 0.7). These results were then used to fit an optimal ARIMA model for each crime category.

Second, for each crime category, we establish baseline ARIMA[p,d,q] and seasonal ARIMA (SARIMA[p,d,q,52]) models to account for trend and seasonality, respectively. These were trained on the weekly total recorded crimes from January 1st, 2018, to February 29th, 2020 (hence a periodicity of 52). The auto-regressive p-parameters capture the number of prior observations included in the model to predict future values, the d-parameters measure the number of times the raw data is differentiated to correct for stationarity, and the q-parameters represent the size of the moving average window. Based on the augmented Dickey–Fuller test, we do not need to correct by trend and seasonal difference if the time series under consideration is stationary, giving ARIMA(0,0,0) and SARIMA(0,0,0,52) baseline models. Conversely, if the time series is non-stationary, we remove the unit-root by first differencing the trend with ARIMA(0,1,0) and then adjusting the seasonality with SARIMA(0,1,0,52). Then, we prescribe the parameter space to be $\{p, q\} \in \{0,1\}$ and iteratively train a model for different configurations of the trend and seasonal auto-regressive and moving average parameters to select the one that minimizes the Akaike information criterion. This is one of the most extensively used statistical criteria to assess the prediction error of a time series forecast model. The only crime category for which a model is not trained is intentional homicide because the incidence of these crimes is too low to produce accurate forecast models.

Finally, for each crime category, we used the ARIMA model trained with the best set of parameters, that is those that minimize the Akaike information criterion, in order to predict the estimated weekly recorded crimes, along with the 95% confidence intervals, for the period from March 1st, 2020, to March 14th, 2021. We then compared the forecast and observed values for the four seasonal periods and considered whether a significant change occurred (at the 5% level) in the offense rate if the observed crimes fall outside the upper and lower bounds on the confidence

interval, as aggregated for the period of interest. It should be noted that confidence intervals widen the further in the future we forecast, thus signaling greater confidence for predictions that are close in time to the end of the training period (February 29th, 2020).

## Results

### Observed trends of daily recorded crimes

Similar crime trends are observed for 2018 and 2019, see Figure 3, while 2020 clearly shows a distinct pattern. Interestingly, the data shows a point increase on January 1st for both property and violent crime. The recorded property crimes in the first 5 months of 2019 were 11% higher than in 2018, 4% lower from June to September, and 11% lower from September onwards, rendering roughly the same total number of crimes for both years. Conversely, the number of violent crimes in 2019 increased by 14% compared to 2018.

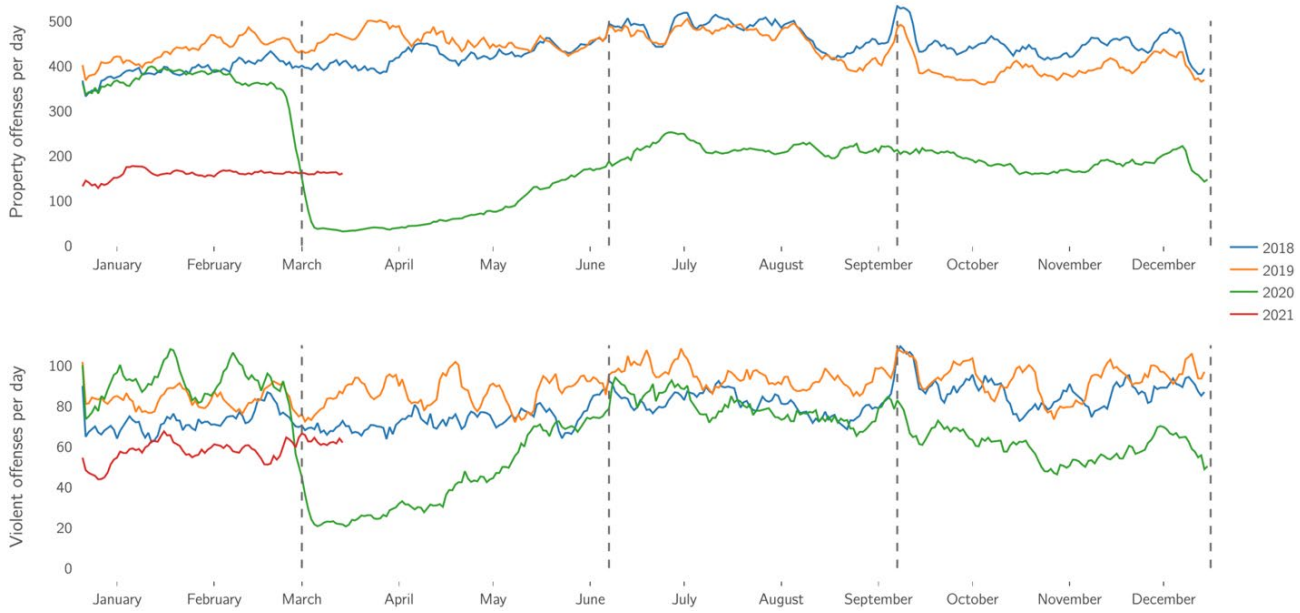


**Figure 3.** Recorded property crime (top) and violent crime (bottom) trends for 2018–2021. The four periods of interest are differentiated by dashed lines at March 15th, June 21st, September 21st, and December 31st.

In 2020, before the lockdown, property crime was 7% lower and violent crime was 23%

higher than for the same period in 2018, whereas compared to 2019, they were 16% lower for property crime and 8% higher for violent crime (see Table 1).

**Table 1.** Daily recorded property and violent crimes for four periods across three years, with comparisons shown for 2020 and 2021.

| | **Property crimes per day** | | | | **Violent crimes per day** | | | |
|---|---|---|---|---|---|---|---|---|
| | **2018** | **2019** | **2020** | **2021** | **2018** | **2019** | **2020** | **2021** |
| **Winter** | 390 | 433 | 362<br>*-7% 2018*<br>*-16% 2019* | 157<br>*-60% 2018*<br>*-64% 2019*<br>*-57% 2020* | 74 | 85 | 91<br>*+23% 2018*<br>*+8% 2019* | 57<br>*-23% 2018*<br>*-32% 2019*<br>*-37% 2020* |
| **Lockdown** | 423 | 457 | 81<br>*-81% 2018*<br>*-82% 2019* | -<br>-<br>- | 73 | 87 | 44<br>-39% 2018<br>-49% 2019 | -<br>-<br>- |
| **Summer** | 475 | 459 | 216<br>*-54% 2018*<br>*-53% 2019* | -<br>-<br>- | 81 | 95 | 80<br>*-2% 2018*<br>*-16% 2019* | -<br>-<br>- |
| **Fall** | 446 | 394 | 184<br>*-59% 2018*<br>*-53% 2019* | -<br>-<br>- | 88 | 94 | 60<br>*-32% 2018*<br>*-36% 2019* | -<br>-<br>- |

From mid-March to late June 2020, we observed a sharp decline in recorded crime rates for both categories (around 80% for property crimes and 40%–50% for violent crimes compared to the same period in the previous two years). Overall, despite increasing from the minimum figures attained at the end of March, the aggregated volume of both crimes from June 22$^{nd}$, 2020 onwards did not reach the levels recorded in previous years. The data show approximately 55%

fewer property crimes in the summer 2020 period than in the previous two years, whereas violent crimes rose to the same levels as in 2018 (albeit 16% lower than in 2019). In the fall of 2020, both property and violent crimes decreased compared to the summer 2020, roughly 55% and 34% compared to the same period in previous years. Overall, during the lockdown, both property and violent crimes plummeted, showed a progressive recovery during the summer (especially for violent crimes), and decreased again in the fall, never reaching the minimum values observed at the end of March 2020, see Figure 3 and Table 1.

Data for the 2021 winter period showed lower levels of both property and violent crimes compared to the same period in previous years (60% for property crimes and 25%–40% for violent crimes). Furthermore, less property crimes in the winter 2021 occurred compared to the fall 2020 (declining from 184 per day in fall 2020 to 157 per day in winter 2021), whereas the number of violent crimes remained fairly static between these periods.

**Forecasted trends of weekly property and violent crimes**

We used the ARIMA models trained on data from January 1st, 2018, to February 29th, 2020, for each crime category to predict the number of offenses in the remainder of 2020 and the first 3 months of 2021. This simulated a counterfactual scenario without the COVID-19 pandemic. We then compared the weekly forecasts and observed data, presenting the aggregated results across the four study periods, see Figures 4 and 5) We also show the 95% confidence intervals for the forecasted data, which we leveraged to assert whether the observed crime data were significantly lower or higher (i.e., outside the confidence interval) than the forecasted data for each crime category and period. Finally, we report the percent change in weekly observed crimes regarding the mean forecasted value for each period and crime, see Table 2.

***Change in weekly observed crimes.*** Table 2 shows the percentage change in weekly observed crimes with respect to the mean forecasted value for each period and crime.

**Table 2.** Relative weekly change in observed crimes, by type, using mean forecasted data for 2018–2021

| | **Type of crime** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Property** | | | **Violent** | | | | |
| | **Burglary** | **Theft** | **Overall** | **Assault** | **Domestic** | **Robbery** | **Sexual** | **Overall** |
| **Lockdown 2020** | -48% | -77% | **-75%** | -44% | +0.4% | -67% | -72% | **-50%** |
| **Summer 2020** | -6% | -50% | **-47%** | -5% | +19% | -38% | -50% | **-19%** |
| **Fall 2020** | -32% | -52% | **-50%** | -31% | -8% | -54% | -60% | **-43%** |
| **Winter 2021** | -28% | -57% | **-43%** | -38% | -3% | -54% | -55% | **-45%** |

***Property crimes.*** The decline in property crimes for the lockdown and summer 2020 periods was significant compared to that predicted from historical data, see Figure 4. Despite lower-than-forecasted values for property crime in the fall 2020 and winter 2021 periods, this was insufficient to conclude on its statistical significance. Observed burglaries and thefts exhibited a significant decline during the lockdown compared to the aggregated predictions, and although observed thefts increased in the summer, they remained significantly lower than the forecast levels. Conversely, burglaries recovered to pre-pandemic levels in the summer. Although the observed burglaries and thefts values in fall and winter were lower than the estimated means, we have insufficient evidence to assert that these were statistically significant at the 95% level.

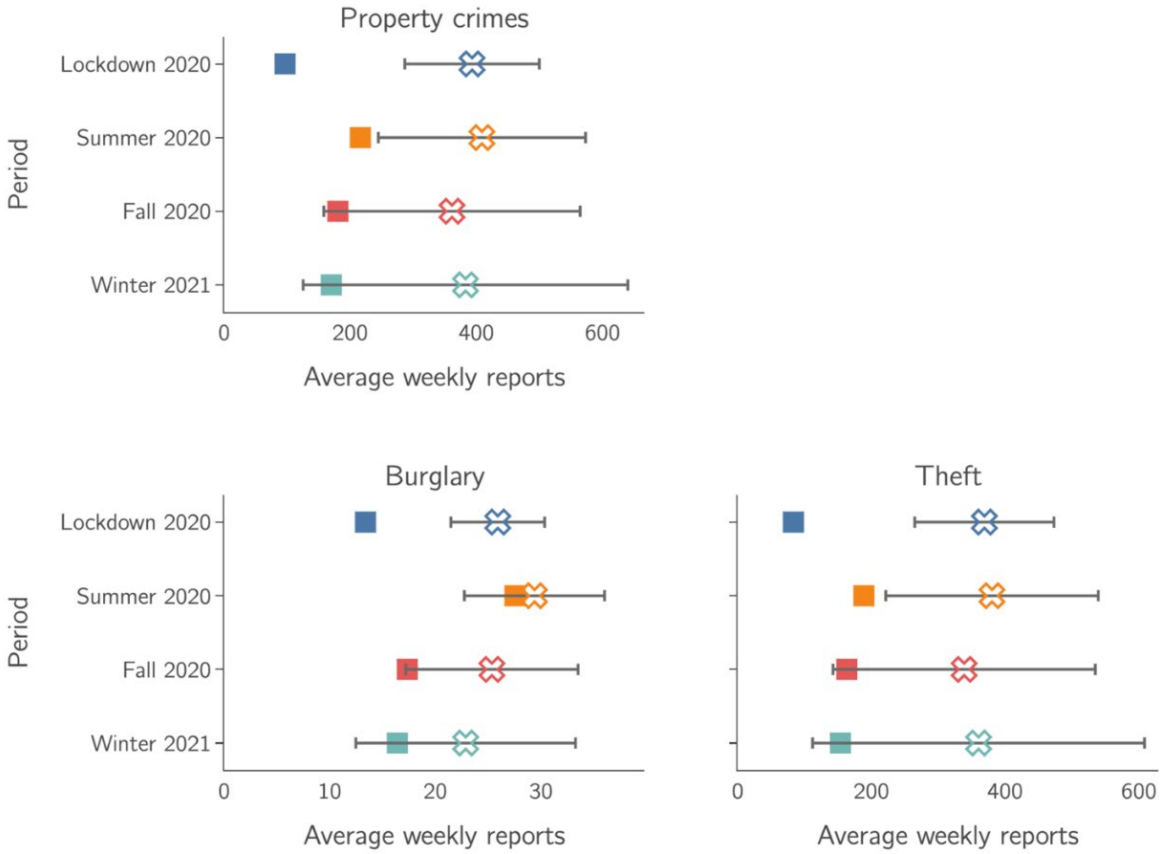


**Figure 4.** Forecast weekly property crimes (crosses, with 95% confidence intervals) compared to observed property crimes (squares), aggregated into four periods for comparison. Data are shown overall (chart above) and by type of property crime (two charts below).

***Violent crimes.*** A statistically significant decline occurred during lockdown compared to the forecast, see Figure 5. The observed violent crime data were still lower than the point estimates using the forecast models in summer, fall, and winter; however, all values were within the confidence intervals, precluding comment on the significance of this decline. Assault and robbery exhibited the same pattern of a significant decrease during the lockdown, recuperation in the summer (almost to pre-pandemic levels for assault, but still significantly lower for robbery), followed by a further decrease in the fall and winter that was still above the minimum observed during lockdown (and only significantly lower than pre-pandemic levels for robbery). Sexual

offenses followed the same pattern, recovering in the summer from the minimum during lockdown and decreasing again in the fall and winter; however, no changes were significantly lower than the forecast data. Finally, domestic violence exhibited a distinct behavior, with the observed 2020 values coinciding with the estimated forecasts across all four periods and showing an even greater, albeit non-significant, number of observed crimes in the summer.

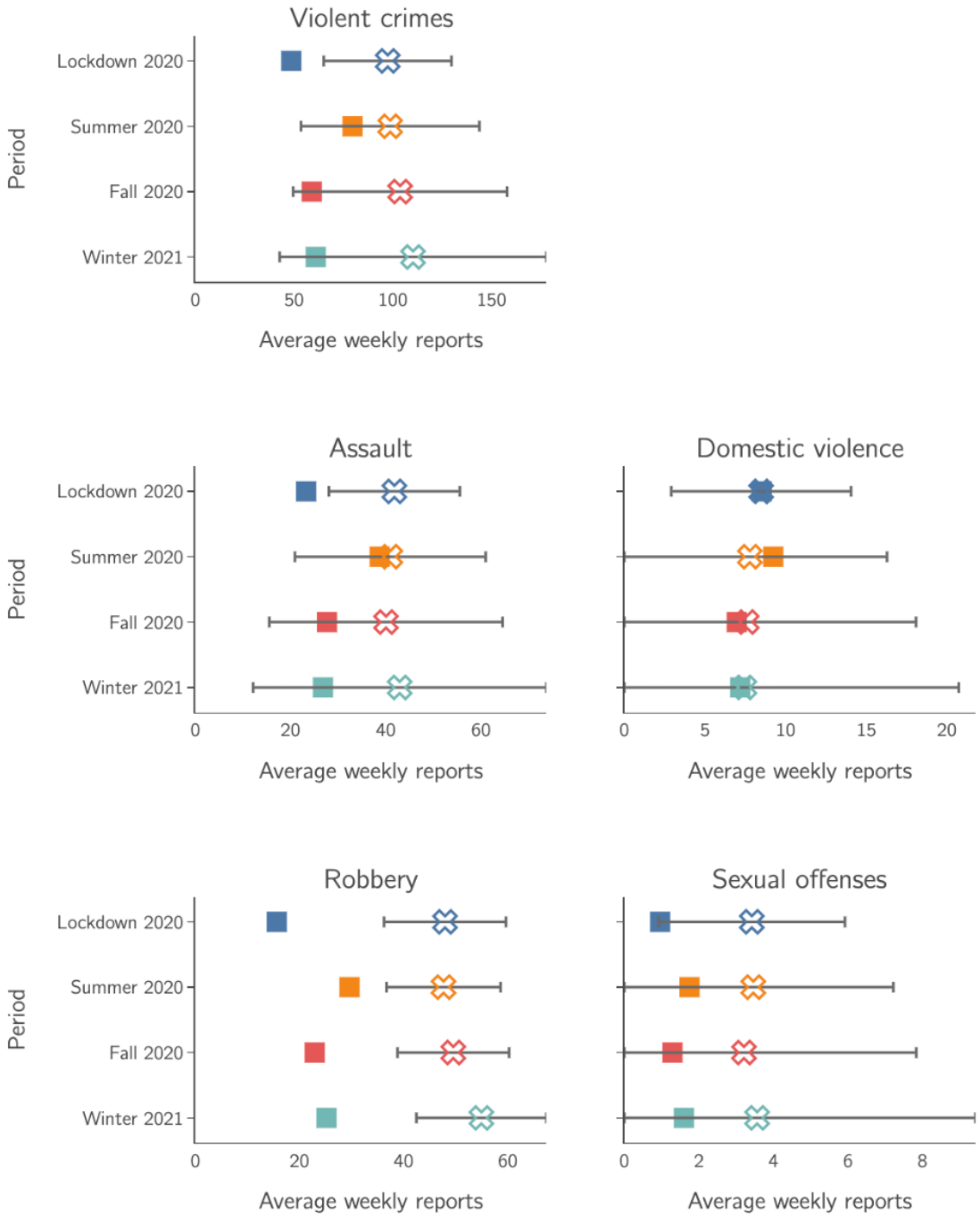

**Figure 5.** Forecast weekly violent crimes (crosses with 95% confidence intervals) compared to observed violent crimes (squares), aggregated into four periods for comparison. Data are shown overall (first above) and by type of violent crime (four charts below).

**Discussion**

The COVID-19 era has led to an unprecedented drop in short-term crime trends in many regions worldwide, though this is neither homogeneous nor universal. Since the 1990s, highly industrialized Western societies have seen a notable and constant downward trend in most traditional types of crime (van Dijk et al., 2021), while cybercrime has grown in parallel (Caneppele & Aebi, 2019). Bearing in mind that various gaps persist in the data infrastructure, limiting the capture and description of crime trends, as well as the analysis of explanations for changes (Baumer et al., 2018), the nature of this relationship remains unclear and the COVID-19 pandemic seems to have reinforced the upward trend in cybercrime (Buil-Gil et al., 2021).

The present study is one of the few works to have focused on analyzing crime trends in the COVID-19 pandemic over the mid-term. We included not only crime recorded data during the lockdown but also the year-on-year comparisons and seasonal variations. This has allowed us to see how a singular and unique event, the COVID-19 pandemic, and the measures taken to prevent its spread, affected different types of crime based on officially recorded data. In this regard, official police-recorded crime data are associated with underreporting, mediated by crime definitions, the nature of police work (e.g., discretionary or operational priorities), and reporting rates that vary by types of crime. Well-known problems, such as a victim's willingness to report or the performance and practices of the justice and health system, can affect crime reporting and recording. This can lead to reporting variations that are dependent on the type of crime and influenced by victimization and harm, the external environment, and personal or household

characteristics (Xie & Baumer, 2019).

Not all population groups and victim types are as likely to report to the same extent under normal conditions, with differences known to exist between the young and elderly, women experiencing intimate partner violence, and minority and non-minority groups (Díaz-Faes & Pereda, 2020; Goudriaan & Nieuwbeerta, 2007; Leon et al., 2021); moreover, these differences may have worsened during the pandemic. Additional barriers to a victim's willingness to report interpersonal crimes during the pandemic have been found, including fear of infection, lockdown requirements, disrupted resources, how to report, and subsequent alternatives, which may preferentially affect isolated children and adolescents, women, or the elderly living in nursing homes. In addition, the low availability of police officers and the severe restrictions to resources and priorities during the pandemic have influenced the reports (Laufs & Waseem, 2020; Maskály et al., 2021). Indeed, despite government-driven policies and media campaigns to promote reporting during and after the lockdown, some studies have shown an overall decrease in crime-related calls to the police during lockdown (Ashby 2020; Dai et al., 2021). At present, the effects of the pandemic on the under- and over-reporting of crime remains unclear.

The results of this study can be discussed both in general and specific terms. The general decline of around 80% for property crimes and 40%–50% for violent crimes has been found when comparing March to June 2020 with the same period in the previous two years, confirming post-lockdown evidence that is emerging (Nivette et al., 2021). This sharp decline was expected due to the mass lockdown and stay-at-home policies, and the ARIMA–SARIMA models confirmed this trend, finding a statistically significant drop in property and violent crimes rates during the lockdown that persisted to the summer for property crime. In connection with the lifting of measures in summer, we expected crime levels to show a sudden and temporary

increase, but much less than the forecast levels. To different degrees, we observed similar patterns during the four periods analyzed for all crime types (i.e., burglary, theft, robbery, assault, and sexual offenses), but not for domestic violence. That is, they increased throughout lockdown, peaked in summer (end of June 2020) alongside the post-lockdown period, and further decreased or stabilized in the fall and winter. However, none reached the predicted levels. With the reintroduction of containment policies on October 25th, 2020, rates for theft, burglary, assault, robbery, and sexual offenses exhibited general decreases in the same pattern (decrease during lockdown, a subsequent increase in summer, followed by a slight reduction or stabilization until March 2021). Only domestic violence showed a distinct pattern, reaching the forecast rates in all periods, even overcoming it in summer 2020 and showing a greater (albeit non-significant) number of observed crimes after the lockdown. These findings confirm our hypotheses, although we did not test homicide because it was not possible to produce a forecast model.

The observed trends result from socio-ecological changes and opportunity structures rapidly mediating short-term outcomes through a shift in urban mobility (see Figure 2). The changing scenario and the containment measures likely drove the low crime levels through criminal opportunity near-mechanisms and interrupted antisocial peer association. Most of the included crimes are highly associated with economic and urban activity in Barcelona where tourism, gentrification, and related processes play key roles in crime levels (Maldonado-Guzmán, 2020), especially in the city center. Such effects have been partially disrupted during the pandemic after previously experiencing rampant growth. Leisure activities, social gatherings, nightlife, and the linked use of alcohol and drugs have been interrupted, reduced, or lost during the pandemic, reducing the potential for interaction- and dynamic-related conflict, as well as

violent incidents in public spaces (Miller, 2013).

Domestic violence presented a different pattern to the other crimes, showing a greater increase in observed levels after the lockdown compared to previous years. Though non-significant, with the potential to differ across specific groups and contexts (Baglivio et al., 2021), this result is consistent with metanalytical evidence (Piquero et al., 2021). Strain and related mechanisms may have mediated the increase in domestic violence, while stay-at-home measures and lasting disruptions to alternatives and resources may have reduced the likelihood of reporting. Trying to understand the nature of domestic abuse from police records is problematic because many incidents are underreported (Felson et al., 2002). Other Spanish studies provide evidence of barriers to formal help-seeking behavior for domestic violence during the lockdown and remote working periods (Vives-Cases et al., 2021), with online survey data showing a 23% increase in intimate partner violence (Arenas-Arroyo, 2021). Sexual offense rates must be interpreted with caution because formal reporting rates are typically low (Kelley et al., 2021). However, this reporting may have been even worse during the pandemic and may have even varied among sexual abuse, assault, and rape, with previous studies showing different rates and trends (Ceccato et al., 2021; Hoehn-Velasco et al., 2021).

In summary, despite the complexity of comparing different cultural contexts and local dynamics in urban areas, we found that conventional crime levels in the extended post-lockdown period in Barcelona showed a downtrend trend consistent with previous studies, but differing in recovery levels that vary across studies with the changes in restrictions (Balmori de la Miyar et al., 2021; Buil-Gil et al., 2021; Hoehn-Velasco et al., 2021; Lopez & Rosenfeld, 2021), inclusive of the first quarter of 2021. This pandemic has confirmed the uncertainties, flaws, and fragilities of the current systems, emphasizing the need to build a future based on sustainability, social

justice, and improve care for behavioral, emotional, social, and mental health (Leach et al., 2021; Ndumbe-Eyoh et al., 2021). The socioeconomic and health effects of the COVID-19 pandemic may increase long-term offending and victimization in the most vulnerable due to existing disparities related to the rise of inequality, individual and community poverty, low income and unemployment levels, economic stress, and weakened health systems (Pratt & Cullen, 2005; Richmond-Rakerd et al., 2020; Sayed & Peng, 2021). Furthermore, mainstream research on crime and violence needs to focus on structural variables (e.g., culture, race, gender, class, or minority identities) to better examine, deconstruct, and understand these phenomena, their implications, and the related nuances (Walklate, 2021).

**Limitations**

First, our study relied on police-recorded crimes, which have important structural and procedural limitations. However, self-report data, such as the Barcelona Victimization Survey (Enquesta de Victimització de Barcelona, Ajuntament de Barcelona, 2021), has also shown a significant decrease in most crimes in 2020 compared to the previous two years. The only difference might be domestic violence, where studies based on Spanish self-reports have shown significant increases (Arenas-Arroyo et al., 2021) that are not found in official records. Nevertheless, this trend seems to vary by province (Vives-Cases et al., 2021) and study, with the need to include more cities in the same country to clarify this result. Second, we did not assess other interpersonal violence events or cybercrime in the present study. Third, in terms of the analytical approach, our forecast models relied entirely on crime data recorded from 2018 onwards. Hence, the conclusions drawn assume that crime records from 2018 until February 2020 are representative of the crime trends in Barcelona, which influences the robustness of the predictions. Furthermore, we only had limited certainty of distant forecasts (e.g., winter 2021)

due to the broad confidence intervals. Finally, analyzing short periods of time does not allow us to account for longer-term trends or seasonal variations, potentially creating masked or exaggerated effects (Payne et al., 2020). Despite these limitations, we believe that the present study contributes to the international body of knowledge of how the COVID-19 pandemic has affected crime levels, being one of the first to analyze crime during a wide period.

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