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# On the Rise in Child and Juvenile Delinquency in Germany After the End of the COVID-19 Pandemic

In 2022, Germany experienced a post-pandemic increase in police-recorded child and juvenile delinquency that is attracting considerable public attention. To inform this debate, this article summarizes basic criminological knowledge on juvenile delinquency and crime statistics, distinguishes potential causes of a post-pandemic increase in delinquency, and provides a disaggregated analysis of the police crime statistics. Our descriptive analysis reveals that the increase is concentrated in the areas of violent and theft offenses and among 12- to 16-year-olds. Additional simulations suggest that the removal of contact-reducing measures has been followed by large age-typical increases in police-recorded crime among adolescents. However, these normalization effects do not completely account for the observed increases among 12- to 16-year-olds. We argue that temporal displacement effects offer the most parsimonious explanation for these excess increases: These cohorts had reduced opportunities to gain the developmentally typical, first criminogenic experiences during the COVID-19 pandemic years leading some adolescents to engage in the underlying activities only after the containment measures had been lifted. While such temporal displacement effects are likely to be temporary, our theoretical discussion suggests that the impairment of schools as places of social learning, as early warning systems, and as shelters from and detection sites of family violence during the COVID-19 pandemic may lead to additional future increases in juvenile delinquency.

*Keywords:* age-crime curve, COVID-19 pandemic, juvenile delinquency, police crime statistics, temporal displacement

## Zum Anstieg der Kinder- und Jugenddelinquenz nach Ende der COVID-19-Pandemie

Im Jahr 2022 kam es in Deutschland zu einem postpandemischen Anstieg der polizeilich registrierten Kinder- und Jugendkriminalität, der in der Öffentlichkeit große Aufmerksamkeit erregte. Um über diese Debatte zu informieren, fasst dieser Artikel kriminologisches Grundwissen über Jugendkriminalität und Kriminalitätsstatistiken zusammen, unterscheidet mögliche Ursachen für einen postpandemischen Anstieg der Delinquenz und liefert eine disaggregierte Analyse der polizeilichen Kriminalitätsstatistik. Unsere deskriptive Analyse zeigt, dass sich der Anstieg auf die Bereiche Gewalt- und Diebstahlsdelikte sowie auf die 12- bis 16-Jährigen konzentriert. Zusätzliche Simulationen deuten darauf hin, dass auf die Aufhebung der kontaktreduzierenden Maßnahmen ein starker alterstypischer Anstieg der

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polizeilich registrierten Kriminalität unter Jugendlichen folgte. Diese Normalisierungseffekte erklären jedoch nicht vollständig den beobachteten Anstieg bei den 12- bis 16-Jährigen. Wir argumentieren, dass zeitliche Verschiebungseffekte die plausibelste Erklärung für diesen übermäßigen Anstieg bieten: Diese Kohorten hatten während der COVID-19-Jahre weniger Möglichkeiten, die entwicklungstypischen, ersten kriminogenen Erfahrungen zu machen, was dazu führte, dass einige Jugendliche die zugrunde liegenden Aktivitäten erst nach Aufhebung der Eindämmungsmaßnahmen aufnahmen. Während solche zeitlichen Verschiebungseffekte wahrscheinlich nur vorübergehend sind, legt unsere theoretische Diskussion nahe, dass die Beeinträchtigung der Schule als Ort des sozialen Lernens, als Frühwarnsystem und als Schutzraum vor und Ort der Aufdeckung von familiärer Gewalt während der COVID-19-Pandemie zu einem weiteren Anstieg der Jugendkriminalität in der Zukunft führen kann.

*Schlagwörter*: Alters-Kriminalitäts-Kurve; COVID-19-Pandemie; Jugendkriminalität; Polizeiliche Kriminalstatistik; Zeitliche Verschiebungseffekte

## 1. Introduction

The recent increase in police-recorded child and juvenile delinquency in Germany has received considerable public attention. Compared to the previous year, the total number of crimes committed by children under age 14 increased by 35.4 % in 2022. For juveniles between 14 and 18, the increase was 22.1 %. Intensified by individual cases of homicide among children, these figures have given rise to a controversial discussion on child and juvenile delinquency, leading some commentators to consider even the lowering of the age of criminal responsibility.

Even if, from a scientific point of view, the available data do not allow to quickly identify the causes of the increase, there is a need to inform the public and political decision-makers and to contribute to realistic and nuanced interpretations. This article serves this purpose, drawing on criminological research on the age-crime curve and causes of juvenile delinquency, as well as a differentiated analysis of Germany's police crime statistics.

As a theoretical contribution to the public debate and future research on post-pandemic trends in juvenile delinquency, we distinguish several potential mechanisms that may result in rising levels of offending. These include the impairment of schools as places of social learning, as early warning systems, and as shelters from and detection sites of family violence during the COVID-19 pandemic. Whereas these mechanisms should have mattered most among younger children, another possibility are temporal displacement effects among early-to-mid adolescents. These youth had little opportunity to gain the kind of age-typical experiences that are conducive to juvenile delinquency during the COVID-19 years but were still pre-disposed to engage in these activities after the end of the pandemic. We also point out other possibilities, some of which being specific to the German situation, such as an increase in the younger segments of the population due to the recent immigration of refugees.

Empirically, we evaluate these mechanisms based on a disaggregated analysis of the most recent data of Germany's police crime statistics. Disaggregating the trends by age groups and types of offenses allows us to paint a more differentiated picture of the recent post-pandemic surge in police-recorded child and juvenile delinquency – and it provides first, albeit indirect evidence on the different mechanisms. We complement this analysis by estimating the length of in-person primary school years before the school closures of 2021 and 2022 for different

cohorts. And we provide an additional breakdown by German citizenship to see whether the increase was also visible when excluding non-German youth.

Our results show that the increase was concentrated in the areas of violent and theft offenses and among 12- to 16-year-olds. Additional simulations suggest that the overall rise was mainly due to a return to pre-pandemic levels and strong age-typical increases. While such normalization effects account for the observed increases among 16- to 18-year-olds, our simulation suggests considerable excess increases among 12- to 16-year-olds. Taken together, the most parsimonious explanation of this pattern are temporal displacement effects among early-to-mid adolescents. These youth had little opportunity to gain the kind of age-typical experiences that are conducive to juvenile delinquency during the COVID-19 years and made up on these opportunities after the end of the pandemic. While this effect is likely to be temporary, there are theoretical reasons to assume that other effects of the COVID-19 years are likely to promote additional future increases in police-recorded child and juvenile delinquency, particularly the impairment of schools as places of social learning, as early warning systems, and as shelters from family violence during the COVID-19 pandemic.

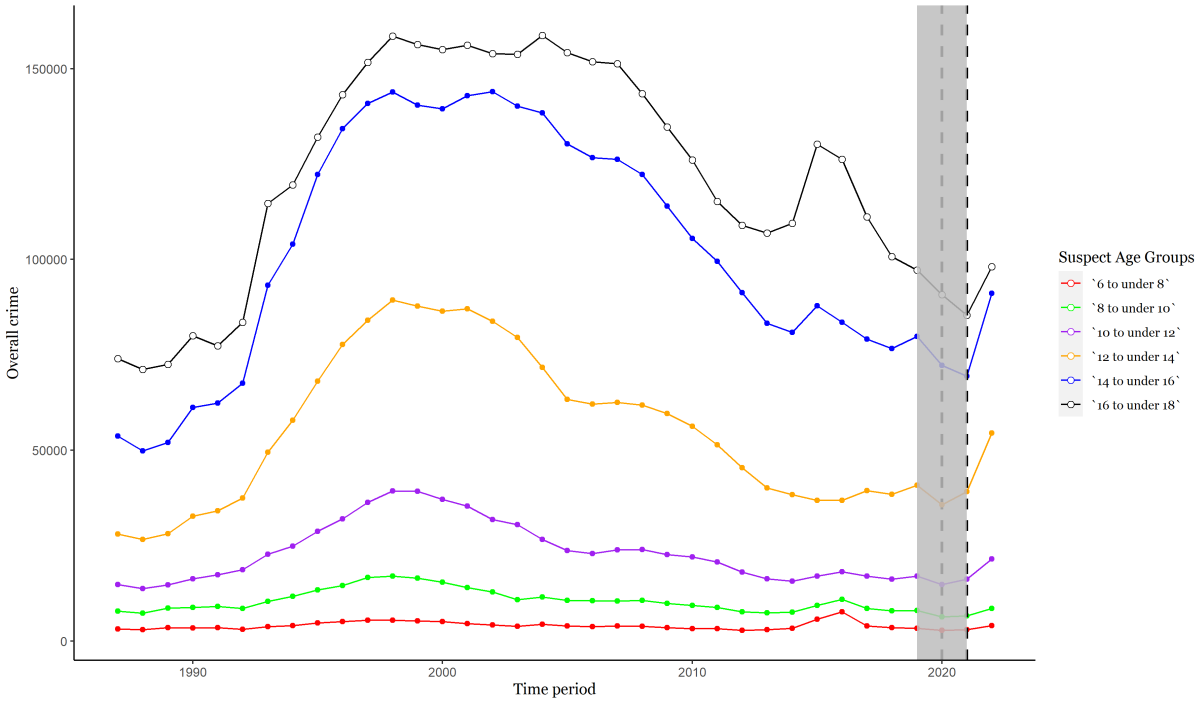
Before we discuss potential mechanisms behind the post-pandemic rise of juvenile delinquency (section 4) and present the results of our empirical analysis (section 5), we need to prepare the ground for an informed evaluation of the reported increase. To this end, we place this trend in the context of the longer historical development of police-recorded crime and point out the nature and limitations of Germany's police crime statistics (section 2). We also provide the reader with a brief summary of key criminological insights into juvenile delinquency (section 3). All of these aspects should be kept in mind when trying to make sense of the post-pandemic rise of police-recorded juvenile delinquency. Of course, criminologically informed readers may want to directly move on to section 4 where we approach the task to assess potential mechanisms behind this phenomenon.

## 2. The Post-Pandemic Rise of Police-Recorded Juvenile Delinquency in Germany

For an adequate evaluation of the post-pandemic rise of police-recorded juvenile delinquency in Germany, it should be placed within the longer and more recent developments. To this end, as well as for the analyses presented below, we use data from the crime suspect statistics, which were downloaded from the official website of the Federal Criminal Police Office (Bundeskriminalamt, 2023).

Figure 1 depicts trends from 1987 to 2022. First, it shows that there has been a significant decline in child and juvenile delinquency since the late 1990s. If we look at the total number of crime suspects across all offense categories, there has been a decrease of 39 % since the peak in this number among children under age 14 in 1998. Second, child and juvenile delinquency continued to decline during the two years of the COVID-19 pandemic (see the grey shaded area in Figure 1). This may have been partly a side effect of the contact-reducing measures used to contain the pandemic. A large proportion of the activities that promote juvenile delinquency did not take place or took place only to a reduced extent. These include, in particular, unsupervised gatherings of youth in public spaces (e. g., clubs or shopping malls) where they engage in unstructured activities or consume alcohol (Bernasco et al., 2013).

*Figure 1.* Time trend of the crime suspect statistics for all age groups under 18 years (except for suspects under 6 years) from 1987 to 2022




If we compare the level of child and juvenile delinquency recorded for 2022 with 2019, i.e., the last year before the COVID-19 pandemic, we observe an increase of 27.7 % for children under 14 and 6.8 % for juveniles between 14 and 18 years of age. These increases are much smaller than those relative to 2021, which we mentioned in the introduction and which were reported in the media (+35.4 % and +22.1 %, respectively). However, even if we take 2019 as a reference point, the rise in police-recorded child and juvenile delinquency is considerable and deserves closer examination.

When interpreting data from Germany's police crime statistics, it is important to keep the nature and several limitations of this data source in mind. An important feature of Germany's crime suspect statistics is that it counts the number of suspects in different categories of offenses (e. g., theft or assault). Hence, a person that is suspected of several crimes of the same type (e. g., several cases of assault) is only counted as one observation in this category. Only suspects who presumably have committed several different offenses enter the statistics multiple times, i.e., as a single case in each of these offense categories (Bundesministerium des Innern und für Heimat, 2023). Therefore, the police crime statistics provide no information on incidences and frequent offenders do not contribute more to a particular category than one-time offenders.

A more fundamental limitation of this official data source is that it includes only those crime suspects who came to the attention of the police through their own investigations or reports to the police. Persons are recorded as suspects if there are sufficient indications after completion of the investigation that they were involved in a crime. This includes persons who acted as accomplices, instigators or accessories (Bundeskriminalamt, 2021). As only crimes registered by the police enter the statistics, changes in the police crime statistics are also influenced by

changes in prosecution (Derin & Singelnstein, 2018). In addition, the police crime statistic depends on the reporting behavior of citizens, changes in recording categories, counting rules, and legal requirements (Birkel, 2003). For our analyses, it is particularly important to consider that violations of the law by younger children are often addressed without police involvement, resulting in an omission of these crimes in the official statistics. Finally, as we break down the data by age groups, our analyses only include those crimes for which suspects are identifiable. Consequently, we can only consider a part of those offenses registered by the police, which – as explained above – is also only a part of all offenses committed (Neubacher, 2023).[2]
Regardless of these limitations, there are no serious alternatives to the police crime statistics if the aim is to examine longer time periods in Germany (Birkel, 2003).[3] Moreover, we aim to contribute to the public discussion which started from the increase in police-recorded juvenile delinquency according to this data source.

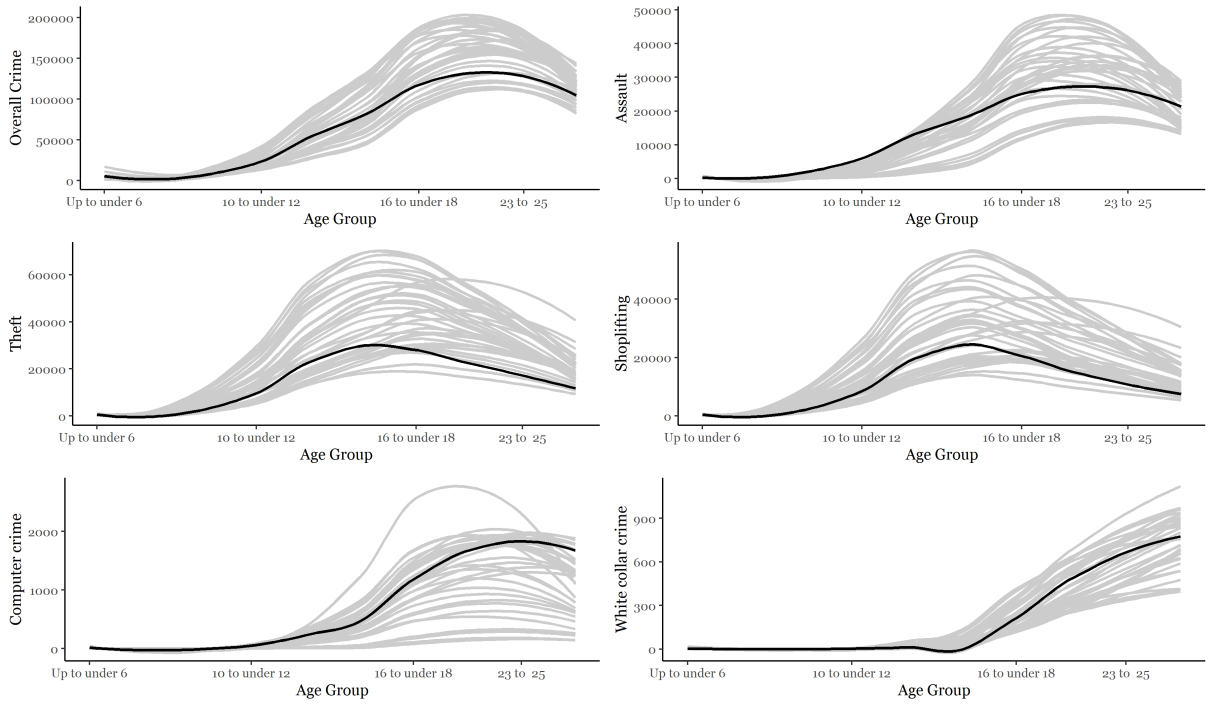
## 3. Basic Facts About Juvenile Delinquency

Any interpretation of the recent rise in the police crime statistics should take into account basic criminological knowledge about juvenile delinquency (see Boers, 2019). First, the vast majority of offenses are minor and associated with low sanction severity, and often not even recorded by the police (Wikström et al., 2012, p. 118). Second, juvenile delinquency is ubiquitous as basically all young people engage in an illegal act while growing up (Boers, 2019, pp. 7-8). Third, at the same time, criminological studies have found that a small share of adolescents is responsible for the majority of offenses, particularly violent offenses in their age group (Boers, 2019, p. 10; Wikström et al. 2012, p. 116). Hence, whenever the focus in on incidences of offenses in particular cohorts, it should be kept in mind that most offenses are committed by a relatively small subgroup of frequent offenders. However, as we mentioned in the previous section, data from Germany's police crime statistics include frequent offenders in the same category (e. g., assault) only as single cases. This means that the statistics overweights crimes by one-time offenders. Still, an important policy implication of this concentration of (violent) offending is that targeting measures of prevention and intervention is crucial, e. g., by identifying and supporting children at risk to become frequent offenders. Fourth, for most individuals, delinquency remains a short-lived transitory phenomenon rather than the beginning of a criminal career. Even without formal sanctions, they return to a lifestyle in which conformity with the law is questioned only in rare circumstances (Moffitt, 1993; Sampson & Laub, 2003).
Prospective longitudinal studies in criminology have documented how offending changes over the life course (e. g., see Kim & Bushway, 2018). The so-called "age-crime curve" describes the phenomenon that offending increases during late childhood, peaks during mid- or late-adolescence and decreases again in adulthood, thus forming a remarkably stable, skewed, bell-shaped

[2] Neubacher (2023) has called this issue the "double dark figure of crime." This would be less problematic if most crimes in the police crime statistics consisted of crimes detected by the police. However, a large portion of recorded crimes appear to stem from private reports (Neubacher et al., 2021), which makes it less likely that suspects are identifiable.
[3] In order to obtain a more realistic picture of the actual incidence of crime, victimization surveys, such as the "Viktimisierungssurvey" conducted by Germany's Federal Police Office (BKA) in 2017 and 2020, are sometimes used. However, such surveys face their own limitations, e. g., systematic measurement errors (Birkel, 2014), so that the police crime statistics may after all generally be more trustworthy (Birkel, 2003).

curve (e. g., see Sampson & Laub, 2003). This regularity is one of the most robust findings in criminology (Hirschi & Gottfredson, 1983; see already Quetelet, 2003 [1831]). The phenomenon is ubiquitous in Western societies and probably beyond (see Steffensmeier et al., 2021; Steffensmeier et al., 2019 for exceptions), although the shape of the curve differs by offense (Steffensmeier et al., 1989) and recent evidence suggests that there has been a slight shift to later adolescence since the 2000s (Matthews & Minton, 2017).

*Figure 2.* Police-recorded frequency of selected offenses across age groups from under six to 25 years from 1987 to 2022.




*Note: Data points are linked by locally weighted scatterplot smoothing (resulting in some negative incidence values).*

In Figure 2, we re-constructed the age-crime curve in Germany for various offenses based on (cross-sectional) data from the police crime statistics. For this purpose, we consider the number of crime suspects in the respective offense categories for different age groups. The black curve shows the crime suspect curve for the current crime statistics of 2022, while the grey curves in the background describe the curves of previous years up to and including 1987 for all age groups until 25.[4] The figure shows that the age-crime curve for theft and shoplifting peaks in the 14 to 16 age group in most years, whereas the age-crime curve for assault tends to peak a few years later. This is in line with previous research (Sweeten et al., 2013, p. 921). Also note that the curve for white collar crime starts to take off only in early adulthood and peaks in mid-

[4] One of the authors has developed a web application that allows to re-construct the age-crime curve for a range of offenses based on data from the most recent police statistics of 2022 and to compare it with every other year back to 1987. This yields a clearer picture of the changes in age structure for various offenses over the years (Nägel, 2023).

adulthood, confirming the view that the age-crime curve is no law-like regularity and varies across types of offenses (Steffensmeier et al., 1989).[5]

In contrast to the broad scholarly consensus regarding the existence of the age-crime curve, a great variety of explanations have been proposed in criminology. Some researchers have explained the increase of offending in adolescence by a temporary need for autonomy. For young people, there is a discrepancy between the autonomy they demand and the legal chances of realizing these autonomy aspirations. This so-called "maturity gap" is overcome by the tendency of adolescents with a low or only moderately pronounced crime propensity to seek inspiration from those adolescents who exude a supposedly stronger autonomy through their delinquent behavior (Moffitt, 1993). But there are also other changes during adolescence and emerging adulthood that may cause delinquency to peak and then go down. As summarized by Sweeten and colleagues (2013), these include “dramatic changes in biological (e. g., pubertal development), neural (e. g., maturation of the prefrontal cortex), cognitive (e. g., improvements in deductive reasoning), emotional (e. g., gains in impulse control), and interpersonal (e. g., changes in the significance of the peer group) functioning, as well as changes in the realms of education (e. g., completion of formal education), occupation (e. g., entrance into the labor force), finances (e. g., movement toward economic independence), romance (e. g., entrance into serious relationships), and residence (e. g., movement out of one’s parents’ home)” (Sweeten et al., 2013, p. 925).

For our analytic purposes, the most important implication is that, under normal circumstances, levels of delinquency will rise for each cohort with the onset of adolescence (Boers, 2019; Nagin et al., 1993; Sweeten et al., 2013). In comparison to younger children, adolescents are increasingly oriented towards their peers and engage in unstructured activities without adult supervision and in settings in which the availability of alcohol and other inducements may contribute to rule breakings. After such experiences have been gained, the vast majority of these young people will go on to live relatively law-conforming lives.

## 4. Potential mechanisms behind the post-pandemic rise of juvenile delinquency

Keeping the nature and limitations of the police crime statistics as well as the basic regularities of juvenile delinquency in mind, we now ask how the COVID-19 pandemic, the associated containment measures, and their collateral consequences may have caused an increase in child and juvenile delinquency. Without aiming for an exhaustive list, we distinguish between several potential mechanisms:

[5] Note that we depict the age-crime curve only up to the age group 23 to 25 since older suspects are grouped together in larger categories (e. g., 25 to 30, 30 to 40). Without weighting, this would yield a biased picture since larger groups contribute more to crime levels than smaller ones. This is also true for the age group 18 to 21 which we nevertheless included since there is only one additional year in this group compared to all others in the above figure.

## 4.1 Impairment of Schools as Places of Social Learning

During the formative elementary school years, the presence of teachers and interaction with peers can play a vital role in fostering children's ability to navigate aggression and conflict through non-violent means (Palmer, 2010). This is especially true since the expansion of all-day care in Germany (Sommerfeld, 2009). For example, the all-day care rate among elementary school children in the most populous German state of North Rhine-Westphalia (NRW) has increased from 0.7 % to 49 % in the last 20 years (Ministerium für Schule und Bildung NRW, 2012).[6] In addition to the social learning processes that take place within the normal school context, purposefully crafted programs have also proven effective in promoting non-violent conflict resolution techniques among elementary school students (Johnson & Johnson, 1996, Clayton et al., 2001). The closure of schools or conversion to homeschooling during the COVID-19 pandemic meant that schools could no longer function as places of social learning. Just as the proportion of elementary school children who cannot swim is estimated to have doubled from 10 % to 20 % in the last five years (according to estimates of the German Life-saving Association DLRG, see Ministerium für Schule und Bildung NRW, 2021), it is likely that some students also need to catch up in learning non-violent conflict resolution strategies.

## 4.2 Impairment of Schools as an Early Warning System

Schools also play an important preventive role by identifying externalizing behavioral problems in children in everyday school life. There is evidence from experimental vignettes that teachers are able to accurately identify students with severe externalizing and internalizing problems (Splett et al., 2018). Schools can thus help to make parents more aware of these problems, direct them to supporting services or to make clear the need for behavioral change. This again requires the regular everyday school life on site, which was stopped when schools changed to homeschooling.

## 4.3 Impairment of Schools as Shelters from and Detection Sites of Family Violence

On average, children who experience parental violence and neglect tend to be significantly more likely to become violent offenders themselves (Widom, 1989). This intergenerational transmission of violence has been repeatedly demonstrated (Weijer et al., 2016, Weijer et al., 2014). Research has also shown the detrimental effect of family violence on the quality of peer relationships among children (McCloskey & Stuewig, 2001), which might further worsen feel-

[6] The German school system has some notable peculiarities. It follows a federal structure, with education policy and legislation falling under the authority of individual states ("Bundesländer"). Additionally, the system is known for its formal stratification, where students are placed into lower, medium, and higher track schools, mostly based on their academic performance. This tracking occurs after primary education (elementary school or "Grundschule"). Secondary education in the Länder (states) is then characterized by division into the various educational paths with their respective certificates and qualifications, for which different types of schools are responsible. For more information on the German educational system, see European Commission (2023).

ings of strain and induce criminal coping in later life stages. In the affected families, the increased time spent at home during lockdowns meant that children were more exposed to these formative experiences. Thus, there is reason to believe that there was an increase in the incidence of unreported domestic violence against children during the pandemic. At the same time, schools were less able to identify and report signs of victimization. This is supported by the fact that reports from schools declined by 1.5 % for the first time in 2020 and also increased only slightly by 5 % in the second COVID-19 year - compared to an increase in school-based suspicious activity reports by 15 % in 2018 and by 17 % in 2019 (Statistisches Bundesamt, 2022).

## 4.4 Temporal Displacement

As noted above, a side effect of contact-reducing pandemic containment measures was that many activities that fosters juvenile delinquency did not occur or occurred at reduced levels. During the COVID-19 period, there was no opportunity for certain birth cohorts to fully gain developmentally typical experiences, such as a change in peer-oriented leisure activities. With the elimination of the containment measures, these birth cohorts have been delayed in changing their activities in 2022. Temporally, at the same time, new birth cohorts had reached the age at which juvenile delinquency becomes more common. This temporal displacement effect thus increased the number of youths who came into contact with criminogenic leisure activities for the first time.

This explanation builds on the criminological notion of crime displacement (Eck, 1993; Gabor, 1981). To be sure, research on crime displacement has generally found no support for the idea that crime will simply relocate following a successful crime prevention (Johnson et al., 2014). However, the vast majority of studies focused on geographic displacement in the proximity of the site of an intervention. According to one review, only 5 % of the identified studies explored the possibility of temporal displacement (Guerette & Bowers, 2009). The largely negative evidence on crime displacement therefore yields no strong conclusions regarding the possibility that the post-pandemic rise in juvenile delinquency is mainly a form of temporal displacement. Still, it would be unrealistic to assume that each act of crime that could not occur during the COVID-19 period would take place in its aftermath. In particular, as we discussed in the previous section, prospective panel studies have shown that offending tends to go down as adolescents become psychosocially more mature (Steinberg & Cauffman, 1996). Hence, we expect some heterogeneity in temporal displacement effects, which should mostly be visible among those adolescents who still have a high crime propensity.

## 4.5 Changes in the Criminal Tendencies of Children and Adolescents due to the COVID-19 Pandemic

Research on the medium- and long-term health effects of COVID-19 infections is still in its infancy (Rong et al., 2023). At this stage, therefore, it cannot be completely ruled out that COVID-19 infections also affect brain development in individual cases and influence crime-related tendencies such as impulsivity or frustration tolerance. However, such hypotheses – as well as that of frustration among adolescents caused by the deprivations of the COVID-19 years

– are to be regarded scientifically as speculations for the time being and would require additional supporting evidence.

Unrelated to the pandemic, another potential cause of the increase in registered cases of juvenile delinquency could be the above-average population growth recorded in Germany in 2022. Overall, the population in Germany grew by 1.3 % (+1 122 000 persons) to a total of 84,4 million inhabitants in 2022. According to the German Federal Statistical Office, this increase is largely due to refugee flows from Ukraine (Statistisches Bundesamt, 2023). The growing number of individuals with foreign citizenship has a notable impact on the population's demographics, as they tend to be younger compared to the German population. Hence, increases in the absolute numbers of young crime suspects could partially simply reflect population growth in the respective age groups.
To assess which of these possible mechanisms were most likely responsible for the increase in child and juvenile delinquency recorded in 2022, we provide a more disaggregated analysis of the police crime statistics.

## 5. Empirical Analyses [7]

### 5.1 Trends in Police-Recorded Crime Across Age Groups and Types of Crime

To inform the discussion about the underlying causes of the increase in registered child and juvenile crime, we subject the data of the police crime statistics from 2018 to 2022 to a more detailed analysis. Our analysis differentiates between different offense categories and age groups of suspects. The selection of the offenses was made with the aim to cover a broad range of offenses. This allows us to identify what kind of offenses drove the post-pandemic rise in Germany's police crime statistic. This is also important against the background of the known limitations of this official data source (see section 2 above), e. g., to rule out that the increase is driven by particular offense types that are known to have been subject to intensified law enforcement efforts.
Figure 3 shows the development of street crime, assault, property crime and violent crime. The age groups 12 to under 14 (orange line) and 14 to under 16 (blue line) are the only groups for which a substantial increase in all four offenses can be observed in 2022 compared to all previous years. For the 16 to under 18 age group (black line), the increase is limited to violent crimes. For all younger cohorts under 12, there are no or only slight increases. Recall however that crimes committed by younger children are less frequently recorded by the police and are therefore less frequently included in the police crime statistics.
Figure 4 shows a similar picture for the development of theft crimes. Substantial increases can be observed in all age groups above 12 for simple shoplifting and for theft without aggravating circumstances and partially for aggravated shoplifting. For the age group 10 to under 12 (purple line), only slight increases can be observed. Younger age groups again show no substantial changes. The police crime statistics data on obtaining services by fraud under Section 256a

[7] Replication code for all analyses can be downloaded from: https://osf.io/qunw7/

(including fare evasion and admission to events without paying the required fee) even reveal a strong decline for the oldest age group shown here.

*Figure 3.* Selected violent crimes recorded by the police from 2018 to 2022 for different age groups

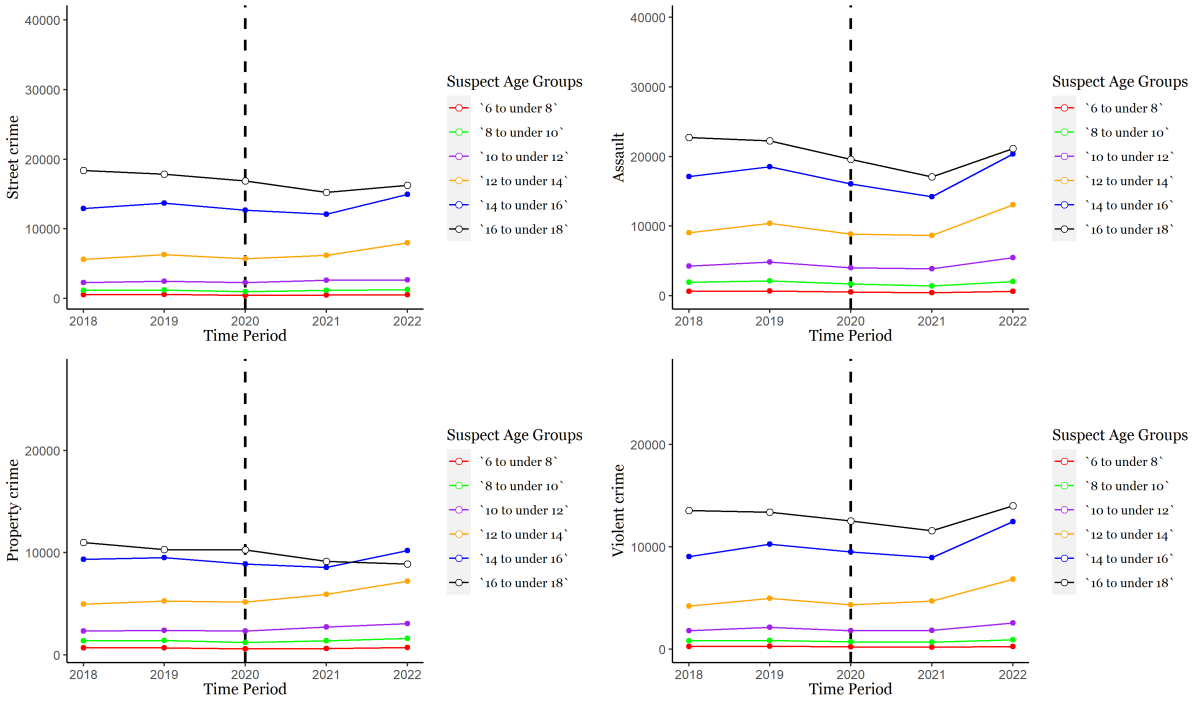



*Figure 4.* Selected police-recorded theft offenses from 2018 to 2022 for different age groups

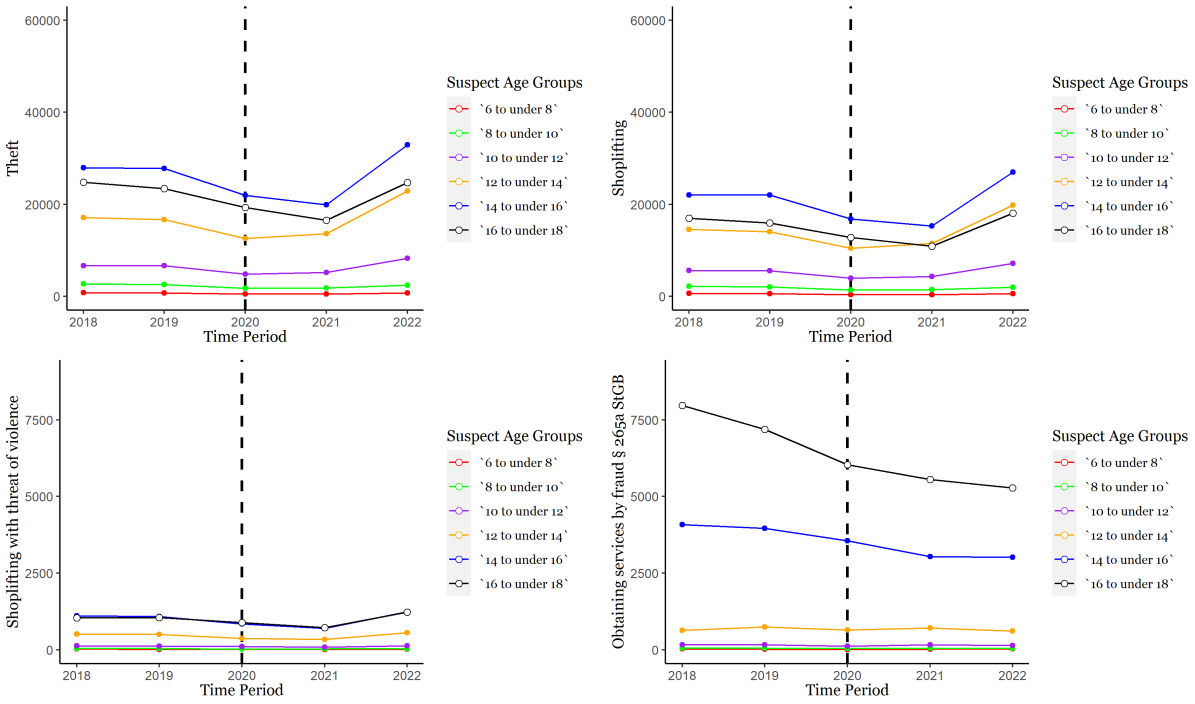
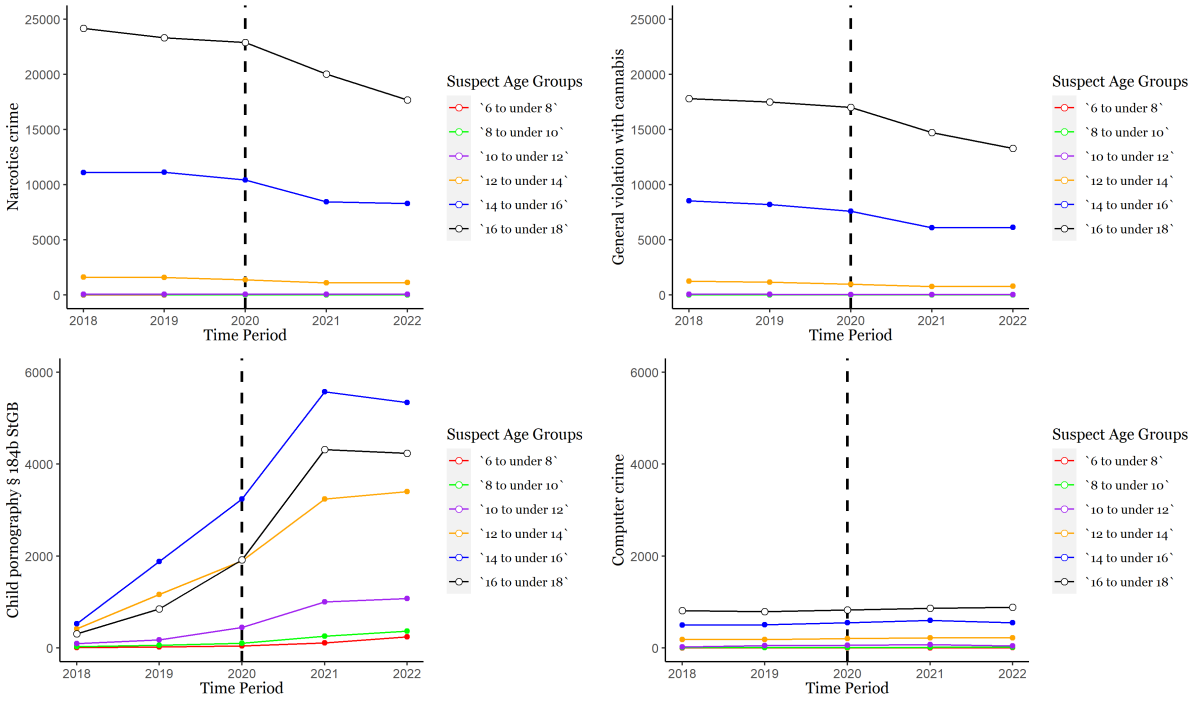


*Figure 5.* Selected police-recorded other offenses from 2018 to 2022 for different age groups




The trends for the offenses shown in Figure 5 are more heterogeneous. While the number of police-recorded offenses in the area of computer crime seems to remain almost unchanged in all age groups, we can observe a decline for the two oldest groups in narcotics offenses and general offenses involving cannabis and its preparations. Recorded cases of distribution, acquisition, and possession of child pornography under Section 184b show increases for the older groups from 2018 to 2021. However, this may be largely due to the intensification of law enforcement and closer international cooperation with foreign law enforcement agencies in this area (Bundesregierung, 2021).

These limitations in interpretation naturally also apply to the other offenses listed here. Nevertheless, taken together, the developments of the offenses registered in the police crime statistics and their distribution among the different age cohorts allow cautious conclusions regarding the potential causes of the recent increase in juvenile delinquency.

## 5.2 Assessing the Plausibility of Different Explanations

Our analysis shows that the increase in police-recorded offenses in 2022 was concentrated primarily in violent and theft offenses and the 12- to 16-year-old age groups. We argue that this pattern provides indirect evidence against the first three mechanisms listed above, which involved schools not being able to fully serve their role during the COVID-19 pandemic. For all three mechanisms, the four years of primary schools – when children in Germany are usually between 6 and 10 years old – should be the most important period. Spending long periods of the day with their schoolmates under adult supervision, children have ample opportunity to learn nonviolent conflict resolution strategies. Likewise, members of the school staff can identify children who show more serious externalizing behaviors (such as aggression) and approach their parents and guardians to discuss these children's needs as well as available measures.

Finally, as small children are particularly vulnerable when it comes to family violence, primary schools may play an important role as protective spaces and contexts in which signs of such victimization can be identified and processed. While schools continue to serve these functions during secondary school, it seems realistic to assume that the primary school years when children are between 6 and 10 years old are the more fundamental and significant period in these respects.

Based on this assumption, we argue that, to explain the overall increase in young crime suspects, these mechanisms should have produced a stronger increase in those age cohorts that were of primary school age in 2020 and 2021. In fact, however, these cohorts show only minor or no changes in the selected offense categories. To provide an overview, Table 1 shows for the relevant age groups in the police crime statistics of 2022 how many years of primary school they completed before the school closed in 2020 and 2021. Children from age 6 to under 8 and those from 8 to under 10 had the least time to benefit from open schools, while the 14 to 16 age group completed all four years of primary school before the pandemic. However, this latter cohort is one of those for which the police data show the largest increases.

*Table 1.* Age categories in the police crime statistics and estimated length of in-person primary school years before the school closures of 2021 and 2022

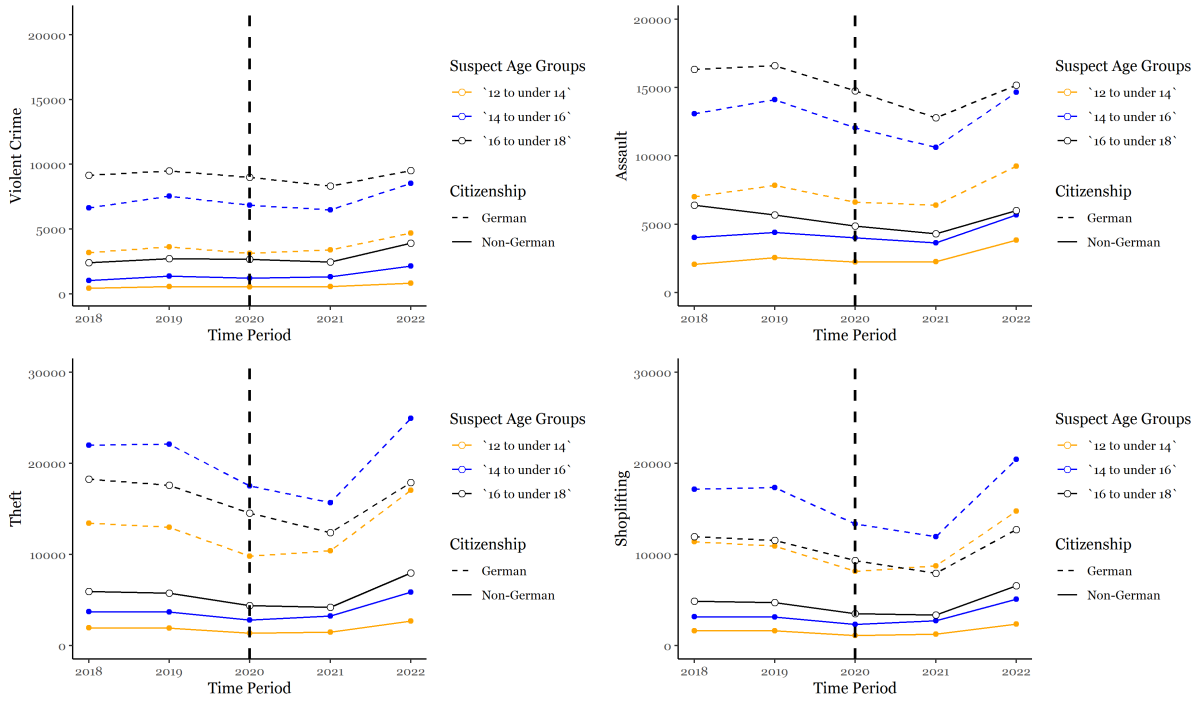
| **Age group in 2022** | **Age group in 2019-2020** | **School grade in 2020** | **School grade in 2022** | **Primary school time before school closures (estimated)** |
|---|---|---|---|---|
| Up to under 6 | Up to under 4 | Kindergarten | Kindergarten - 1st grade | |
| 6 to under 8 | 4 to under 6 | Kindergarten - 1st grade | 1st - 3rd grade | 0.5 years (re-entry 3rd grade) |
| 8 to under 10 | 6 to under 8 | 1st - 3rd grade | 3rd - 5th grade | 1.5 years (re-entry 4th grade) |
| 10 to under 12 | 8 to under 10 | 3rd - 5th grade | 5th - 7th grade | 2.5 years (re-entry secondary school) |
| 12 to under 14 | 10 to under 12 | 5th - 7th grade | 7th - 9th grade | 3.5 years (re-entry secondary school) |
| 14 to under 16 | 12 to under 14 | 7th - 9th grade | 9th - 11th grade | 4 years |
| 16 to under 18 | 14 to under 16 | 9th - 11th grade | 11th - 13th grade | 4 years |
| 18 to under 21 | 16 to under 18 | 11th - 13th grade | | 4 years |

As we will discuss in the concluding section, we do not rule out that there was an impairment of schools as a site to learn nonviolent conflict resolution strategies, as an early warning system, and as a protective space against family violence. As noted earlier, offenses of young children at primary school age are less likely to be recorded by the police. It may therefore well be that there were also increases of delinquency in younger age groups, which simply cannot be depicted on the basis of the police crime statistics. Still, given the results of our analysis, these mechanisms are unlikely to explain the overall increase in this official data source in the year 2022.

Turning to the remaining mechanisms, the concentration of the increases in violent and theft offenses and the 12- to 16-year-old age groups is also difficult to reconcile with the possibility

that the COVID-19 pandemic resulted in changes in children's and adolescents' criminal propensities (the fifth mechanism mentioned above).
Finally, we evaluate the possibility that the increase in police-recorded juvenile delinquency may be partially due to population growth in these age groups, as children were overrepresented in the large inflow of refugees from Ukraine. To this end, we focus on the age groups and type of offenses that we identified as being responsible for the overall trend. Similar to the figures above, Figure 6 again depicts the trends from 2018 up to 2022 but only for the three older age groups and for violent and theft offenses. The figure shows that the increases were very similar for German and non-German adolescents, who include newly arrived immigrants. Hence, even when focusing exclusively on German citizens, we observe a post-pandemic increase in police-recorded juvenile delinquency that it is very similar to the overall trend. This speaks against the view that immigration played a significant role for the recorded increase.

*Figure 6.* Selected police-recorded offenses from 2018 to 2022 for different age groups separated by citizenship




We therefore argue that the most parsimonious explanation for the increases in registered juvenile delinquency is a combination of normalization effects and temporal displacement (see the fourth explanatory approach above). The pandemic-induced decline in recorded crime has been demonstrated for several countries, including Germany (Nivette et al., 2021). Due to the pandemic-related contact restrictions in 2020 and 2021, those children who entered or were in the midst of adolescence (early adolescence being commonly defined as the age range 11-14 and mid-adolescence as 15-17) had little opportunity to spend their time with peers in ways and settings conducive to delinquency. In 2022, we may therefore have observed not only the usual age-typical increases during adolescence, but also temporal displacement effects by which some adolescents made up for missed criminogenic experiences.

## 5.3 Estimating the Potential Strength of Normalization and Temporal Displacement Effects

In a final step, we provide a quantification of the potential strength of temporal displacement effects and relax an assumption on which our previous results were based. Our disaggregated analysis of the police crime statistics was based on a visual representation of trends in different age groups. This entailed a comparison across different cohorts, for example between those who were 12 to under 14 years old in 2019 and those youth who belonged in this age group in 2022. However, it is possible that different cohorts were already on different levels at the start of the pandemic. It is therefore useful to complement our previous analysis of age groups (whose members vary across years) with an analysis of cohorts.

The following simulations estimate the development of juvenile delinquency for different cohorts *if the pandemic and the resulting measures had not taken place*. The difference of this estimate and the actually observed figures yields an idea of how strong temporal displacement effects would have had to be to account for the observed increases.

To provide such numerical estimates, we developed a simple algorithm that estimates the expected post-pandemic increases across age groups and offenses. Our goal was to find a plausible way to calculate how strong the increase in 2022 should have been if it was solely due to: (A) = the pre-pandemic levels of the respective cohort, and (B) = additional age-typical increases. By estimating how much these normalization effects contributed to the observed actual increases from 2021 to 2022, we get a residual measure (C), i. e., the gap between the estimated and actual increases, that may be interpreted as evidence for temporal displacement. Conceptually, temporal displacement effects mean that cohorts who were not able to gain the amount of criminogenic experiences during the COVID-19 years that would have been age-typical make up for some of these missed experiences.

We model the normalization effects in two steps: (A) First, we use the crime level of a particular cohort in the last pre-pandemic year of 2019 as a baseline. Note that individuals of the age group x to under x + 2 years in 2021 belonged to the age group x - 2 to under x in 2019. As the vertical differences between the adjacent age groups in Figure 1 show, the baseline is therefore much lower than the pre-pandemic level of the same-age group in 2019 (which is a different cohort). (B) Second, we asked which age-typical increases would have been realistic if this cohort had not been affected by the restrictions that came with the COVID-19 pandemic. To estimate age-typical increases, we use data from 2010 to 2017 as a reference period. We took the mean of recorded crime suspects in three age groups (i.e., those from age 10 to below 12, those from age 12 to below 14, and those from age 14 to below 16) in the years 2010 to 2015, and calculated the relative increases in crime suspects for the mean of the years 2012 to 2017 when individuals of these cohorts were in the next age group (i. e., those from a cohort aged x years in year y to a cohort aged x + 2 years in y + 2). Intuitively, this yields a rough estimate of the slope of the age-crime curve for the respective age group in a non-pandemic time period.

This estimated relative increase is then multiplied by the number of crime suspects in a given offense category that was recorded in the last pre-pandemic year of 2019 for this cohort. This increase in the absolute number of crime suspects is what would have been realistic for a given cohort in 2021 relative to 2019, if it had not been affected by the restrictions that came with the COVID-19 pandemic. In the first post-pandemic year of 2022, we assume that these cohorts should at least experience this age-typical increase that would have been realistic in 2021 under normal conditions (B). Taken together, the expected numbers of crime suspects in 2022 is the

sum of the actual number of crime suspects for a given offense in 2019 (A) and these age-typical absolute increases (B).[8]

Before turning to results, we need to explicate two assumptions on which this algorithm rests. First, we assume that normalization effects imply a return to levels that would have expected in the absence of the COVID-19 pandemic. On the one hand, this may be an overestimation to the extent that the pandemic caused shocks to the infrastructure of entertainment districts, club scenes, and young people's leisure activities which may have reduced the activity level and associated opportunities for police-recorded incidences even in 2022. On the other hand, one could also argue that the desire of young people to make up for the lost years made some of them even more active after the end of the pandemic than in the year 2019. Against the background of these competing possibilities and without further evidence, we deem it reasonable to hold on to our simple assumption of a return to pre-pandemic trends.

Second, we assume that averaging relative increases over the years 2010 to 2017 yields a reasonable estimate of the increases that would have occurred in the period from 2019 to 2021 in the absence of the COVID-19 pandemic. Our rationale for this approach was to use years that are close in historic time but less sensitive to potential particularities than using a specific two-year period. Reassuringly, if we instead use only the period 2015 to 2017 as a counterfactual, we still get comparable results.[9]

Table 2 shows the expected numbers of recorded crimes based on our algorithm, as well as the actual number of recorded crimes for several offense categories and age groups. The "Δ/Absolute change" column gives a metric of how well our algorithm performed. It is calculated by subtracting the actual number of recorded crimes from the expected number of crimes and dividing the result again by the actual number of recorded crimes. Values can be positive or negative with values close to zero implying a small divergence between our estimation and the actual changes. The column "Percentage points difference" is the difference in percentage points between the observed percentage change in 2022 from 2021 and the change from 2021 to our estimated figures in 2022. Finally, the column "excess increase" gives the difference between the observed crime figures in 2022 and those that we estimated via our algorithm; in other words: the post-pandemic increases net of anything that would have been an age-typical increase.

In interpreting the results in Table 2, it is important to keep in mind that our goal was not offer precise point estimates but to assess whether the hypothesized normalization effects would already be strong enough to explain the observed increases in juvenile delinquency.

Based on Table 2, we cannot confirm this. For most crime categories and age groups, there is a considerable divergence between the actual and the expected increases. Looking only at the overall crime category, our algorithm comes close to the observed crime figures only in the oldest age category which is those aged 16 to under 18 in 2022. For the two younger cohorts, the last column, which again gives the difference between observed and expected increases, shows an excess increase of 17 711 more crimes than expected for those aged 12 to under 14 and 14 064 more crimes than expected for those aged 14 to under 16. Based on our algorithm, we even would have expected a decrease to 36 833 (-5.94 %) from crime levels recorded in 2021 in the youngest age cohort. Since we observed an increase of 39.28 % in this age group, we arrive at a percentage point difference of 45.22 %.

[8] We have provided the software code in the appendix.

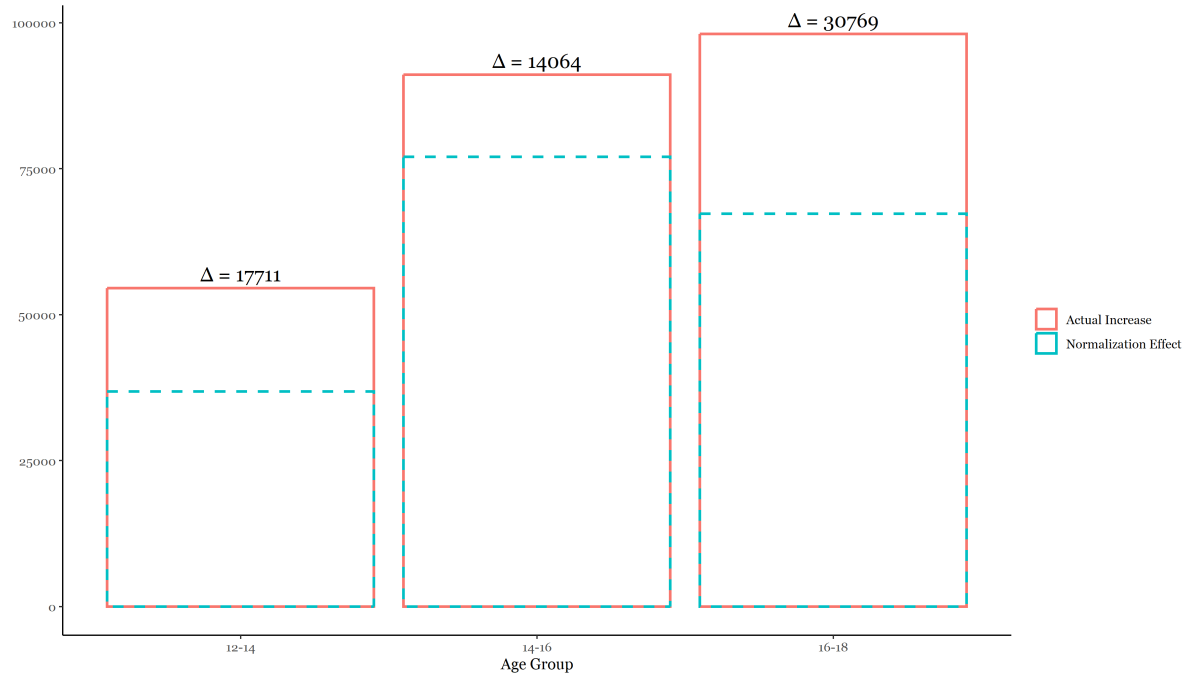
[9] Estimates are somewhat more accurate with our measure of mean absolute divergence being 0.17575 when using 2015 to 2017 as a counterfactual, rather than 0.2104 when averaging over the longer period.

To further illustrate this result, Figure 7 gives a visual overview of the divergence between actual numbers of recorded overall crimes and those calculated by our simple algorithm. The area between the dashed turquoise bar chart (our simulated "normalization effect") and the orange bar chart (the actual increase) depicts the "excess increase".
For the other depicted crime categories in Table 2, the relation between simulated and observed figures differs to some extent from those in the overall crime category. However, we can see that the percentage point differences tend to be larger in the youngest cohorts compared to those in the oldest cohort. Accordingly, the juxtaposition of our simulated "normalization effects" and the observed crimes levels tentatively suggests, that excess increases were - with only minor deviations - generally stronger in the younger as compared to the older cohorts.

*Table 2:* Estimated changes compared to actual increases for selected offense categories and age groups.

| **Offense category** | **Age group** | **Expected increase in 2022** | | **Actual increase in 2022** | | **Fit** | **Excess increase in 2022** | |
|---|---|---|---|---|---|---|---|---|
| | **(from $x_1$ to below x2)** | **Absolute change** | **% change from 2021** | **Absolute change** | **% change from 2021** | **Δ/Absolute change** | **Percentage point difference** | **Absolute difference** |
| Overall crime | 12-14 | 36833 | -5.94% | 54544 | 39.28% | 0,325 | 45.22% | 17711 |
| | 14-16 | 77023 | 10.87% | 91087 | 31.12% | 0,154 | 20.25% | 14064 |
| | 16-18 | 100939 | 18.17% | 98062 | 14.8% | -0,029 | -3.37% | -2877 |
| Assault | 12-14 | 10668 | 23.17% | 13078 | 51% | 0,184 | 27.83% | 2410 |
| | 14-16 | 22472 | 27.87% | 20346 | 42.76% | -0,104 | 14.89% | -2126 |
| | 16-18 | 13732 | 31.48% | 21163 | 23.82% | 0,351 | -7.66% | 7431 |
| Theft | 12-14 | 18396 | 0.78% | 22918 | 65.4% | 0,197 | 67.41% | 4522 |
| | 14-16 | 23418 | 17.71% | 32907 | 65.4% | 0,288 | 47.69% | 9489 |
| | 16-18 | 21547 | 30.34% | 24736 | 49.62% | 0,129 | 19.28% | 3189 |
| Shoplifting | 12-14 | 11498 | 0.45% | 19813 | 73.1% | 0,420 | 72.65% | 8315 |
| | 14-16 | 17996 | 17.81% | 27013 | 76.84% | 0,334 | 59.03% | 9017 |
| | 16-18 | 14183 | 30.08% | 18039 | 65.45% | 0,214 | 35.37% | 3856 |

*Figure 7.* Actual frequencies in overall crime (orange bar chart) compared to estimated frequencies based on our simulation of normalization effects (dashed turquoise bar chart). Delta gives the difference between actual crime levels and simulated ones




## 6. Discussion and Conclusion

After the end of the COVID-19 pandemic, policymakers and scholars have begun to approach the question of how this exogenous shock will affect historic crime trends, especially among those cohorts of children and youth who were affected in crucial developmental periods. In Germany, the total number of crime suspects among children under age 14 increased by 35.4 % in 2022 compared to the year before, and an increase of 22.1 % was recorded among juveniles between 14 and 18. The aim of this article was to inform the discussion about these figures and prepare the ground for future research on this phenomenon in Germany and beyond.

As a theoretical contribution, we distinguished several mechanisms through which the COVID- 19 pandemic may produce short- and long-term increases in juvenile delinquency. Three of them focused on the impairment of schools. In many countries, regular schooling was replaced by homeschooling, so that schools could not fully function as places of social learning, as early warning systems, and as shelters from and detection sites of family violence. Another mechanism assumes temporal displacement effects according to which birth cohorts who could not gain the developmentally typical experiences during the COVID-19 pandemic made up for these experiences once the contact-reducing measures came to an end. Moreover, there have been speculations that the pandemic may have led to changes in the criminal tendencies of children and adolescents. Finally, and unrelated to the pandemic, increases in the absolute numbers of young crime suspects in Germany could partially also reflect recent population growth in the respective age groups due to immigration.

As an empirical contribution, we provided a disaggregated analysis of the most recent data of Germany's police crime statistics. This yields a more differentiated picture of the recent post-

pandemic surge in police-recorded child and juvenile delinquency – and it provides first, albeit indirect evidence on the different mechanisms. Disaggregating the trends by age groups and types of offenses, we could show that the increase in 2022 was mainly concentrated in the areas of violent and theft offenses and the 12- to 16-year-old age groups. The absence of a rise among younger age groups speaks against the first three school-centered mechanisms – assuming that the role of schools as places of social learning, as early warning systems, and as shelters from and detection sites of family violence is particularly important during the primary school years (i. e., from age six until ten). Those age groups who drive the overall increase in police-recorded juvenile delinquency completed primary school already before the COVID-19 pandemic.

The possibility that the COVID-19 pandemic resulted in changes in children's and adolescents' criminal propensities is also difficult to reconcile with the concentration of the increases in violent and theft offenses and the 12- to 16-year-old age groups. And while we cannot rule out that population growth in younger age groups has partly reinforced the rise in registered juvenile crime in Germany, our finding of similar increases among German and non-German subgroups suggests that this mechanism alone is not responsible for the post-pandemic increase in juvenile delinquency. Thus, these two alternative mechanisms seem unlikely and would demand more specific evidence to become credible.

The most parsimonious and plausible explanation for which our analysis provides indirect evidence are temporal displacement effects: In 2022, after the contact-reducing measures were discontinued, the number of crime suspects increased in cohorts for whom such increases were age-typical and to be expected. However, those aged 12 to 16 showed even stronger increases. Given what is known about the age-crime curve from prospective longitudinal studies, a plausible theoretical interpretation of these excess increases are temporal displacement effects among children in early and mid-adolescence. To summarize the picture that emerges from our theoretical discussion and analysis of the official data, it is useful to distinguish between three age groups:

(1) Children below the age of 12 may have been affected by the COVID-19 pandemic and by the school closure in particular, but not well-represented in the police crime statistics. Accordingly, we found no post-pandemic rise in police-recorded crime in this age group.

(2) The increase in police-recorded crime was largely concentrated among those aged 12 to under 16 in 2022. While strong age-typical increases were to be expected for this group of adolescents, the observed magnitudes clearly go beyond such normalization effects. Recall that juvenile delinquency is produced by a mixed population of adolescent-limited and persistent offenders (Moffitt, 1993; Boers, 2019). As suspects are counted only once for each offence category, Germany's police crime statistics are strongly influenced by one-time offenders. This group usually breaks the law as part of an age-typical episodic process of experimentation and gaining experiences with peers in new settings. As such experiences were restricted due to the contact-reducing measures of the COVID-19 years, a significant share of adolescents had to postpone these experiences. In 2022, we therefore observe not only a normal level of police-recorded crime among 12- to 16-year-olds, but an accumulation of first-time (or at least adolescent-limited) offenders, some of which would already have desisted from crime after gaining their first experiences in the years before. Such temporal displacement is limited by developmental processes that promote law abidance and that were not halted during the COVID-19 years. Chief among them is adolescents becoming psychosocially more mature due to further brain development which increases capabilities for forward thinking and prosocial behaviors (Steinberg & Cauffman, 1996).

(3) In line with this tentative explanation, we observed no extraordinary increases of police-recorded crime in the oldest – and therefore most mature – age group who were 16- to 18-years old in 2022. Among this oldest group, psychosocial maturation may have progressed to an extent that some foregone activities were not as interesting anymore. At least, this can be expected for the most vast majority of adolescent-limited offenders. This widespread desistance is particularly important given that Germany's police crime statistics counts crime suspects so that more persistent frequent offenders also contribute only a single case per offense category. Accordingly, this age group just returned to a level that was to be expected given their age, even in the absence of the COVID-19 pandemic (what we termed "normalization effects").

Our attempt to understand the post-pandemic rise in juvenile delinquency as temporal displacement builds on the literature on crime displacement, which has mostly focused on geographic displacement in response to targeted situational crime prevention (Guerette & Bowers, 2009; Johnson et al., 2014). While these studies mostly found no evidence for displacement effects, our phenomenon of interest is of a different kind. In particular, our application of these ideas focused the question of whether adolescents who are shielded from criminogenic settings and activities for two years tend to make up for these experiences later. And our findings suggest that this is only true among younger cohorts who have not matured beyond this developmental period. Moreover, displacement is far from complete. Given intra-cohort variation of maturation, only a fraction of adolescents in the susceptible cohorts will belatedly embark on experiences that lead to acts of crime and enter the police crime statistics. Still, our simulation of normalization and temporal displacement effects suggests that this mechanism could well have been strong enough to explain the observed increases in juvenile delinquency.

Our study has several limitations, some of which may be overcome in future research. First, our interpretation needs to be subjected to more rigorous scrutiny. Econometric methods of causal inference could be used to estimate the causal effect of school closures or other contact restrictions on crime trends under most credible assumptions. Second, a key task for criminological research is to study the short- and long-term consequences of the COVID-19 pandemic for juvenile delinquency in a comparative perspective. As the extent and timing of school closures and other contact-reducing measures varied across countries, such studies may also help to shed further light on underlying mechanisms. Third, our simulation could only use rather broad age groups due to limitations of Germany's police crime statistics. In some countries, the availability of large-scale register data or more fine-grained official statistics may allow for a more reliable and accurate modeling of temporal displacement effects. Finally, future studies should collect data beyond police crime statistics, also in order to cover relevant cases of child delinquency. Here, data on changes in institutional interventions across cohorts (e. g., frequency of admission to specialized health facilities or therapies) as well as original survey data would allow for a more informative picture.

As juvenile delinquency is episodic for the vast majority of youth (see Boers, 2019), increases to pandemic-induced temporal displacement are likely to be temporary phenomena. However, our discussion of possible causes identified a number of other mechanisms that are likely to promote further, subsequent increases in police-recorded child and juvenile delinquency. These include, in particular, the impairment of schools as places of social learning, as early warning systems, and as shelters from and detection sites of family violence during the COVID- 19 pandemic. It is likely that potential effects of these impairments will not yet be reflected in the police crime statistics. In the coming years, however, further increases seem likely

among younger cohorts who were affected by elementary school closures during the COVID- 19 pandemic. This possibility, as well as targeted prevention measures, should therefore receive increased political attention. In this regard, research shows that early investments pay off, as frequent offenders cause several times more financial costs if they are not directed to other pathways early on (Bindler et al., 2020; Miller et al., 2001).

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## APPENDIX: A simple algorithm to estimate increases in juvenile delinquency

We here provide the software code in the R programming language used to estimate the increases in juvenile delinquency as described in the paper:

```
library(knitr)

run_simulation <- function(dfs) {
 # Select age groups
 # In this specification, age groups are fixed to those presented in the paper
 Δ_mean <- function(df, col1, col2) {
  results <- numeric(length(col1))

  for (i in seq_along(col1)) {
   S1 <- df[24, col1[i]]
   S2 <- df[26, col2[i]]
   S3 <- df[25, col1[i]]
   S4 <- df[27, col2[i]]
   S5 <- df[26, col1[i]]
   S6 <- df[28, col2[i]]
   S7 <- df[27, col1[i]]
   S8 <- df[29, col2[i]]
   S9 <- df[28, col1[i]]
   S10 <- df[30, col2[i]]
   S11 <- df[29, col1[i]]
   S12 <- df[31, col2[i]]
   last_pre_Cov_Y <- df[33, col1[i]]
   a <- (S1 + S3 + S5 + S7 + S9 + S11) / 6
   b <- (S2 + S4 + S6 + S8 + S10 + S12) / 6
   # If-condition is only necessary, when age cohort 18 to 21 is chosen

   if (col1[i] == 10 & col2[i] == 11) {
    Δ_mean_2010_2017 <- (b * 2 / 3 - a) / a
   } else {
    Δ_mean_2010_2017 <- (b - a) / a
   }
   Δ_age <- last_pre_Cov_Y * Δ_mean_2010_2017
   Δ <- Δ_age + last_pre_Cov_Y
   results[i] <- round(Δ, 0)
  }
  return(results)
 }

 Observed_relative <- function(df, col_nums) {
```

```
  results <- character(length(col_nums))

  for (i in seq_along(col_nums)) {
    xplus2_2021 <- df[[col_nums[i] + 1]][35]
    xplus2_2022 <- df[[col_nums[i] + 1]][36]
    Δ <- xplus2_2022 - xplus2_2021
    ActualΔ_relative <- Δ / xplus2_2021
    results[i] <-
      paste0("", round(ActualΔ_relative, 4) * 100, "%")
  }

  return(results)
}

Δ_relative_mean <- function(df, col1_list, col2_list) {
  results <- character(length(col1_list))

  for (i in seq_along(col1_list)) {
    col1 <- col1_list[i]
    col2 <- col2_list[i]
    xplus2_2021 <- df[35, col2]
    Δ <- as.numeric(Δ_mean(df, col1, col2)) - xplus2_2021
    Δ_relative <- Δ / xplus2_2021
    results[i] <- paste0("", round(Δ_relative, 4) * 100, "%")
  }

  return(results)
}
excess <- function(df, col1_list, col2_list) {
  results <- numeric(length(col1_list))

  for (i in seq_along(col1_list)) {
    x_2022 <- df[36, col1_list[i] + 1]
    Δ_2022 <- Δ_mean(df, col1_list[i], col2_list[i])
    excess <- x_2022 - Δ_2022
    results[i] <- excess
  }

  return(results)
}
column_names <- c(
  "Expected Absolute change",
  "Expected % change from 2021",
  "Actual % change from 2021",
  "Percentage Point Difference",
  "Excess increase"
```

```
 )
 results <- data.frame()

 for (i in dfs) {
  r_mean <- Δ_mean(eval(parse(text = i)), 7:9, 8:10)
  r_relative_mean <-
   Δ_relative_mean(eval(parse(text = i)), 7:9, 8:10)
  r_observed_relative <-
   Observed_relative(eval(parse(text = i)), 7:9)

  percentage_point_difference <-
   paste0(as.numeric(gsub("%", "", r_observed_relative)) -
   as.numeric(gsub("%", "", r_relative_mean)), "%")
  r_excess <-
   excess(eval(parse(text = i)), 7:9, 8:10)

  results <- rbind(
   results,
   cbind(
    r_mean,
    r_relative_mean,
    r_observed_relative,
    percentage_point_difference,
    r_excess
   )
  )
 }

 kable(results, col.names = column_names)
}

dfs <- c('df_straft', 'df_körpe', 'df_diebs', 'df_laded_einf')

run_simulation(dfs)
```