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ORIGINAL PAPER

Lowering the Minimum Age of Criminal Responsibility: Consequences for Juvenile Crime

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Abstract

Objectives The questions of when and how society should sanction juvenile offenders are subject to ongoing political and scientific debates. In this study, we use a policy reform that lowered the minimum age of criminal responsibility from 15 to 14 years for a 20-month period to investigate whether lower age limits of prosecution and conviction in the legal system affect juvenile crime.

Methods In a quasi-experimental design, we compare monthly crime rates for cohorts of 14-year-olds before, during, and after the temporary reform while controlling for the downward trend in youth crime. We use population-wide administrative registers (N=162,959 individuals) to estimate individual-month panel data models as well as a range of robustness checks.

Results We find no evidence that lowering the minimum age of criminal responsibility reduced the probability of committing crime among 14-year-olds. In fact, we observe an important increase in reported crimes during the reform, most evident among 14-year-olds with prior offending records. We find no reform effects on crime rates among 13-year-olds and 15-year-olds and the reported findings of no general deterrent effects are consistent across different crime types and robust to model specifications.

Conclusions The age limits in the legal systems vary greatly across different jurisdictions and political discussions of when juvenile offenders should enter the criminal justice system are enduring. The findings from this study highlight important policy implications as the "tough-on-crime" motivated reform did not have the intended crime-reducing effects.

Keywords Quasi Experiment · Policy Reform · Registry Data · Deterrence

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> "In those legal systems recognizing the concept of the age of criminal responsibility for juveniles, the beginning of that age shall not be fixed at too low an age level, bearing in mind the facts of emotional, mental and intellectual maturity." *UN Beijing Rules*, *Nov 29*, *1985*.

The age limits for prosecuting juvenile offenders in the legal system vary greatly between different states and countries.[1] Many Western countries have ongoing political discussions about the "right" age limits in their respective legal systems, and there are examples of both movements toward raising the age boundaries (e.g., across US states and in Scotland[2]) and toward lowering the age boundaries (e.g., in the Nordic countries). The traditional argument in favor of low age limits in the justice system is the deterrent effects of punishment that will keep juveniles from committing criminal offenses. Conversely, the proponents of raising the age of criminal responsibility argue that early criminal justice processing of juveniles can lead to labeling and have criminogenic effects or at best only lead to small and short-term benefits in terms of crime reduction. In this study, we use a "tough-on-crime" motivated policy reform reducing the minimum age of criminal responsibility from 15 to 14 to investigate how the risk of early and formal exposure to the criminal justice system affects juvenile crime.

The reoccurring political debates on when and how society should sanction juvenile offenders highlight classic theoretical debates in the literature on the effects of punishment. On the one hand, the notion that punishment can deter criminal behavior is the very core of the legal system and juvenile as well as adult offenders are expected to respond to the threat of punitive sanctions (Apel 2013; Loughran et al. 2016). On the other hand, the principal question of when juveniles are culpable has resurfaced with new findings from neuroscience and psychology documenting a range of developmental factors that limit adolescents' ability to engage in consequential thinking (Scott et al. 2015). To this matter, the minimum age of criminal responsibility plays an important part as it demarks the line at which children are considered old enough to be held responsible in criminal justice proceedings and susceptible to punishment. Although, the UN Committee on the Rights of the Child recommends states to set the minimum age of criminal responsibility to at least 14 (UNCRC 2019), the "right" age for children to enter the legal system is still disputed, and in Europe, for instance, the minimum age of criminal responsibility ranges from 10 in England to 16 in Portugal (CRIN 2020).

A long line of empirical research has investigated the impact of punishment on juvenile delinquency; either the general deterrent effects on crime rates or the specific deterrent or criminogenic effects on individual recidivism. The criminological literature has to a wide extent focused on the latter with studies of subsequent crime effects for juveniles with criminal justice contacts (e.g. Bernburg and Krohn 2003; Farrington 1977; Klein 1974, 1986; McAra and McVie 2007; Liberman et al. 2014; Wiley et al. 2013). Traditionally, this research applied multivariate logistic regression models to identify the effects of formal

[1] The minimum age of criminal responsibility ranges from 10 to 16 in Europe (CRIN 2020). In 22 US states, the statutes specify a minimum age for delinquency adjudication ranging from 6 to 12, whereas 28 states have no minimum age of prosecution in juvenile court. For federal crimes, the minimum age of criminal responsibility is 11 (NJDC 2020).

[2] Several US states have recently raised the age of majority to 18, including Illinois, Connecticut, Massachusetts, Mississippi, and New Hampshire (Loeffler and Chalfin 2017), and the US Supreme Court has delineated the principle that children are developmentally different from adults in ways that matter for fair punishment (Scott et al. 2015). Scotland raised the minimum age of criminal responsibility from 8 to 12 years in May 2019 (Scottish Government 2019).

sanctions such as arrest, court proceedings and sentences (Barrick 2014) and provided support for labelling theories (see reviews in Huizinga and Henry 2008; Farrington and Murray 2014). Recent studies applying different quasi-experimental designs to address selection bias yield more mixed results; with examples of both deterrent and labeling effects as well as null findings (e.g. Agan et al. 2023; Hjalmarsson 2009a; Loeffler and Grunwald 2015a; Motz et al. 2020; Nedelec and Silver 2018; Petrosino et al. 2010).

Research on age limits in the criminal justice system is limited to US jurisdictions and studies typically investigate either waiver policies (e.g. Jensen and Metsger 1994; Risler et al. 1998; Singer and McDowall 1988; Steiner and Wright 2006) or thresholds at which juvenile offenders enter the adult justice system (e.g.Hjalmarsson 2009b; Loeffler and Grunwald 2015b; Loeffler and Chalfin 2017; Lee and McCrary 2017). Both Hjalmarsson (2009b), Lee and McCrary (2017), and Mueller-Smith and colleagues (2023) investigate the discontinuity in criminal behavior across the age of majority. While the first two studies do not find substantial deterrent effects when the severity of sanctions increases from juvenile to adult sentences, Mueller-Smith and colleagues (2023) find lower recidivism rates for first-time defendants prosecuted in the adult court system. Loeffler and Chalfin (2017), Loeffler and Grunwald (2015b), Robinson and Kurlychek (2019) evaluate two early implementations of raise-the-age reforms changing the majority age from 17 to 18 and found no discernable change in juvenile offending or recidivism. Recent work points to the risk of unanticipated policy effects as Loeffler and Braga (2022) find increased recidivism rates for 17-year-olds without prior justice involvement, who were prosecuted in the juvenile justice system after a raise-the-age reform. Overall, previous findings from the US context reveal mixed or no crime effects of the upper age limit in the criminal justice system and providing adult sanctions to juvenile at the ages 16–18.

The extant literature on age policies has focused on the effects of juvenile versus adult justice system around the age of majority, which is in focus in the US debate. Little is known about the first age boundary in the legal system, which defines whether juveniles are culpable and subject to punishment, and which is in focus in the European debate. Hence, one important question yet to be answered is whether the minimum age of criminal responsibility and the embedded risk of punishment can affect children's criminal behavior. Although this age limit has been subject to longstanding debates within European jurisdictions, far less is known about its impact and whether lowering the minimum age of criminal responsibility can deter juveniles from committing crime. While empirical evidence on this question is scarce, a rich literature now acknowledges that childhood and adolescence are particularly sensitive periods and emphasizes the importance of early interventions and prevention (e.g. Heckman 2008). Moreover, research in neurological and behavioral development of children and adolescents documents that they tend to be more impulsive and risk-taking, have lower self-control and be more susceptible to peer influences than adults in ways that limit their decision-making capacity (Steinberg 2014). In line with the fourth Beijing Rule, cited in the opening remark, such evidence calls into question whether legal reforms introducing criminal justice responses at lower age levels can deter juvenile crime.

To answer this research question, we use a Danish reform that lowered the minimum age of criminal responsibility from 15 to 14 for a 20-month period and analyze a large register dataset with population data ($N = 162{,}959$). The longitudinal dataset includes detailed individual information from the Danish National Police on charges of juvenile offenders for the periods across which the minimum age of criminal responsibility was changed. The policy

reform creates exogenous variation in the age of prosecution, conviction and sanctioning of juvenile offenders. Hence, our study adds to the relatively small body of research using legal reforms or other quasi-experimental variation in the formal punishment to assess the impact to juveniles. In practice, we compare outcomes for 14-year-olds immediately before, during, and after the temporary change in the minimum age of criminal responsibility while carefully controlling for the declining trend in juvenile crime during the observation period.

The analytic setup also includes analyses of the subsequent repeal of the reform allowing us to study whether the introduction and the repeal of the reform produce symmetric results. Furthermore, we investigate reform effects for juveniles aged 15 before and after the reform as a placebo test. In addition, we estimate reform effects for juveniles aged 13 before and after the reform to investigate potential spillover effects, e.g. increasing crime rates among younger cohorts, which was a concern in the political discussions regarding the minimum age of criminal responsibility. By doing both, we add to approaches applied in previous studies to investigate deterrence effects of the age of majority (e.g. Hjalmarsson 2009b; Lee and McCrary 2017; Loeffler and Chalfin 2017). Moreover, the policy reform, invoked for only 20 months, creates a unique natural experiment, which allows us to provide the first estimates of the effects of the minimum age of criminal responsibility on juvenile crime rates. Thus, we make a novel contribution to the literature by investigating effects of the first age boundary in the legal system, which determines whether children in conflict with the law are prosecuted or not. In times with declining trends in juvenile crime and a new focus on age-policies in many Western countries, the current study contributes with relevant knowledge on the effects of a policy reform altering the system responses to juveniles at the fringes of the criminal justice system.

The Danish Reform and Its Theoretical Perspectives

From 1930 to 2010, the minimum age of criminal responsibility was 15 in Denmark. This changed in 2010 as a legal reform lowered the minimum age of criminal responsibility from 15 to 14 in Denmark during a 20-months period (July 1, 2010 to March 1, 2012). The policy reform was a break with a long-standing tradition in the Nordic counties to have child welfare authorities, rather than the criminal justice system, handling cases regarding children involved in crime before the age of 15. The Nordic welfare states have traditionally been portrayed as "*Nordic exceptionalism*" in which rehabilitative rather than punitive models characterize the legal practices (Pratt 2008; Pratt and Erikson 2013). However, in the past decades, there has been a punitive turn in Denmark and the policy reform from 2010 is just one example of changes in the view on juvenile offenders; from social disadvantaged children in need of help to delinquent youth in need of consequent action by the state (Brinkgaard 2023; Kyvsgaard 2004).

Compared to the other legal systems with separate juvenile courts, e.g. in England and Wales, or US states, the Nordic countries have a higher minimum age limit regarding criminal responsibility, today 15 in all the Nordic countries, and typically process criminal cases concerning children under the age limit in the child welfare system. Hence, the minimum age of criminal responsibility is a significant threshold to juveniles, as it defines whether criminal cases are handled by the child welfare authorities or in the criminal justice system. Furthermore, as there is no juvenile justice system in Denmark, the minimum age of crimi-

nal responsibility, and not the age of majority, demarcates the line for prosecution, conviction and sanctioning in the "adult" justice system.

The political aim of the Danish policy reform in 2010 was to introduce a more consequent response to juvenile delinquency through lowering the age limit for prosecution in the criminal justice system in order to deter juvenile crime and help juvenile offenders to a better future.[3] The reform was introduced by a right-of-center government and the financing of the reform was part of the annual state budget negotiations in the fall of 2009, which led to considerable media debate (Storgaard 2013). The bill with the amendments to the penal law lowering the minimum age of criminal responsibility to 14 was submitted March 17, 2010, approved June 1, 2010 and enacted by July 1, 2010. Only 20 months later, however, the age limit was re-established at 15 in March 2012 by a new left-of-center government.

Underlying the "tough-on-crime" motivated policy was the notion that juvenile offenders make rational crime decisions and, therefore, are susceptible to changing their behavior as a response to the introduction of criminal sanctions. Formulated with reference to deterrence theory, juveniles would refrain from engaging in criminal behavior when the anticipated costs of committing crimes exceed the anticipated benefits (Becker 1968; Gibbs 1975). Thus, the policy reform was expected to have crime-reducing effects as the threat of prosecution, conviction, and sanctions in the criminal justice system would raise the cost and therefore deter juveniles from committing crimes.

However, it is important to note that deterrent effects of formal sanctions ultimately rely on the individual's perception of punishment. As stated by Paternoster (2010: 786), *'deterrence theory is a social psychological theory of threat communication in which the causal chain runs from the objective properties of punishment through the perceptual properties of punishment to crime'*. Hence, the legal system and its reforms are only effective if information trickles down and influences individuals' perception of punishment and behavior, and studies have shown that this might not always be the case (Nagin 1998; Apel 2013).

Data and Method

Administrative Data and Sample

We use population data for seven Danish birth cohorts born 1993–99 and combine it with information from a wide range of different administrative registers using unique personal identifiers. The dataset includes all children aged 13–15 from November 1, 2008 to December 31, 2013. The reform lowered the minimum age of criminal responsibility for a period of 20 months, and the sample is therefore constructed with a symmetric observation period of 20 months on either side of the reform. Hence, we observe the cohorts of 14-year-olds

[3] See reform proposal L 164: "Forslag til lov om ændring af straffeloven, retsplejeloven og lov om erstatning fra staten til ofre for forbrydelser". http://www.ft.dk/ripdf/samling/20091/lovforslag/l164/20091_l164_fremsaettelsestale.pdf, passed on the June 1, 2010 http://www.ft.dk/samling/20091/lovforslag/L164/som_vedtaget.htm. The legal affairs spokespersons of two of the three political parties that voted for the reform (the Liberal Party of Denmark and the Danish People's Party) believed that the reform would have general deterrence effects. Kim Andersen, legal affairs spokesperson, Liberal Party of Denmark (Venstre): "*I'm convinced that lowering the age of criminal responsibility will prevent crime. It will make some young people think twice before committing crime* (1st reading of the bill, April 15, 2010: https://www.folketingstidende.dk/samling/20091/salen/M75/20091%5FM75%5Freferat.pdf#L164).

affected by the reform (July 2010 to January 2012) and compare them with cohorts of 14-year-olds 20 months before the reform (November 2008 to June 2010). To ensure that we have information about background characteristics across all individuals, we restrict the sample to individuals with Danish residence on January 1 of the year they turn 10.

Our panel data is constructed as a person-month level dataset with monthly records of (as-if) charges. The primary estimation sample includes 162,959 children, each contributing to the model in the 12 months they are age 14, in total 1,955,508 individual-month observations. In addition to the main analysis of the reform effects on 14-year-olds' crime rates, we estimate reform effects using similar samples of 13-year-olds and 15-year-olds to investigate potential spillover effects and perform placebo analyses, respectively. Furthermore, to test whether the reform and it's repeal produce symmetric effects, we use additional cohorts and time spells to analyze symmetric time periods with 14-year-olds after the repeal of the reform as well as investigate potential announcements effects before the reform period.

Criminal Offenses and Crime Outcomes

In our analyses, we measure individual criminal activity based on administrative data, in particular official charges for offenses against the criminal code. The Danish National Police record all contacts with individuals, including official charges, irrespective of whether the charge leads to a court ruling, i.e. a conviction. If an offense is committed by a person who is below the minimum age of criminal responsibility, the police will record the offense as an "as-if" charge, meaning that the child would have been charged with the offense had it reached the minimum age of criminal responsibility. The Danish Police are required by law to register offenders below the minimum age of criminal responsibility in the Central Police Register if they violate the Penal Code Act, Weapons Act or Drugs Act. By combining the Central Police Registers on charges and as-if charges, we can measure reported criminal offenses throughout childhood and adolescence for each individual. As convictions only exist for juveniles above the minimum age of criminal responsibility, we cannot use conviction records to compare reported crimes for 14-year-olds before and after the reform.[4] Furthermore, the use of as-if charges and charges to investigate crime rates for juveniles aged 10–17 is within the national standard and applied in example the yearly reports from the Danish Ministry of Justice on developments in juvenile crime (see e.g. Danish Ministry of Justice 2020). Hence, we focus on charges as outcome measure to analyze potential reform effects on reported crimes in order to include same-age controls groups before and after the reform.

In the Central Police Registers, charges and as-if charges are categorized into offenses against the Penal Code Act (sexual assault, assault, property, and other offenses against the penal code), the Traffic Act, the Drugs Act, the Weapons Act and other special acts. The official reports of offenses against the Traffic, Drugs, and Weapons Acts may be sensitive

[4] In our sample, the conviction rate is 63% for the 14-year-olds with a charge of a penal code offense during the reform period, compared to 67% for 15-year-olds. US studies on crime tend to measure individual crime by arrests, but actual arrests of juveniles are uncommon in Denmark. According to the Law on Administration of Justice, the police can arrest a person whom they have reason to suspect of a criminal offence subject to public prosecution, but only if an arrest is regarded necessary to prevent further criminal offenses, to ensure the subject's presence for the time being or to prevent them from communicating with others. An arrest is not to be made if imprisonment would be a disproportionate measure in relation to the nature of the offence or other circumstances.

to police efforts, and police officers are not required to report traffic offenses committed by children below the minimum age of criminal responsibility. Therefore, we restrict the outcomes to offenses of the Penal Code Act and use an indicator of at least one as-if charge or charge of the penal code in each month throughout the empirical analyses.[5] Administrative data may underreport offending and reoffending, based on a number of factors such as the willingness by victims to report the offense to the Police and the rate at which crimes go unsolved (National Academy of Sciences 2022). While this data limitation is important to acknowledge, the evaluation of this policy reform and its potential crime effects would not be possible to conduct using Danish self-report data, as they are only collected every sixth year among school children aged 13–17, and prior data only includes two waves collected in 2006 and 2012, respectively (Pedersen 2013).

Control Variables

The use of register data enables us to include a rich set of control variables constructed from multiple official administrative registers which we now describe. We measure child background information at birth: gender, birth weight, premature birth, immigrant status, and include the following variables from birth to age 9: ADHD diagnosis, prescribed Ritalin and prescribed other psychotropic drugs. Information on child criminal history ages 10–12 is based on police reported as-if charges and includes age of reported first offence, number of prior offenses and the type of prior offenses. We include the following indicators for family background measured in the year the child was age 9: family type, parental income, occupation, education, and their criminal history (child ages 0–9). Finally, information on the number of months relative to the reform month, July 2010 and police district are included to control for cohort/time and local trends. Our dataset also includes control variables for age measured in months and calendar month to account for age and seasonal trends. See Table A1 in the Appendix for means and standard deviations of the covariates.

Method and Analytic Strategy

The ambition with this study is to estimate the effect of lowering the minimum age of criminal responsibility on the probability of committing crime. In so doing, we exploit the July 1, 2010-policy reform that lowered the minimum age of criminal responsibility from 15 to 14, while comparing cohorts of 14-year-old children who are differentially affected by the policy.

Our empirical specification is the following:

$$y_{it} = \alpha_1 Reform_{it} + f\left(Reform_dist_{it}\right) + X_{1it}\beta_1 + Z_{1i}\gamma_1 + u_{it} \quad (1)$$

where y_{it} is an outcome indicating whether child i is charged with at least one penal code offense in month t; $Reform_{it}$ is an indicator of whether the reform is in place for child i in month t; $f(\bullet)$ is a first-degree polynomial in distance in time to the reform date that is allowed to differ on both sides of the cutoff to control for the downward trend in crime during our observation period; X_{1it} consists of age measured in months using a linear spec-

[5] Traffic-related crimes constitute 9% and weapon and drug offenses 6% of the total number of offenses committed by 14-year-old offenders during the reform period.

ification or indicators to control for the crime–age relationship, and calendar month indicators to control for seasonal variation in juvenile crime, whereas Z_{1i} consists of variables measured at a fixed point in time, primarily at child age 9: child characteristics and family background controls as well as police district fixed effects to control for local variation in police resources to apprehend and charge offenders and local variation in criminal and legal income opportunities. u_{it} is the unobserved error term. α_1 is the parameter of interest; it measures the effect of the introduction of formal sanctions on criminal acts committed by 14-year-olds. Our empirical set-up is essentially a regression discontinuity design in time, and closely related to a single interrupted time series design (Bloom 2003).

The key identifying assumption in the current setup is that, except for the policy change, all other factors, observed and unobserved, are continuous with respect to time. The assumption implies that 14-year-olds must not reschedule the timing of crime to take place immediately before the reform in an attempt to avoid the new, stricter regime (see McCrary 2008). It also implies that the police must not change their policing or reporting strategies because of the reform, which can be a concern in these types of reform studies (see Loeffler and Chalfin 2017). In our analyses, we first investigate the validity of the empirical design, including potential violation of this assumption and then present our main results from the formal analyses.

To substantiate our empirical findings, we present results from additional analytic setups using the extensive Danish register data to alter the observation window and include extra time-periods before and after the policy reform as well as younger and older cohorts of juveniles. First, we present results from analysis of the effects of the reform and subsequent repeal of the reform for 14-year-olds, which allows us to study whether the reform and its repeal produce symmetric effects. Second, we analyze potential spillovers of the reform by using a sample of 13-year-olds and perform placebo analyses using a sample of 15-year-olds before and during the reform. Third, we investigate announcements effects of the preceding political and media debate about the lowering of the minimum age of criminal responsibility in Denmark. As the public debate peaked already in the fall 2009, 9–12 months before the bill was formally passed in parliament, we include extra analyses in which we move the observation period back in time to examine whether juvenile crime rates were affected already prior to the reform due to anticipation effects. We also run heterogeneity analyses for different subgroups and types of penal code offenses and a set of standard checks for regression discontinuity models. Finally, the reform effects can phase in over time, and we therefore include additional results with a comparative event study setup as a robustness check to investigate parallel pre-trends assumptions and potential delayed reform effects.

Results

Design Validity

To investigate strategic, behavioral adjustments to the reform and to perform a first, descriptive investigation of the impact of the reform, we plot the distribution of monthly crime rates of 13-, 14- and 15-year-olds around the time of the introduction of the reform in Fig. 1. The monthly crime rate is defined as the number of individuals with at least one (as-if) charge of the Penal Code Act per individual in the age group. Figure 1 illustrates why our formal

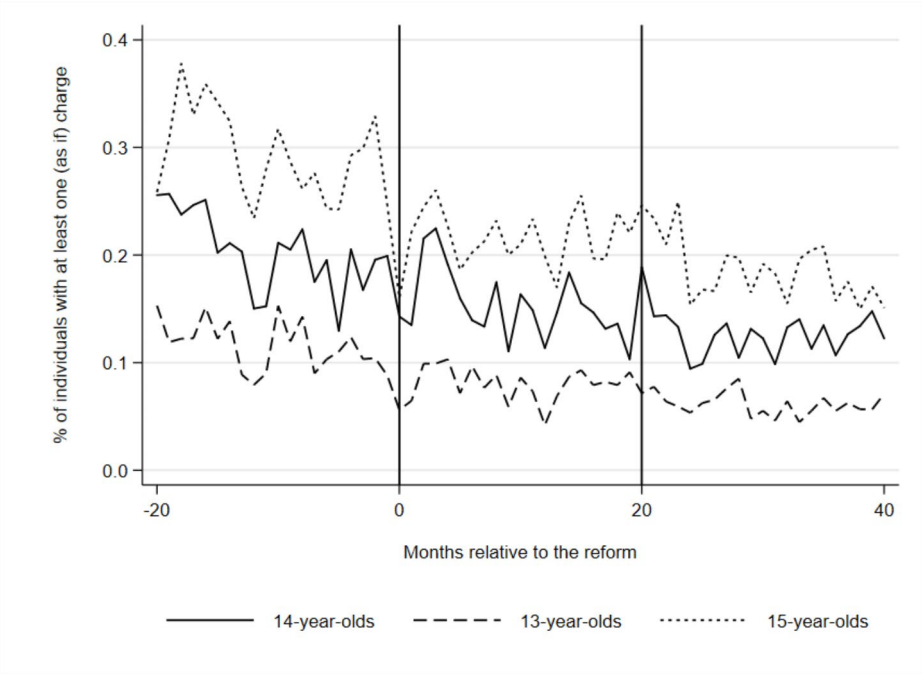


Fig. 1 Monthly prevalence rates for reported (as-if) charges of penal code offenses for 13-, 14- and 15-year-olds 20 months before, during and after the reform
Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99
Notes: Figure shows the percentage of individuals in the age group with at least one (as-if) charge for a penal code offense in a given month. Population of 13-, 14- and 15-year-olds reported 20 months before the reform, 20 months during the reform, and 20 months after the reform. The reform period in which the minimum age of criminal responsibility changed to 14 is marked with vertical lines in July 2010 and February 2012

analyses must account for time, age, and calendar months, all of which are potential confounders of the reform effect. Over the reform period, we see a tendency for crime rates to go down for all age groups, which is in line with national and international trends (Andersen et al. 2016; Danish Ministry of Justice 2016; Hockenberry and Puzzanchera 2020; Youth Justice Board 2020). The figure also reveals the well-established crime-age relationship and strong seasonality in crime as crime rates plummet around July 1, subsequently increasing over the summer. Importantly, we see no tendency for the bunching of criminal activity among 14-year-olds immediately prior to the introduction of the reform; this would have indicated strategic retiming of crime. This picture is also confirmed when considering the reported offending rates in the months around the 14th birthday for juveniles before, during, and after the reform, which show similar trends (see Fig. A1 in the appendix).

We also look at the official reporting to check potential changes in police behavior that could influence the empirical analyses. One concern is that police officers could be reluctant to formally charge 14-year-olds after the reform because of the more severe consequences for children in question. However, we find no evidence of such police responses to the reform. As we see in Fig. 2, which zooms in on the curve for 14-year-olds from Fig. 1, the reporting of crimes for 14-year-olds changed from as-if charges in the months prior to the

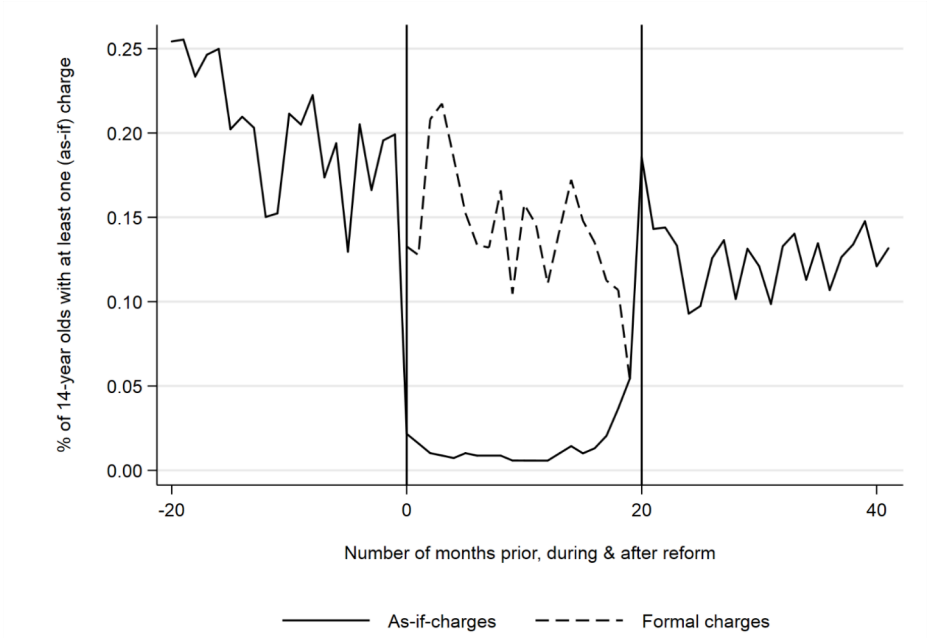


Fig. 2 Percentage of 14-year-olds with at least one as-if charge and at least one formal charge each month 20 months before, during and after the reform.
Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99
Notes: Figure shows the percentage of 14-year-olds with at least one as-if charge and at least one formal charge 20 months before the Danish reform that lowered the minimum age of criminal responsibility from 15 to 14 (1st of July 2010) until 20 months after the repeal of the reform (28th of Feb. 2012). Vertical lines at 0 and 20 months indicate the reform period

reform to formal changes during the reform period and then back to as-if charges in the months after the repeal of the reform. The monthly share of 14-year-olds with at least one as-if charge started to increase already 3 months before the repeal of the reform. This is likely to be caused by the repeal of the reform which entitled 14-year-olds who were formally charged during the last 3 months of the reform to have the charge withdrawn, in which case it was converted from a charge to an as-if charge in the Police Register. Such potential conversion does not affect our results as our dependent variable is defined as an indicator for having at least one as-if or formal charge in a given month. There are no signs that reported crime rates in the months around the 14th birthday for juveniles were affected by the reform, as there is no drop in the prevalence rates in months after they turn 14 (cf. Fig. A1). Another way to gauge the validity of the design is to look for discontinuities in observable characteristics. We do so by comparing background characteristics of the sample of 14-year-olds on either side of the introduction of the reform. As expected, we find no evidence of any significant differences (see Tables A1, A2 and Fig. A2 in the Appendix). Overall, the descriptive investigation provides support for the validity of our design.

Empirical Findings: General Deterrence Effects?

Table 1 shows the results from our formal analyses with gradually richer conditioning sets. All models control for the distance in time to the reform and standard errors are clustered at the individual level. Our preferred specification VI shows a small positive coefficient, corresponding to a 10% increase in the crime rate among 14-year-olds after July 1, 2010. Yet the estimated effect is not significant at conventional levels. The findings suggest that there is no general deterrent effect of lowering the minimum age of criminal responsibility. In fact, we can rule out general deterrent effects as small as –0.00012, corresponding to more than a 7% reduction in 14-year-olds' crime rates. By contrast, we can only rule out an increase in their crime probability that is larger than 0.000464, corresponding to 26% relative to the mean, and indicating that the estimated effect according to our preferred specification VI should not be interpreted as a null effect.

Along with the main analysis of the reform effects, we present results from additional analytic setups and robustness checks to substantiate the empirical findings. We first test whether our results are symmetric for the introduction and the repeal of the reform by including observations for children who turn 14 after the minimum age of criminal responsibility was re-established at 15 (on March 1, 2012). As the general downward trend in juvenile crime tails off in months during and after the reform for both 13-, 14-, and 15-year-olds (see Fig. 1), we run separate models to estimate the effect of the repeal of the reform, comparing crime rates among 14-year-olds in time-periods during (treatment group) and

Table 1 Effects of the reform for 14-year-olds on monthly reported offending rates (penal code offenses)

	I	II	III	IV	V	VI
Effects of the reform	–0.00012	0.00003	0.00003	0.00017	0.00017	0.00017
	(0.00013)	(0.00013)	(0.00013)	(0.00015)	(0.00015)	(0.00015)
Number of months prior to the reform (20–1, otherwise 0)	0.00001	0.00002^{+}	0.00002+	0.00003*	0.00003*	0.00003*
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Number of months during the reform (1–19, otherwise 0)	–0.00001	–0.00002*	–0.00002+	–0.00003*	–0.00003*	–0.00003*
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Controls						
Age month specification	No	Linear	Dummies	Dummies	Dummies	Dummies
Calendar month dummies	No	No	No	Yes	Yes	Yes
Child and family background	No	No	No	No	Yes	Yes
Police district fixed effects	No	No	No	No	No	Yes
Observations	1,955,508	1,955,508	1,955,508	1,955,508	1,955,508	1,955,508
Individuals	162,959	162,959	162,959	162,959	162,959	162,959
Mean outcome	0.00177	0.00177	0.00177	0.00177	0.00177	0.00177

Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99

Notes: Table shows estimated effects of the reform lowering the minimum age of criminal responsibility (from July 2010 to February 2012) on the monthly reported as-if charges (penal code offenses) for the population of 14-year-olds. Estimates are coefficients from linear panel models on the probability of an (as-if) charge in a given month and each column represents a gradually richer conditioning set. Standard errors are clustered at the individual level and reported in parentheses, $+p<0.10$, $*p<0.05$, $**p<0.01$, $***p<0.001$. Control variables: number of months relative to reform, age, calendar month, child gender, immigrant status, birth weight, child ADHD diagnosis, child using prescriptive drugs, child's criminal history (ages 10–12), parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), parents' criminal history, police district. The mean number of individuals with at least one (as–if) charge per month is 67.6 for the 13-year-olds, 125.6 for the 14-year-olds and 178.9 for the 15-year-olds

after the repeal of the reform (control group). The estimation results are reported in Table 2 for three specifications: (i) no controls, (ii) time and age controls, and (iii) all controls. The three specifications produce results with almost unchanged coefficient estimates of 0.00024 (0.00031) versus the main estimate 0.00017 (0.00015). Hence, the results are symmetric on both sides of this policy change, and there are no significant reform effects on the probability of committing crime among 14-year-olds.

We proceed to investigate whether the reform affected crime rates among 13- and 15-year-olds (results reported in Table 2). If the age limits in the criminal justice system influence juveniles' decision-making, then there may be spillover effects of the reform to offenders below the minimum age of criminal responsibility if they substitute for offenders above that age. Hence, the reform might increase crime rates among 13-year-olds who are just below the new minimum age of criminal responsibility in the reform period. However, we find no evidence that the reform had any impact on the group of younger children. Although the political debates in Denmark often include arguments stating that criminal offences are 'pushed down' to juveniles below the minimum age of criminal responsibility, we cannot detect such behavior in our empirical analyses.

Table 2 Additional analyses: repeal of the reform and reform effects for 13- and 15-year-olds

	I	II	III	Mean
Baseline result: reform effects for 14-year-olds	–0.00012	0.00017	0.00017	0.00177
(obs. = 1,955,508)	(0.00013)	(0.00015)	(0.00015)	
Repeal of reform:				
Effects for 14-year-olds (during vs. after)	0.00023	0.00022	0.00024	0.00138
(obs. = 1,980,575)	(0.00031)	(0.00031)	(0.00031)	
Spillover effects:				
Reform effects for 13-year-olds	–0.00036***	–0.00014	–0.00010	0.00095
(obs. = 1,903,320)	(0.00009)	(0.00011)	(0.00011)	
Placebo tests:				
Reform effects for 15-year-olds	–0.00053***	–0.00024	–0.00023	0.00255
(obs. = 1,972,224)	(0.00015)	(0.00018)	(0.00018)	
Combining 13-, 14-, and 15-year-olds:				
Reform effects for 14-year-olds	0.00005	0.00019*	0.00026**	0.00177
(obs.= 5,831,052)	(0.00006)	(0.00009)	(0.00009)	
Controls:				
Number of months relative to reform	No	Yes	Yes	
Age month specification	No	Dummies	Dummies	
Calendar month dummies	No	Yes	Yes	
Child and family background	No	No	Yes	
Police district fixed effects	No	No	Yes	

Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99

Notes: Table shows estimated effects of the reform for 13-, 14- and 15-year-olds as well as estimated effects of the repeal of the reform using 14-year-olds during the temporary reform as the treatment group and 14-year-olds after the repeal of the reform as control group. Reported estimates are coefficients from linear panel models on the probability of an (as-if) charge in a given month during the reform, and each column represents a gradually richer conditioning set. Standard errors are clustered at the individual level and reported in parentheses, $+p<0.10$, $*p<0.05$, $**p<0.01$, $***p<0.001$. Control variables: number of months relative to reform, age, calendar month, child gender, immigrant status, birth weight, child ADHD diagnosis, child using prescriptive drugs, child's criminal history (ages 10–12), parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), parents' criminal history, police district

We also examine whether the reform affected crime rates among 15-year-olds. Since this group was above the minimum age of criminal responsibility both before and after the introduction of the reform, we consider this a placebo-type analysis. As expected, we find no evidence that the crime rates of 15-year-olds changed because of the reform (see Table 2). Since neither 13- or 15-year-olds are affected, we run a model including those as untreated individuals in order to increase statistical power of the estimated reform effects for 14-year olds (final row in Table 2). The estimated reform effect increases to 0.00026 (0.00009) in our preferred specification with the richest control set, which is significant at a 1% level. Thus, under the assumption of no spillover effects to 13- or 15-year-olds, we can rule out deterrent effects and find evidence that the reform was counterproductive and increased crime among 14-year-olds by 15% relative to the mean, which is an important effect.[6]

Table 3 shows results from heterogeneity analyses of reform effects for different subgroups and types of penal code offences. Results are robust to excluding children who committed crime prior to age 14, but the point estimate increases substantially and becomes positive and statistically significant at a 10% level for individuals who committed crime prior to age 14. Although the result is not significant at conventional levels, the positive coefficient could indicate an increase in the likelihood of repeat-offending for the more crime-prone 14-year-olds during the reform period. The lower panel of Table 3 distinguishes between different types of penal code offenses and reveals no significant reform effects.

Finally, we perform a range of robustness checks of the reform effects (see Table A3 in the Appendix). The first set of analyses are standard checks for the regression discontinuity design: including an indicator variable for the cut-off month, including additional polynomials of the distance to reform variable, reducing bandwidth by excluding 14-year-olds furthest away from the reform and employing a "donut hole" strategy excluding records for 14-year-olds closest to the reform. In addition, we estimate models with interactions terms between age and police districts and as well as models that cluster standard errors at that level too. The results are robust to all of these specification changes. The final set of checks reported in Table A3 in the Appendix study potential announcement effects. First, we exclude individuals turning 14 between the announcement of the reform and its actual enactment, and then we investigate whether the real response already happened when the media debate took off in October 2009. We find no evidence of juveniles reacting to these announcements.

To investigate potential reform effects evolving over time and pre-trends in crime rates, we present results from a comparative event study setup where we compare crime rates for each of the calendar months for the different cohorts before, during, and after the reform. Figure A3 shows monthly crimes rates for the cohorts of 14-year-olds four months prior to the reform (March-June 2010) and 20 months during the reform (July 2010 to February 2012) and the corresponding crimes rates for two control groups: pre-reform group (March 2008 to February 2010) and post-reform group (March 2012 to December 2013). The figure illustrates the seasonality in crime rates as well as a general downward trend that is leveling out over time. There are no visual indications of a reform effect that develops over time. This is also confirmed by the estimation results from two comparative event study models

[6] As a sensitivity check, we have analyzed whether the reform affected 16- and 17-year-olds, and we have performed the panel data analysis combining 14-, 16-, and 17-year-olds, not reported. Results are almost identical to results when we included 15-year-olds, only, which again supports that spillover effects do not drive results.

Table 3 Heterogeneity analyses: reform effects for different subpopulations and offence types

	I	II	III	Mean
Baseline result: reform effects for 14-year-olds	–0.00012	0.00017	0.00017	0.00177
(obs. = 1,955,508)	(0.00013)	(0.00015)	(0.00015)	
Different subpopulations:				
Boys (obs. = 1,004,484)	–0.00005	0.00025	0.00020	0.00238
	(0.00021)	(0.00024)	(0.00024)	
Girls (obs. = 951,024)	–0.00018	0.00009	0.00013	0.00113
	(0.00015)	(0.00016)	(0.00016)	
Without prior offenses by age 13 (obs. = 1,935,828)	–0.00021+	0.00004	0.00005	0.00152
	(0.00012)	(0.00013)	(0.00015)	
With prior offenses by age 13 (obs. = 19,680)	0.00878+	0.01137+	0.01143+	0.02647
	(0.00527)	(0.00608)	(0.00660)	
Different types of offences:				
Assault (obs. = 1,955,508)	–0.00003	0.00008	0.00007	0.00030
	(0.00005)	(0.00006)	(0.00006)	
Burglary (obs. = 1,955,508)	–0.00004	–0.00001	0.00000	0.00016
	(0.00004)	(0.00004)	(0.00004)	
Shoplifting (obs. = 1,955,508)	–0.00008	0.00005	0.00004	0.00056
	(0.00007)	(0.00008)	(0.00008)	
Theft of vehicles (obs. = 1,955,508)	0.00000	0.00001	0.00001	0.00025
	(0.00005)	(0.00005)	(0.00005)	
Vandalism (obs. = 1,955,508)	–0.00006	–0.00005	–0.00005	0.00023
	(0.00004)	(0.00005)	(0.00005)	
Controls:				
Number of months relative to reform	No	Yes	Yes	
Age month specification	No	Dummies	Dummies	
Calendar month dummies	No	Yes	Yes	
Child and family background	No	No	Yes	
Police district fixed effects	No	No	Yes	

Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99

Notes: Table shows result from heterogeneity analyses of reform effects including results for different subpopulations of 14-year-olds and different outcomes (selected subcategories of penal code offenses). Reported estimates are coefficients from linear panel models on the probability of an (as-if) charge in a given month during the reform, and each column represents a gradually richer conditioning set. Standard errors are clustered at the individual level and reported in parentheses, $+p<0.10$, $*p<0.05$, $**p<0.01$, $***p<0.001$. Control variables: number of months relative to reform, age, calendar month, child gender, immigrant status, birth weight, child ADHD diagnosis, child using prescriptive drugs, (child's criminal history ages 10–12), parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), parents' criminal history, police district

reported in Fig. A4. The coefficient plots report monthly interaction effects anchored in June, just prior to the reform and there is no uniform picture pointing to a delayed reform effect. Across all 38 post-reform estimates, we find five significant and negative effects. Four of them in Panel B (in April, July, October and December) which reflects that the initial differences between the reform and post-reform group in June 2010 diminishes as the downward trend is the leveling out post-reform (as shown in Fig. A3). Furthermore, it is important to note that all estimates for the pre-reform months are insignificant, thus supporting the identifying assumption of a parallel trend between the two groups.

Overall, the empirical analyses show that lowering the minimum age of criminal responsibility did not reduce the probability of committing crime among 14-year-olds. We find no evidence of spillover effects to 13- or 15-year-olds, and when we include all three age groups in a joint model, we see a significant increase in crime rates among 14-year-olds during the reform. That new offenders drive this uptick in crime would be against theoretical predictions since the reform uniformly increased the costs of committing crime. In fact, our results suggest that the observed increase in reported crime rates is particularly evident among 14-year-olds with a prior record, which can indicate higher reoffending rates during the reform period.

Conclusion and Discussions

Research on age limits in the criminal justice system has typically focused on juveniles at the age of majority and the effects of adult prosecution. With this study, we contribute to the literature by investigating the first age boundary in the legal system, which determines whether children are prosecuted or not. We use a temporary policy reform in Denmark to examine the potential consequences of lowering the minimum age of criminal responsibility for juvenile crime. Much against the political intentions, we find no evidence that the reform lowered crime rates. Actually, we can rule out more than a 7% reduction in the 14-year-olds crime probability. Under the assumption of no spillover effects to 13- or 15-year-olds, we find evidence that the reform was counterproductive and increased crime among 14-year-olds by 15% relative to the mean, which is an important effect. The uptick in crime during the reform is particularly evident among 14-year-olds with prior criminal records. Thus, the results from our empirical analyses suggest that the policy reform that introduced more severe consequences by lowering the age limit of criminal responsibility did not have the intended deterrent effects on criminal behavior.

Several theoretical explanations prevail for why changing the age of criminal responsibility did not reduce juvenile crime rates. First, an important premise for the reform to be an effective preventive policy is that juveniles, in particular those at risk of delinquency, know the minimum age of criminal responsibility and its legal implications. As there were no prior Danish studies on juveniles' knowledge about the legal system, we conducted a survey among 665 pupils enrolled in 6th–9th-grade in 2017 to shed light on this aspect (a detailed description of the survey is provided in Appendix B). The survey results suggest that juveniles in general, and in particular the age groups around the minimum age of criminal responsibility, are aware of the age limit and know the differences in the official reactions to juvenile offenders above and below the minimum age of criminal responsibility.[7] It is, of course, not possible to turn back time and say whether juveniles knew the reform and updated their perception about the severity of punishment for criminal behavior committed

[7] Most 6th–9th graders are quite familiar with the criminal justice system, and their knowledge increases with grade. While 71% of 8th–9th graders (14–15 years old) correctly identify the minimum age of criminal responsibility, when asked to list the age limit in an open question, the number is only 40% for 6th–7th graders (12–13 years old). The majority of the pupils are aware of which authorities handle criminal cases committed by juveniles below the minimum age of criminal responsibility (65%) and above the minimum age of criminal responsibility (79%). However, they are not as well informed about the legal sanctions; only 37% know that first-time theft "only" results in a fine, while another 31% believe consequences are harsher. See results in Appendix B.

by 14-year-olds. We do know that the reform of the minimum age of criminal responsibility was widely debated in the mass media; yet, we cannot be sure that the information also reached the 14-year-olds at that time. It is possible that law-abiding juveniles who would not have committed criminal acts in the first place are more knowledgeable about legal reforms. However, our survey results suggest that juveniles at higher risk of offending are as well informed about the criminal justice system as other young people. Either way, the imminent threat of prosecution in the criminal justice system did not result in behavioral changes among the 14-year-olds at the time of the reform.

Second, different theoretical perspectives on delinquent behavior also challenge the common perception among policy-makers that juvenile offenders make rational crime decisions and therefore susceptible to changing their behavior in response to new punitive policies. Potential offenders may engage in crime despite being aware of the legal reform. This will be the case if juveniles on the margin of crime are susceptible to the expected benefits such as money, thrills, or peer approval and less focused on the expected cost of crime. They may irrationally believe that they will not be caught, or they may commit crime spontaneously due to myopia or impetuosity. These explanations are in conjunction with knowledge from neuroscience suggesting limited decision capacity in adolescence caused by immaturity, which reduce executive functions such as impulse control and risk avoidance (Scott et al. 2015). These perspectives have been included in criminological theory emphasizing the importance of irrationality, impulsiveness and extreme present bias (e.g. Nagin and Pogarsky 2004) as well as recent economic theory extending Becker's static model on crime to a dynamic model that allows for impatient and even myopic behavior (see Lee and McCrary 2017). The findings of this study highlight the importance of including these perspectives on delinquent behavior in debates on when juveniles are culpable in order for policy-makers to recognize the challenges they face when implementing new legal reforms with the ambition to reduce juvenile crime. The Danish policy reform was "tough-on-crime" motivated and uniformly increased the costs of committing crime, but the threat of prosecution and punishment in the criminal justice system did not change 14-year-olds' behavior and we find no empirical evidence that lowing the minimum age of criminal responsibility is successful in deterring crime. In fact, the results point to an important increase in crime rates during the reform period, which is particularly evident among 14-year-olds with prior records which can suggest higher reoffending rates. These findings can be explained with reference to labeling theory and coincide with prior studies documenting increased criminal behavior among juveniles who experience criminal justice processing (e.g. Agan et al. 2023; Motz et al. 2020; Petrosino et al. 2010). The criminal label can increase future offending by formal reactions such as exclusion from conventional opportunities (e.g. Sampson and Laub 1997) or informal reactions by exclusion from non-deviant groups (e.g. Paternoster and Iovanni 1989) and an altered self-perception (e.g. Lemert 1951). Yet, another possible explanation is that the police were more likely to register re-offences during the reform when criminal cases for 14-year-olds were handled in the criminal justice system.

Obviously, our analyses only provide evidence of the total effects of the policy reform; it remains to be studied which exact mechanisms can explain the findings. Furthermore, we cannot firmly say anything about the extent to which our results carry over to adolescents older than 15 or to legal systems outside Northern Europe. However, the study provides results relevant to debates on the "right" age limits in the legal systems, as we did not find the crime-reducing effects that were the political argument for lowering the age limit at

which juveniles are held criminal responsible. More than ten years has passed since the legal reform in Denmark, but the questions of how and when we should sanction juveniles may be even more important today. As the decline in crime rates over the last decade have made delinquency less prevalent among juveniles the potential negative consequences of a criminal label may be even more prominent now.

Appendix A. Supplementary figures and tables

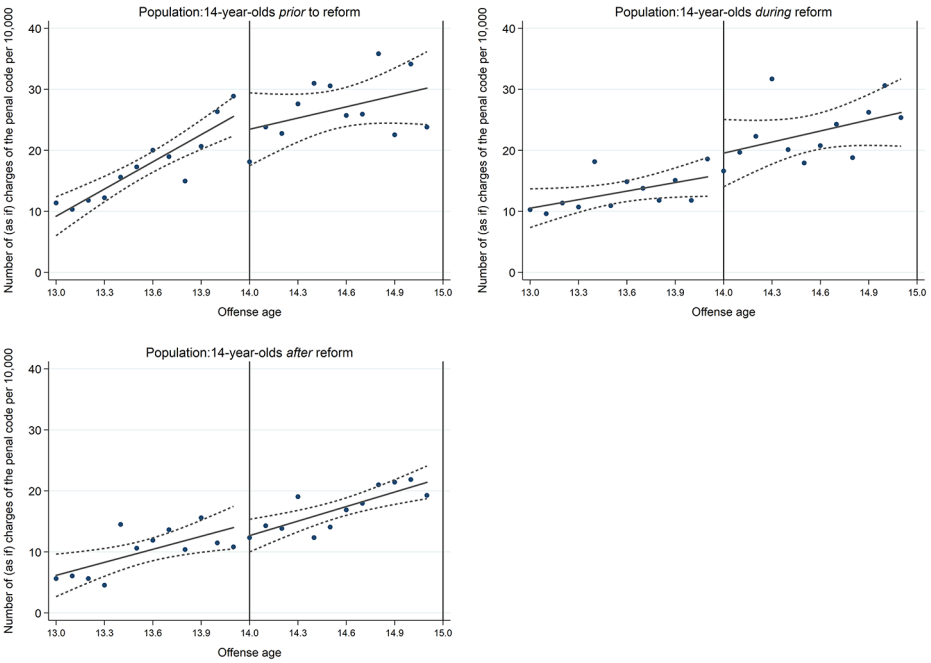


Fig. A1 Number of (as-if) charges of penal code offenses per 10,000 by month ages 13–15 for children who are 14 pre-, during or post-reform
Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99
Notes: Figure shows scatterplots of the number of reported (as-if) charges of the penal code per 10,000 in a given month between ages 13–15 for children who are age 14 in the year prior to the reform of the minimum age of criminal responsibility (top-left figure), during the reform (top-right figure) and in the year after the repeal of the reform (bottom-left figure). Solid grey lines are local linear trend lines and dashed lines indicate 95% confidence intervals

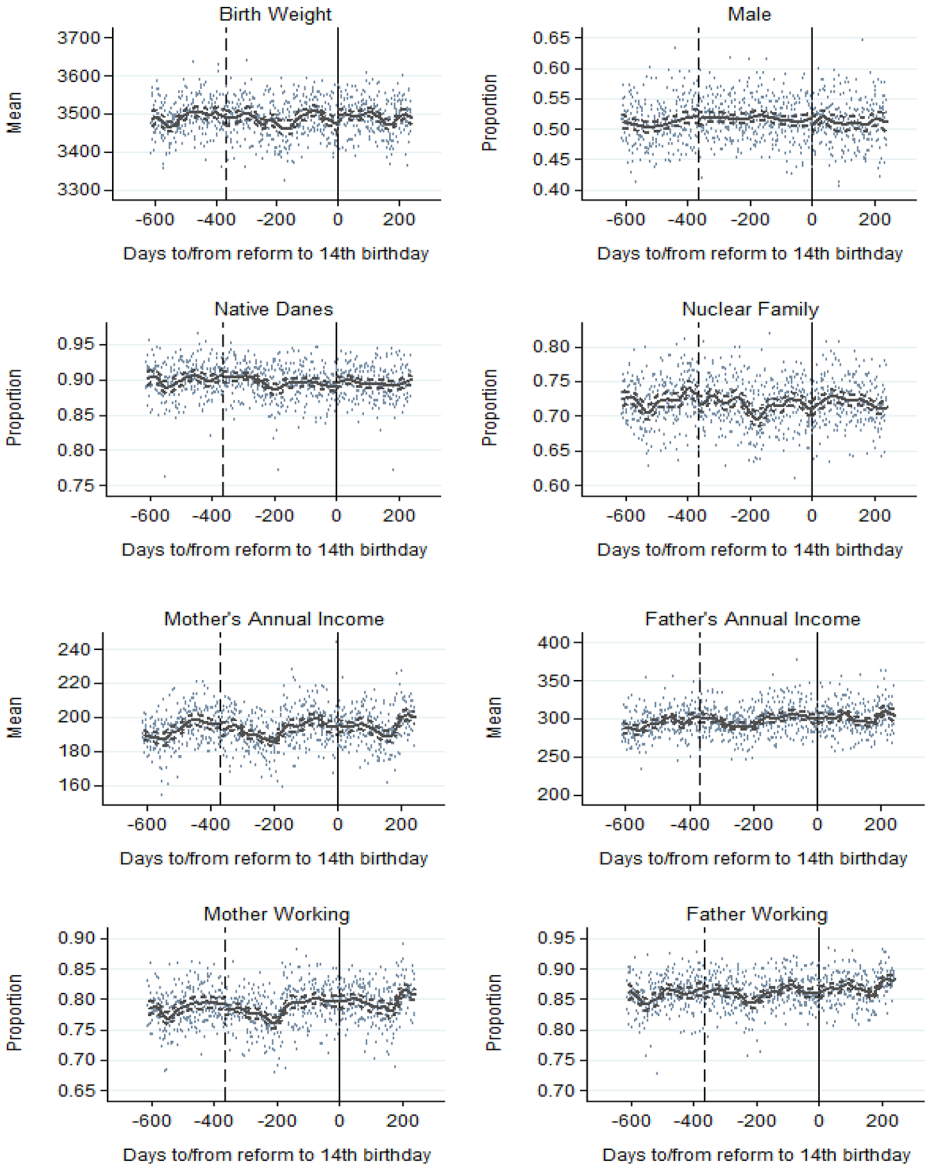


Fig. A2 Mean of selected control variable by distance to/from reform to 14th birthday
Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99
Notes: Figure shows scatterplots of selected variables by distance to/from reform date to 14th birthday, e.g. at the vertical line at 0, the plot shows mean of variable for individuals turning 14 years on July 1, 2010. Solid line is a local polynomial smoothed line and the corresponding dashed lines indicate 95% confidence intervals

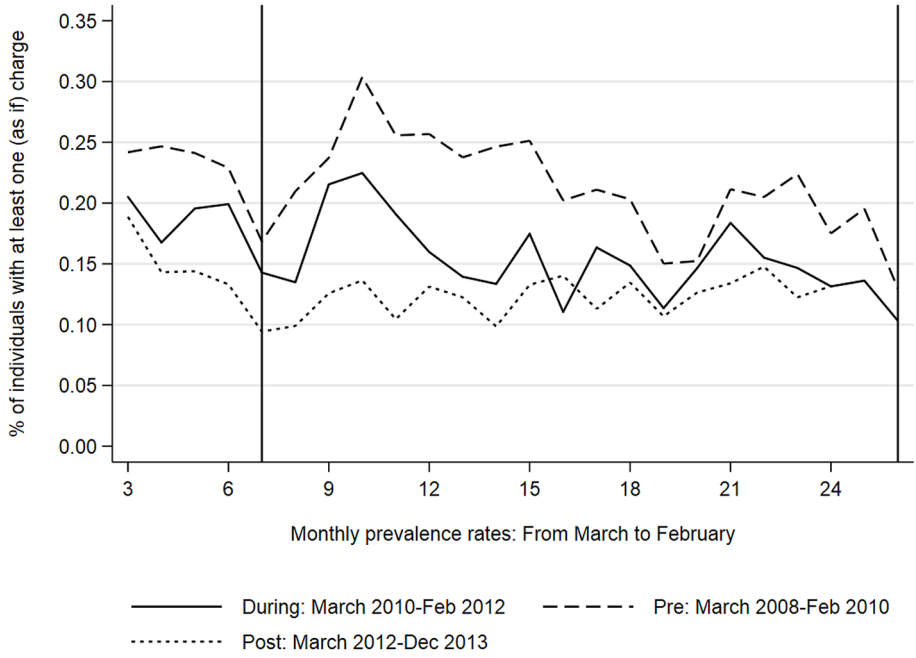
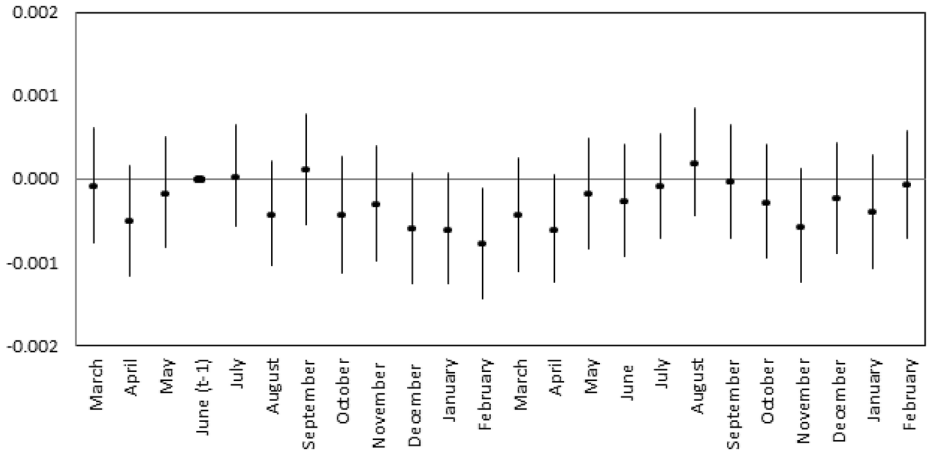


Fig. A3 Comparative event study setup: Monthly prevalence rates for 14-year-olds with at least one (as-if) charge for groups before, during and after the reform
Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99
Notes: Figure shows the percentage of 14-year-olds with at least one (as-if) charge in each of the calendar months from March (3 months prior to the reform) to the February (end of the reform period) for the 3 groups before, during and after the reform respectively. The reform period in which the minimum age of criminal responsibility changed to 14 is marked with vertical lines in July 2010 and February 2012

Panel A: 14-year-olds before and during reform



Panel B: 14-year-olds during and after reform

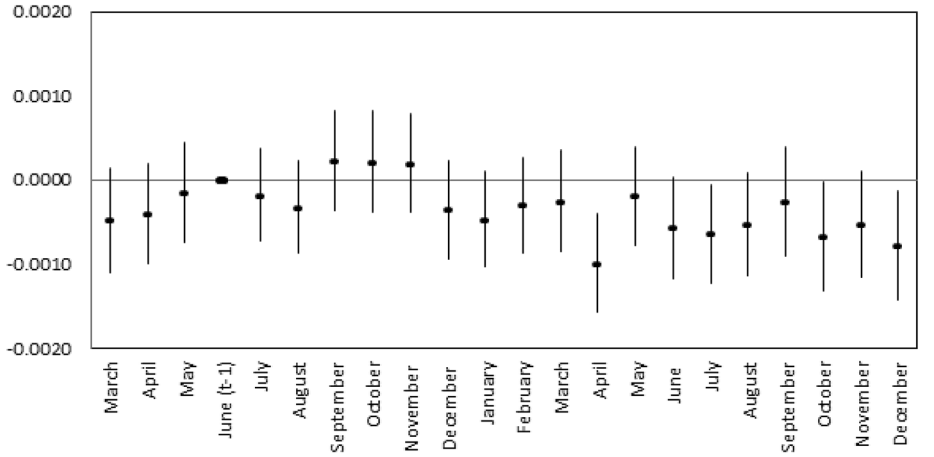


Fig. A4 Comparative event study setup: estimated effects of the reform for 14-year-olds on monthly reported offending rates (penal code offenses)
Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99
Notes: The figure shows estimates and 95%-confidence intervals from two comparative event study models anchored in June, just prior to the reform. Panel A shows estimates based on a comparison between 14-year-olds before the reform (March 2008 to February 2010) and 14-year-olds before during the reform (March 2010 to February 2012), Panel B shows estimates based on a comparison between 14-year-olds during the reform (March 2010 to December 2011) and 14-year-olds after the reform (March 2012 to December 2013). The models include controls for individual, family and police districts variables listed in equation 1

Table A1 Summary statistics of samples: means and P-values for mean differences

		Pre-reform (1)	Pre- & during-reform (2)	During-reform (3)	P-value for diff.	P-value for diff.
		Mean	Mean	Mean	(1–3)	(2–3)
Child background	Male	0.51	0.52	0.51	0.628	0.078
	Female	0.49	0.48	0.49	0.628	0.078
	Ethnic Dane	0.90	0.90	0.90	0.014	0.444
	Western immigrant 1st & 2nd generation	0.00	0.01	0.01	0.134	0.262
	Non-Western immigrant 1st & 2nd generation	0.08	0.08	0.09	0.041	0.552
	Birth weight	3490.9	3485.9	3491.6	0.862	0.122
	Birth weight < 1500 g	0.01	0.01	0.01	0.788	0.893
	Birth weight < 2500 g	0.05	0.05	0.05	0.039	0.771
	Born prematurely	0.03	0.04	0.04	0.000	0.147
	Born extremely prematurely	0.01	0.01	0.01	0.080	0.865
	ADHD diagnose (ages 0–9)	0.01	0.01	0.01	0.000	0.135
	Use of Ritalin (ages 0–9)	0.01	0.01	0.01	0.003	0.053
	Use of other psychotropic drugs (ages 0–9)	0.03	0.04	0.04	0.000	0.001
Criminal history	Charged with offense (ages 10–12)	0.01	0.01	0.01	0.000	0.012
	Number of prior charges (ages 10–12)	1.63	1.55	1.42	0.044	0.138
	Age at first reported offense	11.29	11.23	11.26	0.565	0.479
Family background (age 9)	Nuclear family	0.72	0.72	0.72	0.522	0.275
	Parent and new partner	0.09	0.09	0.09	0.967	0.151
	Single parent	0.18	0.18	0.18	0.535	0.529
	Not living parents	0.01	0.01	0.01	0.742	0.643
	Mother's annual income (DKK 1000, deflated)	193.17	193.18	194.64	0.114	0.094
	Father's annual income (DKK 1000, deflated)	294.04	298.30	301.61	0.000	0.033
	Mother working	0.79	0.79	0.80	0.000	0.000
	Father working	0.86	0.86	0.87	0.000	0.000
	Primary and secondary school – mother	0.24	0.24	0.23	0.001	0.001
	Vocational education – mother	0.38	0.38	0.37	0.080	0.261
	General upp. secondary edu. – mother	0.07	0.07	0.07	0.733	0.292
	Short-cycle higher edu. – mother	0.04	0.04	0.05	0.157	0.085
	Medium-cycle higher edu. – mother	0.19	0.19	0.19	0.173	0.023
	Long-cycle higher edu. – mother	0.07	0.08	0.08	0.000	0.000
	Primary and secondary school – father	0.26	0.25	0.25	0.001	0.001
	Vocational education – father	0.40	0.40	0.40	0.867	0.401
	General upp. secondary edu. – father	0.05	0.05	0.05	0.166	0.750
	Short-cycle higher edu. – father	0.08	0.08	0.08	0.091	0.758
	Medium-cycle higher edu. – father	0.11	0.10	0.10	0.125	0.846
	Long-cycle higher edu. – father	0.09	0.10	0.10	0.000	0.016

Table A1 (continued)

		Pre-reform (1)	Pre- & during-reform (2)	During-reform (3)	P-value for diff.	P-value for diff.
		Mean	Mean	Mean	(1–3)	(2–3)
Family Background (age 9)	Mother convicted of criminal offense	0.03	0.03	0.03	0.358	0.242
	Mother sentenced to prison or suspended prison sentence	0.01	0.01	0.01	0.230	0.325
	Father convicted of criminal offense	0.08	0.09	0.09	0.000	0.410
	Father sentenced to prison or suspended prison sentence	0.03	0.04	0.04	0.001	0.046
	Missing identifier (mother)	0.00	0.00	0.00	0.904	0.924
	Missing identifier (father)	0.02	0.02	0.02	0.834	0.225
	Missing register data child age 9 (mother)	0.01	0.01	0.01	0.490	0.511
	Missing register data child age 9 (father)	0.04	0.04	0.04	0.786	0.197
	Observations	47,441	69,785	45,733		

Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99

Notes: Table shows summary statistics for the population of 14-year-olds, divided into three groups according to whether they are age 14 pre-reform, pre-and during-reform or only during-reform. The last two columns show the p-value from t-tests of difference in means between the groups

Table A2 Formal balance test of covariates

Child background	Female	0.00318	(0.00215)
	Ethnic Dane	–0.00369**	(0.00130)
	Western immigrant 1st & 2nd generation	0.00015	(0.00030)
	Non-Western immigrant 1st & 2nd generation	0.00272*	(0.00119)
	Birth weight	–5.61146	(4.19261)
	Birth weight < 1500 g	0.00179*	(0.00089)
	Birth weight < 2500 g	0.00039	(0.00033)
	Born prematurely	0.00650**	(0.00075)
	Born extremely prematurely	0.00182**	(0.00034)
	ADHD diagnose (ages 0–9)	–0.00015	(0.00037)
	Use of Ritalin (ages 0–9)	0.00031	(0.00035)
	Use of other psychotropic drugs (ages 0–9)	–0.00030	(0.00083)
Child criminal history	Charged with offense (ages 10–12)	0.00012	(0.00043)
	Number of prior charges (ages 10–12)	–0.00036	(0.00095)
	Age at first reported offense	0.00108	(0.00487)
Family background (at child age 9)	Nuclear family	–0.00261	(0.00193)
	Parent and new partner	0.00165	(0.00122)
	Single parent	0.00055	(0.00164)
	Not living parents	0.00046	(0.00041)
	Mother's annual income (DKK 1000, deflated)	–0.59979	(0.61969)
	Father's annual income (DKK 1000, deflated)	–1.02015	(1.08194)
	Mother working	0.00278	(0.00176)
	Father working	–0.00332*	(0.00155)
	Primary and secondary school – mother	–0.00111	(0.00182)
	Vocational education – mother	–0.00386+	(0.00208)
	General upp. secondary edu. – mother	–0.00028	(0.00109)
	Short-cycle higher edu. – mother	0.00120	(0.00088)
	Medium-cycle higher edu. – mother	0.00358*	(0.00170)
	Long-cycle higher edu. – mother	0.00063	(0.00115)
	Primary and secondary school – father	–0.00066	(0.00187)
	Vocational education – father	–0.00397+	(0.00210)
	General upp. secondary edu. – father	–0.00070	(0.00095)
	Short-cycle higher edu. – father	0.00083	(0.00115)
	Medium-cycle higher edu. – father	0.00059	(0.00132)
	Long-cycle higher edu. – father	0.00202	(0.00127)
	Mother convicted of criminal offense	–0.00012	(0.00071)
	Mother sentenced to prison or suspended prison sentence	0.00003	(0.00038)
	Father convicted of criminal offense	0.00216+	(0.00119)
	Father sentenced to prison or suspended prison sentence	0.00084	(0.00080)
	Missing identifier (mother)	–0.00017	(0.00031)
	Missing identifier (father)	0.00189**	(0.00059)
	Missing register data child aged 9 (mother)	–0.00021	(0.00043)
	Missing register data child aged 9 (father)	0.00195	(0.00084)
	Controls:		
	Number of months prior	Yes	
	Number of months after	Yes	
	Observations	1,955,508	

Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99

Notes: Table shows results from multiple regression models for the population of 14-year-olds before and during the reform. Reported estimates of the post-reform dummy regressed on each of the control variables respectively while controlling for the number of months relative to reform. Standard errors are clustered at the individual level and reported in parentheses, $+p < 0.10$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

Table A3 Robustness analyses: effects of the reform for 14-year-olds on monthly reported offending rates (penal code offenses)

Baseline result: Effects of the reform (obs. = 1,955,508, mean = 0.00177)	0.00017 (0.00015)
Different reform specifications:	
Including dummy variable for reform month (obs. = 1,955,508, mean = 0.00177)	0.00017 (0.00016)
Distance to reform (quadratic) (obs. = 1,955,508, mean = 0.00177)	–0.00024 (0.00027)
Distance to reform (quadratic and cubic) (obs. = 1,955,508, mean = 0.00177)	–0.00001 (0.00035)
Excluding 14-year-olds furthest away from the reform (14th birthday November–December 2008 and January–February 2012) (obs. = 1,816,104, mean = 0.00175)	0.00010 (0.00016)
Excluding 14-year-olds closest to the reform (14th birthday June, July and August 2010) (obs. = 1,742,040, mean = 0.00178)	0.00015 (0.00015)
Additional model specifications:	
Including interactions terms for age-by-police districts (obs. = 1,955,508, mean = 0.00177)	0.00017 (0.00015)
Cluster at age-by-police districts level (obs. = 1,955,508, mean = 0.00177)	0.00017 (0.00012)
Announcements effects:	
Excluding 14-year-olds born 17 March–30 June 1996 (obs. = 1,715,076, mean = 0.00177)	0.00014 (0.00016)
Effects of media debate October 2009–June 2010 (obs. = 1,030,623, mean = 0.00177)	–0.00068 (0.00270)
Controls:	
Number of months relative to reform	Yes
Age month specification	Dummies
Calendar month dummies	Yes
Child and family background	Yes
Police district fixed effects	Yes

Source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993–99

Notes: Table shows result from robustness analyses to test of different model assumptions and specifications (e.g. higher-order polynomials in distance to reform, bandwidth definitions and announcements effects). Reported estimates are coefficients from linear panel models on the probability of an (as-if) charge in a given month during the reform. Standard errors are clustered at the individual level and reported in parentheses, $+p < 0.10$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. Control variables: number of months relative to reform, age, calendar month, child gender, immigrant status, birth weight, child ADHD diagnosis, child using prescriptive drugs, child criminal history (ages 10-12), parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), parents' criminal history, police district.

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Data Availability Due to GDPR regulations, the research datasets supporting this study are not publicly available.

Declarations

Competing Interests The authors have no competing interests to declare that are relevant to the content of this article.

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References

Agan A, Doleac JL, Harvey A (2023) Misdemeanor prosecution. Q J Econ 138(3):1453–1505. https://doi.org/10.1093/qje/qjad005

Andersen LH, Anker AST, Andersen SH (2016) A formal decomposition of declining youth crime in Denmark. Demogr Res 35:1303–1316. https://doi.org/10.4054/DemRes.2016.35.44

Apel R (2013) Sanctions, perceptions, and crime: implications for criminal deterrence. J Quant Criminol 29(1):101–135. https://doi.org/10.1007/s10940-012-9170-1

Barrick K (2014) A Review of Prior Tests of Labeling theory. In: Farrington DP, Murray J (eds) Labeling theory. Transaction, New Brunswick, NJ, pp 89–112

Becker G (1968) Crime and punishment: an economic approach. J Polit Econ 76:169–217. https://doi.org/10.1086/259394

Bernburg JG, Krohn MD (2003) Labeling, life chances, and adult crime: the direct and indirect effects of official intervention in adolescence on crime in early adulthood. Criminol 41:1287–1318. https://doi.org/10.1111/j.1745-9125.2003.tb01020.x

Bloom HS (2003) Using short interrupted Time-Series analysis to measure the impacts of Whole-School reforms: with applications to a study of accelerated schools. Eval Rev 27(1):3–49. https://doi.org/10.1177/0193841X02239017

Brinkgaard L (2023) En Ungdom Uden kriminalitet: Straf, Velfærd Og neoliberalisme i Danmark, 1990–2010. TEMP - tidsskr Hist 13(25):114–136. https://doi.org/10.16993/temp.135458

Chalfin A, McCrary J (2017) Criminal deterrence: A review of the literature. J Econ Lit 55(1):5–48. https://doi.org/10.1257/jel.20141147

Child Rights International Network (CRIN) (2020) Minimum Ages of Criminal responsibility in Europe. Located: November 1, 2020 at https://archive.crin.org/en/home/ages/europe.html

Danish Ministry of Justice (2016) Udviklingen i børne- Og ungdomskriminalitet 2006–2015 [The development in crime among children and youth, 2006–2015]. Justitsministeriets Forskningskontor

Danish Ministry of Justice (2020) Udviklingen i børne- Og ungdomskriminalitet 2006–2019 [The development in crime among children and youth, 2006–2019]. Justitsministeriets Forskningskontor

Dohmen T, Falk A, Huffman D, Sunde U, Schupp J, Wagner GG (2011) Individual risk attitudes: measurement, determinants, and behavioral consequences. J Eur Econ Assoc 9(3):522–550. https://doi.org/10.1111/j.1542-4774.2011.01015.x

Farrington DP (1977) The effects of public labelling. Br J Criminol 17(2):112–115
Farrington DP, Murray J (2014) Labeling theory. Empirical tests. Advances in criminological theory.Volume 18. Routledge, New York
Gibbs JP (1975) Crime, punishment, and deterrence. Elsevier, New York
Heckman JJ (2008) Schools, skills, and synapses. Econ Inq 46:289–324. https://doi.org/10.1111/j.1465-7295.2008.00163.x
Hjalmarsson R (2009a) Juvenile jails: A path to the straight and narrow or hardened criminality? J Law Econ 52(4):779–809. https://doi.org/10.1086/596039
Hjalmarsson R (2009b) Crime and expected punishment: changes in perceptions at the age of criminal majority. Am Law Econ Rev 11(1):209–248. https://doi.org/10.1093/aler/ahn016
Hockenberry S, Puzzanchera C (2020) Juvenile court statistics 2018. National Center for Juvenile Justice, Pittsburgh, PA
Huizinga D, Henry KL (2008) The effect of arrest and justice system sanctions on subsequent behavior: findings from longitudinal and other studies. In: Liberman AM (ed) The long view of crime. Springer, New York, pp 220–254. https://doi.org/10.1007/978-0-387-71165-2_7
Jensen EL, Metsger LK (1994) A test deterrent effect of legislative waiver on violent juvenile crime. Crime Delinquency 40(1):96–104. https://doi.org/10.1177/0011128794040001007
Klein MW (1974) Labeling, deterrence, and recidivism: A study of Police dispositions of juvenile offenders. Soc Probl 22:292–303. https://doi.org/10.2307/799765
Klein MW (1986) Labeling theory and delinquency policy: an experimental test. Crim Justice Behav 13(1):47–79. https://doi.org/10.1177/0093854886013001004
Kyvsgaard B (2004) Youth justice in Denmark. Crime Justice 31:349–390. https://doi.org/10.1086/655344
Lee D, McCrary J (2017) The deterrence effect of prison: dynamic theory and evidence. Adv Econ 38:73–146. https://doi.org/10.1108/S0731-905320170000038005
Lemert E (1951) Social pathology. McGraw-Hill, New York
Liberman AM, Kirk DS, Kim K (2014) Labeling effects of first juvenile arrests: secondary deviance and secondary sanctioning. Criminol 52:345–370. https://doi.org/10.1111/1745-9125.12039
Loeffler CE, Braga AA (2022) Estimating the effects of shrinking the criminal justice system on criminal recidivism. Crim Public Policy 21(3):595–617. https://doi.org/10.1111/1745-9133.12588
Loeffler CE, Chalfin A (2017) Estimating the crime effects of Raising the age of majority. Crim Public Policy 16:45–71. https://doi.org/10.1111/1745-9133.12268
Loeffler CE, Grunwald B (2015a) Processed as an adult. A regression discontinuity estimate of the crime effects of charging nontransfer juveniles as adult.. J Res Crime Delinquency 52(6):890–922. https://doi.org/10.1177/0022427815581858
Loeffler CE, Grunwald B (2015b) Decriminalizing delinquency: the effect of Raising the age of majority on juvenile recidivism. J Leg Stud 44(2):361–388. https://doi.org/10.1086/684297
Loughran TA, Paternoster R, Chalfin A, Wilson T (2016) Can rational choice be considered general theory of crime? Evidence from individual-level panel data. Criminol 54(1):86–112. https://doi.org/10.1111/1745-9125.12097
Loughran TA, Paternoster R, Piquero AP (2018) Individual difference and deterrence. In: Nagin DS, Cullen FT, Jonson CL (eds) Deterrence, choice, and crime: contemporary perspectives. Advances in Criminological Theory, vol 23. Routledge, New York
McAra L, McVie S (2007) Youth justice? The impact of system contact on patterns of desistance. Eur J Criminol 4:315–345. https://doi.org/10.1177/1477370807077186
McCrary J (2008) Manipulation of the running variable in the regression discontinuity design: A density test. J Econometrics 142:698–714. https://doi.org/10.1016/j.jeconom.2007.05.005
Motz RT, Barnes JC, Caspi A, Arseneault L, Cullen FT, Houts R, Wertz J, Moffitt TE (2020) Does contact with the justice system deter or promote future delinquency? Results from a longitudinal study of British adolescent twins. Criminol 58(2):307–335. https://doi.org/10.1111/1745-9125.12236
Mueller-Smith MG, Pyle B, Walker C (2023) Estimating the Impact of the Age of Criminal Majority: Decomposing Multiple Treatments in a Regression Discontinuity Framework. NBER-working paper, 31523. https://doi.org/10.3386/w31523
Nagin DS (1998) Criminal deterrence research at the outset of the twenty-first century. In: Tonry MH (ed) Crime and justice: an annual review of research, vol 23. University of Chicago Press, Chicago, pp 1–42. https://doi.org/10.1086/449268
Nagin DS, Pogarsky G (2004) Time and punishment: delayed consequences and criminal behavior. J Quant Criminol 20(4):295–317. https://doi.org/10.1007/s10940-004-5866-1
National Academy of Sciences (2022) The limits of recidivism: measuring success after prison. National Academies, Washington, DC. http://nap.nationalacademies.org/26459

National Juvenile Defender Center (NJDC) (2020) Comparative Stata Data, Minimum Age for Delinquency Adjudication. Located: November 1 2020, at https://njdc.info/practice-policy-resources/state-profiles/multi-jurisdiction-data/minimum-age-for-delinquency-adjudication-multi-jurisdiction-survey/
Nedelec JL, Silver IA (2018) Challenging assumptions: A genetically sensitive assessment of the criminogenic effect of contact with the criminal justice system. J Contemp Crim Just 35:69–86. https://doi.org/10.1177/1043986218810599
Paternoster R (2010) How much do we really know about criminal deterrence? J Crim Law Criminol 100:765–823
Paternoster R, Iovanni L (1989) The labeling perspective and delinquency: an elaboration of the theory and an assessment of the evidence. Just Q 6:359–394. https://doi.org/10.1080/07418828900090261
Pedersen ML (2013) Selvrapporteret kriminalitet. En sammenligning mellem Odense og Storkøbenhavn 2012 og Storkøbenhavn 2006 og 2012. [Self-Reported crime: A comparison between Odense and greater Copenhagen 2012 and greater Copenhagen 2006 and 2012]. Justitsministeriets Forskningskontor
Petrosino A, Turpin-Petrosino C, Guckenburg S (2010) Formal system processing of juveniles: effects on delinquency. Campbell Syst Rev 2010:1. https://doi.org/10.4073/csr.2010.1
Polinsky AM, Shavell S (1999) On the disutility and discounting of imprisonment and the theory of deterrence. J Leg Stud 28:1–16. https://doi.org/10.1086/468044
Pratt J (2008) Scandinavian exceptionalism in an era of penal excess: part I: the nature and roots of Scandinavian exceptionalism. Brit J Criminol 48(2):119–137. https://doi.org/10.1093/bjc/azm072
Pratt J, Erickson A (2013) Contrasts in punishment: an explanation of anglophone excess and nordic exceptionalism. Routledge, London. https://doi.org/10.4324/9780203096116
Risler EA, Sweatman T, Nackerud L (1998) Evaluating the Georgia legislative waiver's effectiveness in deterring juvenile crime. Res Soc Work Pract 8(6):657–667. https://doi.org/10.1177/104973159800800603
Robinson K, Kurlychek M (2019) Differences in justice, differences in outcomes: A DID approach to studying outcomes in juvenile and adult court processing. Justice Eval J 2(1):35–49. https://doi.org/10.1080/24751979.2019.1585927
Sampson RJ, Laub JH (1997) A life-course theory of cumulative disadvantage and the stability of delinquency. In: Thornberry TP (ed) Developmental theories of crime and delinquency. Transaction, New Brunswick
Scott E, Grisso T, Levick M, Steinberg L (2015) The U.S. Supreme court and the transformation of juvenile sentencing. Models for change. Systems Reform in Juvenile Justice
Scottish Government (2019) Description located 17/11–2019 at https://www.gov.scot/policies/youth-justice/raising-age-criminal-responsibility/
Singer SI, McDowall D (1988) Criminalizing delinquency: the deterrent effects of the new York juvenile offender law. Law Soc Rev 22(3):521–536. https://doi.org/10.2307/3053628
Steinberg L (2014) Age of opportunity: lessons from the new science of adolescence. Houghton Mifflin Harcourt, Boston, New York
Steiner B, Wright E (2006) Assessing the relative effects of state direct file waiver laws on violent juvenile crime: deterrence or irrelevance? J Crim Law Criminol 96(4):1451–1477
Storgaard A (2013) Unge lovovertræderes strafansvar, retssikkerhed og lavalder. In: Nordlöf K (ed) Argumentation i nordisk straffrätt. Nordstedts, Stockholm, pp 200–215
United Nations Committee on the Rights of the Child (UNCRC) (2019) Convention on the Rights of the Children. General comment No. 24 on children's rights in the child justice system
Vischer T, Dohmen T, Falk A, Huffman D, Schupp J, Sunde U, Wagner GG (2013) Validating an ultra-short survey measure of patience. Econ Lett 120(2):142–145. https://doi.org/10.1016/j.econlet.2013.04.007
Wiley SA, Slocum LA, Esbensen FA (2013) The unintended consequences of being stopped or arrested: an exploration of the labeling mechanisms through which Police contact leads to subsequent delinquency. Criminology 51:927–966. https://doi.org/10.1111/1745-9125.12024
Youth Justice Board (2020) Youth justice statistics 2018/2019. England and Wales. Statistical bulletin. Ministry of Justice, UK

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