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### Lowering the minimum age of criminal responsibility: Consequences for juvenile crime and education

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## Consequences for juvenile crime and education

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### Abstract

This paper exploits a Danish policy reform combined with population-wide administrative registers to investigate whether being above the minimum age of criminal responsibility deters juveniles from crime. We study young individuals' tendency to commit crime as well as their likelihood of recidivism by exploiting police records on offenses committed by the population of children and youth, including those below the minimum age of criminal responsibility. The reform lowered the minimum age of criminal responsibility from 15 to 14 years. We find that the reform did not deter 14-year-olds from committing crime. Moreover, conditional on committing crime in the first place, youths affected by the lower minimum age of criminal responsibility were *more* likely to recidivate and less likely to be enrolled in the 9<sup>th</sup> grade, just as they have lower grades at the 9th grade exit exam, conditional on participating. The latter results are consistent with labeling effects of processing in the criminal justice system.

Keywords: Juvenile delinquency, sanctions, general deterrence, individual deterrence, labeling effects

JEL-codes: K14, K42, I21

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## 1. Introduction

Youth crime has decreased considerably in recent years. This development is seen across a variety of settings, including the US, the UK, and the Scandinavian countries (Danish Ministry of Justice, 2014, 2016). At the same time, many western countries have on-going political discussions about the "right" age-limits in the criminal justice system, and there are examples of both movements towards raising the age boundaries (e.g. across US states<sup>1</sup>) and advocacies towards lowering the minimum age of criminal responsibility (e.g. in Denmark). This paper exploits a "tough-on-crime" motivated reduction in the age of criminal responsibility in Denmark during the summer of 2010 to investigate how the risk of early, and formal, exposure to the justice system affects youth crime and education.<sup>2</sup>

A vast literature studies the impact of tough, consequential sanctions, such as incarceration, on future outcomes for adults, and finds mixed results.<sup>3</sup> A smaller literature considers the impact of juvenile incarceration. Aizer and Doyle (2015) find detrimental effects on recidivism and education, whereas Hjalmarsson (2009a) finds the opposite. Previous studies on age boundaries in the youth justice system have largely focused on the age at which juvenile offenders transfer to the adult justice system and results are mixed. There are both examples of studies finding no effects of the majority age (e.g. Hjalmarsson 2009b; Loeffler and Chalfin 2017; Loeffler and Grundwald 2015) and studies documenting general deterrent effects (Hansen and Waddell 2014; Lee and McCrary 2017; Levitt 1998).<sup>4</sup>

Our study, in contrast, is concerned with less intrusive sanctions to juveniles at the margin of the criminal justice system. We investigate the consequences of criminal justice system processing and the receipt of a criminal record at an early age. Little is known about this area. Yet a rich literature

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<sup>1</sup> There are several states in the US, which have raised the age of majority up to eighteen, for example Illinois, Connecticut, Mississippi, Massachusetts, and New Hampshire (Loeffler and Grundwald 2015).

<sup>2</sup> The idea that the severity of punishment could deter crime at least dates back to Beccaria's (1764) treatise and to Bentham (1789).

<sup>3</sup> Some studies find that incarceration is effective in terms of reducing recidivism (e.g. Bhuller et al. 2016; Di Tella and Schargrodsky 2013; Landersø 2015), while other studies find the opposite (e.g. Bales and Piquero 2012; Cochran, Mears and Bales 2014; Green and Winik 2010; Michel, Rosholm and Simonsen 2017; Nagin and Snodgrass 2013). In addition, results on the impact of incarceration on labour market outcomes are mixed. Some authors find beneficial effects in the short- to medium run (e.g. Bhuller et al. 2016; Kling 2006; Landersø 2015) and suggest that this is due to rehabilitation and prevention programs, while Michel, Rosholm and Simonsen (2017) find detrimental effects and Kling (2006) reports faded out after 7-9 years. Drago, Galbiati and Vertova (2009) find general deterrence effects of longer sentences for a sample of former inmates.

<sup>4</sup> We use the term "general deterrence" to denote the general prevention of crime and the term "individual deterrence" to denote discouragement of the individual from future criminal acts (like e.g. Bell, Jaitman and Machin 2014). The latter is sometimes denoted "specific deterrence" (e.g. Di Tella and Schargrodsky, 2013)

now acknowledges that childhood and early youth are particularly sensitive periods (e.g. Heckman, 2008) and emphasizes the importance of early interventions and prevention. Importantly, while IQ is considered set after the first decade of life, behavior seems malleable at later ages; see e.g. Cunha, Heckman, Lochner and Masterov (2006) and Cunha and Heckman (2008). Whether the presence of official sanctions earlier on in life deters juvenile crime is unclear, as is whether experiencing formal punishment earlier on in life reduces recidivism.

The Danish reform, exploited here, lowered the minimum age of criminal responsibility from age 15 to age 14. The political aim was clearly to deter juvenile crime.<sup>5</sup> The reform was communicated to the public through substantial media coverage, especially in the year before the reform. In fact, the term “minimum age of criminal responsibility” was mentioned more than 300 times in the national newspapers during that year (see further details below). As a result, juveniles were likely to be aware of the policy reform that changed the age-limit of prosecution, conviction, and sanctions of young offenders in the Danish criminal justice system.<sup>6</sup> It is possible, therefore, that the reform could have deterred 14-year-old youth from committing crime.

Our data are uniquely well suited to study this question. The longitudinal register data includes information about all offences for which the Danish police have charged a juvenile offender or would have charged a juvenile offender, in case the offender were above the minimum age of criminal responsibility. We have information for the periods across which the minimum age of criminal responsibility was lowered and analyze monthly records of reported crimes from November 1st 2008 to January 31st 2012. Via unique personal identifiers, we link these longitudinal data to background information for children and their parents as well as to information about academic performance. Our quasi-experimental strategy is to compare outcomes for 14-year-olds just before and after the change in the minimum age of criminal responsibility, while carefully controlling for the downward trend in youth crime during the observation period. Robustness analyses include estimation of placebo effects for youths close to but above the minimum age of criminal responsibility throughout the same period

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<sup>5</sup> *“I am convinced that lowering the age of criminal responsibility will prevent crime. It will force some youths to think twice before committing crime”* (in Danish: *“Jeg er sikker på, at nedsættelse af den kriminelle lavalder vil have en præventiv effekt. Det vil få nogle unge og børn til at tænke sig om en ekstra gang og lade være med at gå ud i kriminelle handlinger.”*), Kim Andersen, legal affairs spokesperson, Liberal Party of Denmark (Venstre). (The 1st reading of the bill, Thursday the 15th of April 2010: <http://www.ft.dk/samling/20091/lovforslag/1164/beh1-75/2/forhandling.htm?startItem=#nav>).

<sup>6</sup> In studies exploiting policy reforms to investigate deterrent effects, an important intermediate outcome and indeed a precursor to identifying deterrence is the extent to which potential offenders are aware that the policy has changed (Waldo and Chiricos 1972; Nagin 1998; Apel 2013).

and investigation of potential spillover effects on delinquency by youths close to but below the minimum age of criminal responsibility in the same period. By doing both, we add to approaches used by a number of recent papers to investigate general deterrence effects of the age of majority (Lee and McCrary 2017; Hjalmarsson 2008; Hansen and Wadell 2014).

We find no evidence that the reform lowered the probability of committing crime among 14-year-olds. Yet conditional on committing crime in the first place, youths were, in fact, *more* likely to recidivate. Hence, we find no evidence that interactions with the criminal justice system and the receipt of a criminal record at an early age induce less crime. We also find some evidence that schooling outcomes, such as the tendency to be enrolled in regular 9<sup>th</sup> grade classrooms and language arts exam grades, deteriorate more among offenders processed in the criminal justice system.

We structure the remainder of the paper as follows: Section 2 presents the background for the study, Section 3 introduces the institutional details and discusses the policy reform, and Section 4 presents our data. Section 5 estimates general deterrence effects of the minimum age of criminal responsibility, while Section 6 considers individual deterrence effects on recidivism and schooling outcomes. Finally, Section 7 concludes.

## 2. Background

### 2.1 Theoretical framework

In economics, criminal offending is regarded as a rational decision where the potential offender commits a crime if expected benefits outweigh expected costs. Common for most theories in the field are three behavioral predictions: crime is deterred by increasing the probability of being caught (due to, for instance, policing intensity), increasing severity of punishment (in terms of time, income, or psychic costs), or increasing opportunity costs (in terms of, for instance, labor market opportunities), see review by Chalfin and McCrary (2017).

The seminal paper by Becker (1968) presents a static model where individuals face a gamble.<sup>7</sup> They may either commit a crime and with probability  $1-p$  receive the benefit from crime, and with probability  $p$  be caught and punished instead, or they may abstain from crime and derive a non-crime

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<sup>7</sup> See also Stigler (1970) and Polinsky and Shavell (1984).

risk-free utility. In this set-up, the three predictions outlined above follow naturally. Ehrlich (1973) focuses on the opportunity costs of legitimate and illegitimate activities as being important for how potential offenders respond to incentives. Lee and McCrary (2017) develop a dynamic extension of Becker's model of crime, where individuals draw crime opportunities from a distribution of criminal offers. Each period the individual decides whether to commit a crime, and if he commits a crime, he is randomly apprehended. Their dynamic set-up emphasizes the potential importance of myopia and the interplay between sentence length and degree of myopia.<sup>8</sup>

Crime policies may affect criminal behavior through three main channels (corresponding to the three predictions mentioned above): certainty of the punishment, i.e. the risk of detection, apprehension and conviction given commission of crime; severity of the punishment, i.e. the onerousness of the legal consequences given a sanction is imposed; and opportunity costs. The effects of such policies rely crucially on the extent to which juveniles are aware of the changes in policies and whether they subsequently adapt their expectations.

Crime policies may affect criminal behavior through the threat of punishment, i.e. general deterrence, and due to the experience of punishment, i.e. individual deterrence. Incarceration will mechanically reduce crime due to incapacitation, but the experience of punishment may also change the individual's future behavior by changing his information about the costs and benefits of criminal behavior (e.g. deter the individual from future crime by instilling an understanding of the consequences/costs) or, somewhat more speculative, his preferences for criminal relative to legal activities. The lowering of the minimum age of criminal responsibility from 15 to 14 increases the severity of the expected punishment of offenders aged 14. This threat may have a general deterrent effect on criminal behavior among 14-year-olds. Moreover, the experience of punishment at the age of 14 may deter the individual from future crime. The reform may also affect intertemporal choice. First, if crime requires investments in crime-related human capital or learning by doing, then an increase in the expected punishment of 14-year-old offenders may affect not only their current decision-making but also their number of crimes committed in the future. Second, punishment itself may affect the returns to crime versus legal activities. Serving time in a halfway house may facilitate the acquisition of criminal human capital (creating spillovers or criminogenic effects using the term from criminology) and/or

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<sup>8</sup> See Polinsky and Shavell (1999) for another example of a dynamic model of crime in which the behavior of the offender is sensitive to their time preferences.

stigmatize the offender. Therefore, introducing more severe punishments to juvenile offenders may reduce crime in the short run, but increase crime in the longer run.

Policies may affect individuals other than those initially targeted. In our case, the reform may also have consequences for 13-year old offenders. If there are a limited number of criminal opportunities that adolescents compete for, then offenders below the minimum age of criminal responsibility may be substitutes for offenders above that age. Therefore, the reform may increase crime for adolescents below the new minimum age of criminal responsibility. If, on the other hand, juveniles above the minimum age of criminal responsibility serve as role models for juveniles below that age, then they may be complements. If the reform is successful in deterring crime among 14-year olds, it may also reduce crime among 13-year old individuals due to role model effects.

## 2.2 Prior evidence on the effects of sanctions on juvenile crime

While the literature on the effects of sanctions on adult crime is well developed,<sup>9</sup> research on the effects of sanctions on juvenile crime is still limited. The literature falls into two broad strands: the literature on general deterrence effects of changes in the severity (rather than certainty) of punishment of juvenile crime and the literature on the effects of experiencing punishment for juvenile crime on reoffending and education.

Previous empirical studies on general deterrence effects aim at measuring the effect of the risk of juvenile incarceration. A number of empirical studies in criminology have estimated general deterrence effects of transferring juveniles charged with serious crimes to adult court instead of juvenile court handling using time-series data on arrest rates for US states (see e.g. Singer and McDowall 1988; Jensen and Metsger 1994; Risler, Sweatman and Nackerud 1998; Steiner and Wright 2006). They have exploited changes in the American system of juvenile justice which since the mid-1970s has been moving away from its traditional rehabilitative orientation toward a model based on the adult criminal justice system. Legislative waiver policies usually set a minimum age of 14 to 16 years for automatic transfer to criminal court (Feld 1987). The offenses covered by legislative

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<sup>9</sup> One strand of literature considers the effect of sentencing policy generally, or sentence enhancements on crime, see e.g. Loftin, Heumann and McDowall (1983); Helland and Tabarrok (2007); Drago Galbiati and Vertova (2009); Buonnano and Raphael (2013); Kilmer, Nicosia, Heaton and Midgette (2013); Bell, Jaitman and Machin (2014). Another strand of literature investigates the effect of a capital punishment regime or the incidence of executions on murder, see e.g. Grogger (1991); Cochran, Chamblin and Seth (1994); Donohue and Wolfers (2005); Land, Teske and Zhang (2009). For an overview of this literature, see the recent literature reviews by Chalfin and McCrary (2017) and Nagin (2013).

waiver policies are typically violent crimes or other felonies (Jensen and Metsger 1994). Deterrence is one of the major arguments underlying this growth in the use of legislative waiver.

Singer and McDowall (1988) investigated the general deterrent effect of New York's legislative waiver statute enacted in 1978. This Juvenile Offender Law lowered the age at which a juvenile is mandated to be tried in criminal court to either 13 or 14 years depending on the crime. This legislation also mandated that penalties be similar to those for adults and required that all sentences be served in secure facilities. Singer and McDowall (1988) assesses the effect of this legislation on serious juvenile crimes. They concluded that the law had no effect on homicides, assaults, rapes, and arsons committed by juveniles, but that it might have prevented robberies from increasing. In line with the findings by Singer and McDowall, the studies by Jensen and Metsger (1994), Risler, Sweatman and Nackerud (1998), and Steiner and Wright (2006) all find that file transfer laws have little or no effect on violent juvenile crime.

More recently, economists have used a different approach to investigate the deterrence effect of tough punishment of juvenile crime. They have investigated the deterrence effect of the laws that govern the age of criminal majority, since these laws generate differences in juvenile and adult punishment (Levitt 1998). Using US state-level panel data for the period 1978-93, Levitt (1998) finds that harsher punishment for juveniles are strongly associated with lower rates of juvenile offending. Further investigation suggests that the crime reduction comes from general deterrence and not incapacitation or individual deterrence. The use of individual-level data allows for estimation of the effect of deterrence without the potential confounding influence of incapacitation that necessarily arises in aggregate data (Mocan and Rees 2005). Using micro-level data, more recent studies by economists have exploited the idea that laws that govern the age of majority generate large discontinuities in the sanctions faced by individual offenders when they cross the age threshold (Lee and McCrary 2017; Hjalmarsson 2009b; Hansen and Wadell 2014). Despite the fact that the expected sentence length for an adult offender is more than twice as long as that faced by a juvenile offender, these studies surprisingly find little or only weak evidence of a deterrent effect. Few studies have used an experimental design to evaluate the deterrence effect of formal sanctions of juvenile offenders.<sup>10</sup>

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<sup>10</sup> A notable exception is the study by Piliavin, Gartner, Thornton and Matsueda (1986). Their evaluation of 5,050 participants from three distinct groups of persons at high risk of formal sanction (including youth) support the reward component of the rational-choice model, but fail to support the cost or deterrent component, as measured by perceived risks of formal sanctions.



The idea in our study is instead to exploit a change in the laws that govern the minimum age of criminal responsibility for investigation of the deterrence effect of formal sanction of juvenile offenders as these laws generate large discontinuities in the sanctions faced by young juvenile offenders. We thereby widen the scope to the youth population at the fringes of the criminal justice system. Besides the age group under consideration, our approach differs from the earlier studies on the age of majority in two important ways. For one, we exploit detailed monthly criminal records for a sample of individuals turning 14 before and after the reform. This allows us to handle potential confounding age- and time trends in crime in our estimations. Second, earlier studies examine the effects of differences in the severity of sanctions within the criminal justice system, namely between the juvenile and adult criminal justice system, while we examine the differences in the severity of sanction between the social system and criminal justice system.

The second broad strand of literature on deterrence of juvenile crime investigates the effects of experience of juvenile punishment on reoffending, also referred to as individual deterrence (Bell, Jaitman and Machin 2014) or specific deterrence by criminologists (Nagin 2013). Within this literature, one line of studies explores the effects of experiencing soft sanctions, like having police contact, being arrested and convicted in court for criminal offenses. Investigation of such effects necessarily requires individual-level panel data and an empirical approach, which deals with negative selection into arrests, prosecution and conviction. There is a large literature on this in criminology. Most existing criminological studies attempt to identify a causal link by controlling for observed individual characteristics (e.g. match individuals on self-reported delinquency). Such studies include classic labeling studies using self-report data and official records (e.g. Farrington 1977; Bernburg and Krohn 2003; Morris and Piquero 2013; Wiley, Slocum and Esbensen 2013; Liberman et al. 2014) and studies of the effects of formal sanctions on education (see e.g. De Li 1999; Tanner, Davies and O'Grady 1999; Bernburg and Krohn 2003; Sweeten 2006; Hjalmarsson 2008). The results of these studies are consistent with the hypothesis that public labeling increases deviant behavior among youth who are stopped or arrested by the police or processed in the criminal justice system. It is a challenge, of course, to properly handle selection in this context. One example of a criminological study applying more rigorous methods is Loeffler and Grundwald (2015) who investigate a reform in Illinois that raised the maximum age of juvenile court from 17 to 18 for offenders who commit a misdemeanor. Using a Difference-in-Difference approach with multiple control groups, they find little evidence of an effect. Finally, the systematic review by Petrosino, Turpin-Petrosino and Guckenburg (2010) examines 29 randomized controlled trials and quasi-experimental studies on the

effects of experiencing traditional juvenile system processing on future criminal behavior. The review finds no evidence that traditional juvenile system processing has crime control effects. In fact, juvenile system processing increased subsequent delinquency compared to diversion to programs, counselling, or doing ‘nothing’.

Within the second broad strand of literature on deterrence of juvenile crime, another line of studies investigates the effects of juvenile offenders experiencing tough sanctions, like juvenile incarceration. The criminological study by Loughran, Mulvey, Schubert Fagan, Piquero and Losoya (2009) estimates the effects of sentencing length for serious juvenile offenders and find null effect of institutional placement on future rearrest rates and self-reported crime. Studies applying methods that are more sophisticated also control for unobserved household fixed characteristics. Using this approach, Hjalmarsson (2008) finds that incarcerated juveniles have lower propensity to be reconvicted of crime. Besides unobserved heterogeneity, a second complicating factor in identifying the causal effect of juvenile incarceration is that effects for juveniles on the margin of juvenile incarceration may differ from the average juvenile, and the former group is most likely to be affected by policy changes (Aizer and Doyle 2015). One way to deal with this is to use a regression-discontinuity design exploiting sentencing rules to identify the impact of juvenile incarceration on recidivism as done by Hjalmarsson (2009a). The study finds that at the margins where the sanctioning becomes more severe, juveniles just above the threshold were found to be less likely to recidivate. Aizer and Doyle (2015) instead exploit exogenous variation in juvenile detention stemming from the random assignment of cases to judges who vary in their sentencing. With this strategy, they address the issue of negative selection into juvenile incarceration and estimate effects for those at the margin of incarceration where the judge assignment matters for the incarceration decision. Their findings suggest that juvenile incarceration reduces the probability of high school completion and increases the probability of adult incarceration.

Our study also adds to this small literature which exploits natural experiments like random assignment of judges with different sentencing practices (e.g. Aizer and Doyle 2015) or social experiments (e.g. Klein 1986) to estimate the effects of experiencing formal sanction on reoffending of juvenile offenders.

### 3. The minimum age of criminal responsibility and the reform

Denmark has no separate juvenile justice system. Juvenile offenders above the minimum age of criminal responsibility are sentenced by the same criminal law and in the same courts as adult offenders. Within this institutional setting, the minimum age of criminal responsibility is a significant threshold for young offenders, as it not only defines whether the individual's case is handled by the social authorities or in the criminal justice system, but also whether they obtain a criminal record.

In comparison to the many legal systems with separate juvenile justice courts (e.g. in Scotland, England, or states in the US), the Nordic countries have a higher minimum age-limit of criminal responsibility (today 15 in all countries) and typically process criminal cases concerning children under the age limit in the social service system. At the same time, it is the minimum age of criminal responsibility (and not the age of majority) that in Denmark demarcates the line for prosecution in the adult criminal justice system and for the receipt of a formal criminal record.

Processing of a juvenile suspect of a criminal offence differs significantly between offenders below and offenders above the minimum age of criminal responsibility. The local social authorities in Denmark handle cases with “as if charges” of a criminal offence *below* the minimum age of criminal responsibility. The police can investigate the criminal act and detain the offender (if the conditions of arrest are fulfilled), but the case is not presented before a judge and the offender is under normal circumstances not entitled to legal representation. A social worker, who must be present during any police interrogation, accompanies the offender and not a lawyer. Hence, it is solely up to the local social authorities to settle the case and decide upon the enactment of further measures described in the law of social services. Examples of consequences are participation in supervised activities, support to the family and in the most severe cases out-of-home-placement in foster care or in an institution,<sup>11</sup> see Kyvsgaard (2004).

Cases with juveniles *above* the minimum age of criminal responsibility are handled in the criminal justice system under the same rules of investigation, prosecution, and court ruling as cases with offenders over the majority age (eighteen). The types of sanctions are in most cases identical for adult and juvenile offenders and range from fines, charge withdrawal with conditions and community service to suspended and unsuspended prison sentences (Kyvsgaard 2004). The criminal law does

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<sup>11</sup> Juvenile offenders aged 10-17 who commit serious crimes are confined in the same highly secure institutions regardless of whether they are under or above the minimum age of criminal responsibility.

contain provisions to limit the severity of the sentencing of offenders aged 15 to 17 and some special sanctions and measures to be used in cases with juvenile offenders.<sup>12</sup> In the relative few cases when juvenile offenders are arrested, placed in custody, or sentenced to a prison term, they are typically confined in secure institutions or under special circumstances in separate units in the adult prison system (Clausen 2013).<sup>13</sup> Juvenile offenders above the minimum age of criminal responsibility who are found guilty also receive a criminal record. The timeframe for which convictions remain on a criminal record depends on the sentence type; records of fines and charge withdrawal with conditions are erased after 1 year,<sup>14</sup> suspended sentences after 3 years, and prison sentences after 5 years.

Criminal offenses committed by 14-year-olds during the reform period are most frequently property crimes (68 percent) such as shoplifting (26 percent), petty theft (9 percent), vandalism (9 percent) and burglary (7 percent). Other offense types are violence (13 percent), traffic-related crimes (9 percent) and weapon and drug offenses (6 percent). In 2011, 71 percent of the cases with conviction of a juvenile offender aged 14 led to a fine, 18 percent to a suspended sentence and 2 percent to a prison sentence (incl. youth sanctions) (Statistics Denmark, 2012). Therefore, our study of the impact of severity of sanctions on juvenile offending is dominated by softer crimes leading to softer sanctions, in particular fines.

The brief outline of the Danish criminal system shows significant differences in the sanctions of juvenile offenders below or above the minimum age of criminal responsibility. This is the feature of the criminal justice system that we exploit in this paper to investigate the impact of the severity of softer sanctions on young people's offending.

We exploit a reform of the criminal law changing the minimum age of criminal responsibility in Denmark. From 1930 to 2010, the minimum age of criminal responsibility was 15 in Denmark. As of July 1, 2010, the right-wing government changed the penal law and lowered the age of criminal

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<sup>12</sup> First, in the Danish legal system it is in general considered a mitigating circumstance that the offender is under eighteen at time of the offense. Second, if a juvenile offender is already subject to measures authorized by social legislation for children, charges can be withdrawn if he/she makes an unqualified confession. Third, offenders under the majority age cannot be sentenced a lifetime conviction (Storgaard 2013).

<sup>13</sup> On a given day, around 10 juvenile offenders above the minimum age of criminal responsibility serve in separate units in the adult prison system (Clausen, 2013).

<sup>14</sup> This category (fines and charge withdrawal with conditions) is the only one with a reduction in the duration of a criminal record to offenders under the age of 18; otherwise, the terms are the same as for adult offenders. In all cases, the police keep an official record of the criminal offenses for 10 years to be available under particular circumstances (<https://www.politi.dk>, accessed on March 13, 2017).

responsibility to 14. Within a timeframe of 20 months, however, the age limit was re-established at 15 by a new left-wing government as of March 1, 2012.

The government had set up a commission on juvenile crime who worked from December 2007 to September 2009 to suggest how to target and improve interventions to reduce juvenile crime. The commission explicitly recommended *not* reducing the minimum age of criminal responsibility.<sup>15</sup> However, on March 17, 2010, the government introduced a bill, which lowered the minimum age of criminal responsibility, and the bill was passed on June 1, 2010. The bill received a lot of attention in the news and in the public in terms of marches and happenings in the larger cities.<sup>16</sup>

Figure 1 documents the media attention on the policy change by plotting the number of newspaper articles mentioning the minimum age of criminal responsibility. The histogram shows that the attention was at a maximum in October 2009 immediately after the commission on juvenile crime published their final recommendations. The financing of the reform was part of the annual state budget negotiations (Storgaard 2013). This suggests that the general public was well aware of the changes taking place, and it also suggests that people may have anticipated a reduction in the age of criminal responsibility already 6-12 months before the bill was formally passed by Parliament. On the one hand, this figure supports the notion that juveniles knew of the policy change.<sup>17</sup> On the other hand, it also indicates that strategic retiming could have affected crime prior to the reform due to anticipation, and we investigate this in detail in our empirical analyses.

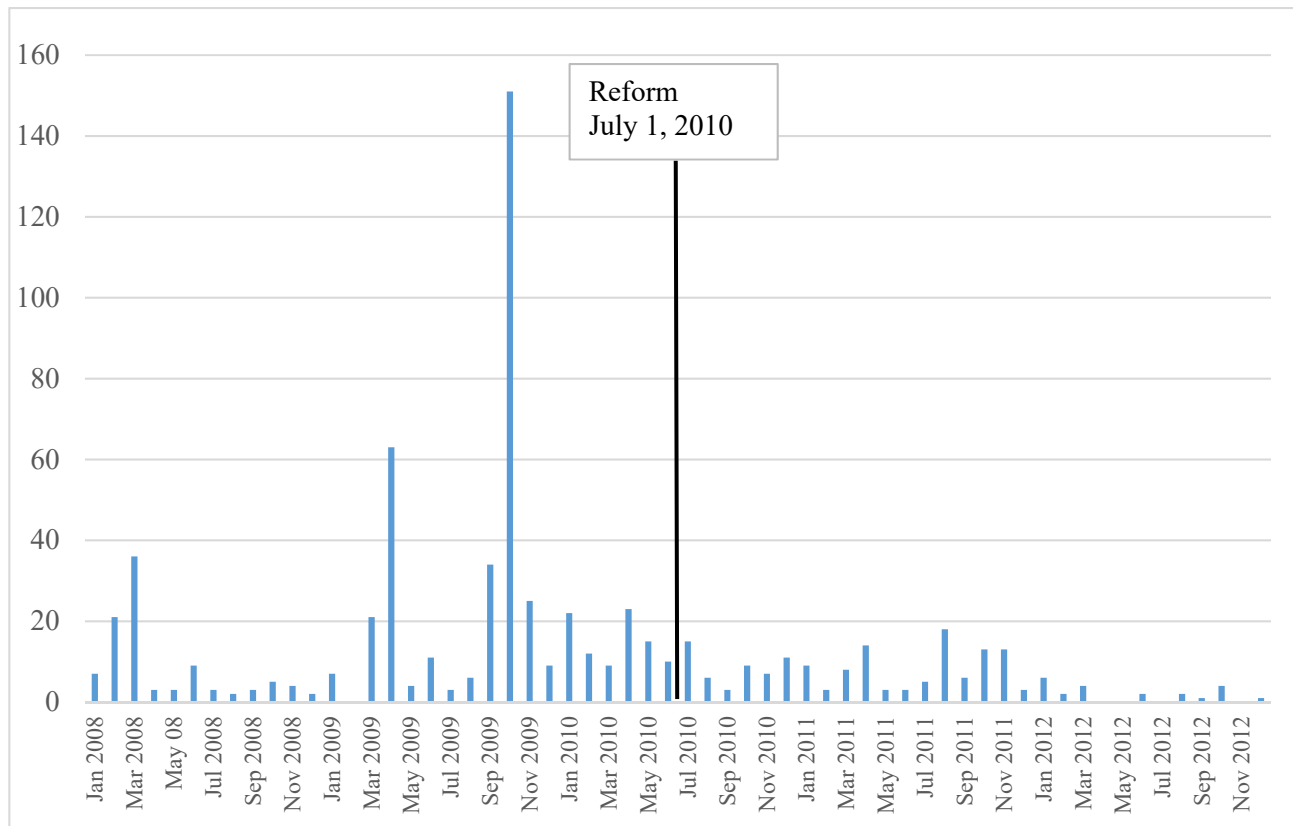
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<sup>15</sup> For details, see Danish Ministry of Justice (2009).

<sup>16</sup> The political attention also resulted in a descriptive evaluation of the reform by the Danish Ministry of Justice (2015).

<sup>17</sup> In case 13- and 14-year-olds or their parents do not follow the news, such information is also part of the school curriculum in social studies in 8<sup>th</sup> and 9<sup>th</sup> grade. Furthermore, all police districts have an interdisciplinary framework for prevention of juvenile crime involving the schools, the social services and the police (denoted SSP). This is a network of relevant authorities who collaborate with the purpose of preventing juvenile crime in the local area, e.g. by visiting schools. They are concerned with general, specific as well as individual-oriented policies and interventions.

Figure 1. Number of national newspaper articles about the minimum age of criminal responsibility, 2008-2012.



Notes: The figure shows number of articles in 17 Danish national newspapers mentioning the term “minimum age of criminal responsibility”, total number of articles is 694.

Data source: Constructed based on data from [Infomedia.dk/mediearkivet/](http://Infomedia.dk/mediearkivet/).

The policy reform constituted a natural experiment creating exogenous variation in the age limit for prosecution, conviction, and sanctions (including a criminal record) of young offenders in the Danish criminal justice system. The reform introduced a more severe punishment to a younger age group from one day to the next as the age of criminal responsibility was lowered to 14. We study this change in the risk of criminal justice involvement of juvenile offenders over time and investigate the potential deterrent effect of the policy reform: Does lowering the age-limit from 15 to 14 deter 14-year-olds from committing crimes?

A behavioral response relies on a general awareness of the change and a general understanding that the severity of the punishment increases when offenders cross the minimum age of criminal responsibility.

#### 4. Data

*Primary data sources and samples:* We extract our data from eight primary sources. Our key data set is The Central Police Register that records individual charges (date of charge, date of committing the offense, and type of offense) and convictions (date of conviction, verdict, and sentence) for the full Danish population as well as all contacts of individuals and firms with the police. We first merge the Central Police Register with the Population register containing individual demographic characteristics such as birth date, gender, current residence, parent identifiers, household composition, country of origin, and immigrant status (available 1980-2014). We next add a series of other registers: the Education Register and Surveys, which records educational attainment (1980-2014); the Lower Secondary School Grade register with information on grades obtained in the 9<sup>th</sup> grade (2002-2014), the income register (1980-2014); the occupation register (1980-2014); the medical birth register that includes information about birth outcomes (1980-2010); the Psychiatric Central Register that records ADHD diagnoses (1994-2010); and the Prescription Drug register (1997-2010). See Table A1 for detailed information and primary data sources for each variable.

From these sources, we extract data for seven Danish cohorts, namely the 1993-1999 birth cohorts, combine the information using unique personal identifiers, and compile it into a panel dataset with monthly records of reported crimes from November 1st 2008 to January 31st 2012. The dataset includes all children aged 13, 14, and 15 during this period. To ensure that we have available pre-reform information about background characteristics across all individuals, we restrict the sample to consist of individuals with Danish residence January 1st in the year they turn 10.<sup>18</sup> Table 1 lists the covariates included in the analyses (see Table A2 in the appendix for means and standard deviations of the covariates).

*Criminal offenses and crime outcomes:* In our analysis, we measure individual criminal activity based on charges for offenses against the criminal code, which are recorded in the charge registers from the minimum age of criminal responsibility.<sup>19</sup> Charges are usually a predecessor of a conviction, i.e. court rulings that the individual is guilty as charged.<sup>20</sup>

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<sup>18</sup> In principle, a small share of these individuals may have left the country after their 10<sup>th</sup> birthday. As long as this tendency is balanced with regards to exposure to the reform, our conclusions will be unaffected by emigration. It is, in theory, possible that the reform will lead to more emigration; the appropriate way to interpret our estimates, then, is as the total effect of the reform, including those effects stemming from out-migration.

<sup>19</sup> We observe all charges even after the criminal record has been deleted from the individual's file.

<sup>20</sup> For a random 10 percent sample of Danes born in 1980 followed until age 21, 28% of charges led to a conviction (Damm and Dustmann 2014). US studies on crime tend to measure individual crime by arrests. But arrests are uncommon

In addition to recording arrests, charges and convictions, the Danish Police records all contacts with individuals and firms. 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 person would have been charged with the offense, had the person reached the minimum age of criminal responsibility. The Danish Police is 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 the Drugs Act.<sup>21</sup> Moreover, the Police reports crime detection rates for violations of the Penal Code Act, Weapons Act or the Drugs Act on a quarterly basis as part of their quarterly publication of key statistics. To achieve a high crime detection rate, the Police has an incentive to find and register offenders of these laws, irrespective of whether the offenders are above or below the minimum age of criminal responsibility. By combining the central police registers on charges and "as if charges", we can measure criminal offenses throughout the entire childhood and youth for each individual.

In the Central Police Registers, charges and "as if charges" are categorized into offenses against the Penal Code Act (sexual assault, violent crime, crimes against property and other offenses against the penal code), offenses against the Traffic Act, offenses against the Drugs Act, offenses against the Weapons Act, and offenses against the Tax Acts or other special acts. Throughout our analyses, we restrict the outcomes to offenses of the Penal Code Act. We plot the number of offenses for each birth cohort in our sample in Figure A1. In our analysis we compare criminal behavior of children aged 14 before and after the policy reform because the policy reform of interest targeted this age group. We use two measures of criminal behavior of children aged 14: an indicator for at least one "as if charge" or charge of the penal code in a given month and an indicator for recidivism defined as re-offending after first penal code "as if charge" or charge at age 14.

*Educational outcomes:* We study a series of educational outcomes before age 17 including the propensity to be enrolled in a regular 9<sup>th</sup> grade as opposed to special schools or boarding schools; the propensity to participate in the 9<sup>th</sup> grade exam; and exam grades (standardized at the cohort level; mean zero and standard deviation of one). We distinguish between exam grades in language arts and math.

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in Denmark. According to the Danish "Law on Administration of Justice" (Retsplejeloven. Article 755, part 1), the police can arrest a person whom they have reason to suspect guilty of a criminal offence subject to public prosecution, but only if an arrest is regarded as necessary in order to prevent further criminal offenses, ensure the subject's presence for the time being or to prevent his communication with other people. Further, an arrest should not be made if imprisonment would be a disproportionate measure in regard of the nature of the offence or other circumstances.

<sup>21</sup> BEK nr. 881 af 04/07/2014.



Our analyses control for child background variables, child criminal history from age 10 to 13, and parental background variables at age 9. See Table 1 for details.

**Table 1. List of covariates from official administrative register data**

<i>Child background</i>	Gender, age, ethnicity, birth weight, premature birth, ADHD (diagnosis and use of prescription ADHD drugs) before age 9, use of other psychotropic drugs before age 9.
<i>Child crime history (age 10-13)</i>	Age of criminal onset, number of prior offenses, type of prior offenses.
<i>Family background (child age 9)</i>	Family structure (nuclear family, parent with new partner, single parent, not living with parents), education level mother/father, income mother/father, labor market position mother/father, convicted of criminal offense mother/father, suspended or unsuspended prison sentence mother/father, police district based on residence.

## 5. General deterrence effects of the minimum age of criminal responsibility

The first goal of this paper is to estimate the effect of being above the minimum age of criminal responsibility on the probability of committing crime. In doing so, we exploit the July 1, 2010 policy reform that lowered the age of criminal responsibility from 15 to 14. Observations exposed to the reform are individual-month observations for children who i) turned 14 in the months after the introduction of the reform (post-reform sample) or ii) turned 14 up to 11 months before the reform and, therefore experienced part of their 14<sup>th</sup> year after the reform (pre-/post reform sample), using only their monthly observations *after* the reform. Observations *not* exposed to the reform include children who i) experienced their entire 14<sup>th</sup> year in the months prior to the reform (post-reform sample) and ii) children who had turned 14 prior up to 11 months before to the reform, using their monthly observations *before* the reform (pre-/post reform sample). Since the reform was in place for 20 months, we use a bandwidth of 20 months around each side of the reform date.<sup>22</sup>

<sup>22</sup> Alternatively, one could have analyzed the effects of turning 14, using data after the introduction of the reform only, which would be similar to the approach used in studies exploiting the laws that govern the age of majority (e.g. Hjalmarsson 2009b; Levitt 1998). We prefer our strategy to this because the specific policy reform constituted a rather salient change, the exact date of which could not be anticipated. Individuals can easily foresee their own birthday and adjust their behavior in a period before the actual event. In addition, other things could change with birthday too. Figure A2, however, shows descriptive evidence that turning 14 does not affect crime rates, neither before nor after the introduction of the reform.

Our empirical specification is the following:

$$y_{jt} = f(\text{Reform\_dist}_{jt}) + \alpha \text{Reform}_{jt} + \mathbf{X}_{jt}\boldsymbol{\beta}_1 + \mathbf{Z}_j\boldsymbol{\beta}_2 + u_{jt} \quad (1)$$

where  $y_{jt}$  is an outcome indicating whether child  $j$  is charged with at least one penal code offense in month  $t$ ;  $\text{Reform}_{jt}$  is an indicator of whether the reform is in place for child  $j$  in month  $t$ ;  $f(\cdot)$  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);<sup>23</sup>  $\mathbf{X}_{jt}$  consists of age (measured in months) using a linear specification or indicators (to control for the crime-age relationship) and calendar month indicators (to control for seasonal variation in juvenile crime), whereas  $\mathbf{Z}_j$  consists of variables measured at a fixed point in time (child age 9): child characteristics and parental background controls and 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).  $u_{jt}$  is an unobserved error term.  $\alpha$  is the parameter of interest; it measures the effect of the introduction of formal sanctions for crime committed by 14-year-old children.

Our primary sample consists of the population 14-year-olds in a window starting from 20 months prior to the policy reform and ending 20 months after the introduction of the reform. We also investigate potential spillovers of the reform to 13-year-olds using a similar observation window and perform a placebo analysis using the sample of 15-year-olds.

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). In the empirical analyses, we investigate potential violation of this assumption by studying crime rates of 13- and 15-year-olds around the reform. It also implies that the police must not change their policing or reporting strategies from one day to the next because of the reform.

We check this assumption by looking at the distribution of reported crime across ages and across types of penal code offenses before and after the reform. To further investigate this issue and perform a first, descriptive, investigation of the impact of the reform, in Figure 2 we plot the distribution of

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<sup>23</sup> Our results are robust to using higher-order polynomials.

monthly crime rates of 13-, 14- and 15-year-olds around the time of the introduction of the reform. The monthly crime rate is defined as the number of individuals with a least one (as if) charge of the Penal Code Act per individual in the age group. Over the reform period, we see a tendency for crime rates to go down for all age groups, in line with international trends, but also an uptake in crime with age. Crime rates increase over the summer following the reform but higher crime rates over the summer is a general tendency present in all years (and for all age groups) and illustrates why our formal analyses must account for calendar months. Importantly, we see no tendency for bunching of crime of 14-year-olds just prior to the introduction of the reform; this would have indicated strategic retiming of crime. This picture is also confirmed when we look at the reported offending rates in the months around the 14th birthday for juveniles affected by the reform in Figure A2.

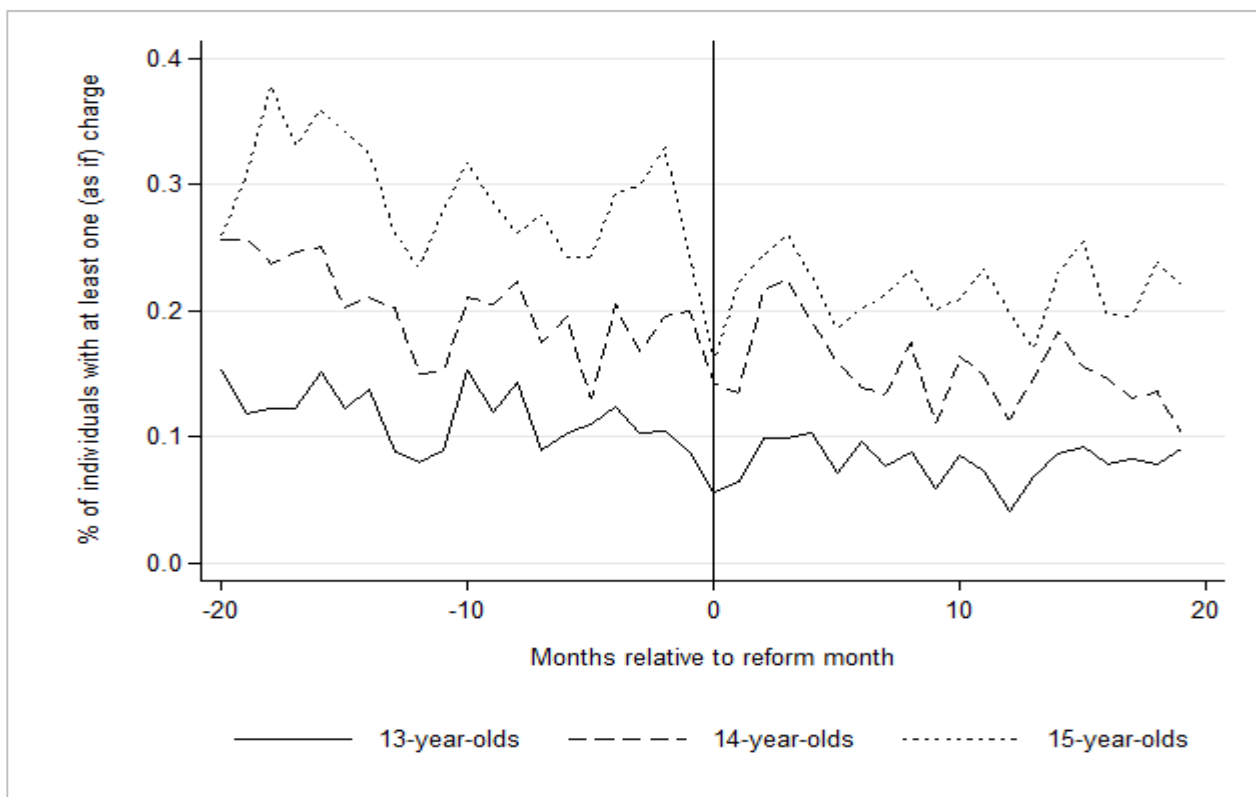
Another way to gauge the validity of the design is to look for discontinuities in observable characteristics. We do this by comparing observable background characteristics of the sample of 14-year-olds on either side of the introduction of the reform. As expected and shown in Table A3 and Figure A3, we find no evidence of any economically significant differences. Furthermore, when we look at the age-crime-curves for our estimation samples in Figure A1 there are no signs of the official reporting of offenses changing with the minimum age of criminal responsibility (or the reform).

Table 2 shows the results from our formal analyses with gradually richer conditioning sets. All models control for distance in time to the reform. We present the results for six different specifications. Each specification contains more controls than the previous specification. Standard errors are clustered at the individual level. Our preferred specification VI shows a small positive coefficient, corresponding to 10% increase in the crime rate among 14-year-olds in July 2010. Yet the estimated effect is miniscule and not significant at conventional levels. The findings suggest that there are no general deterrent effect of lowering the minimum age of criminal responsibility. We can in fact rule out general deterrent effects as small as -0.00012 (corresponding to less than 10% of the crime rate in the relevant age group).

We have performed a range of robustness checks (see Table A4). Our baseline result for the preferred specification is repeated at the top of the table (bandwidth July 1, 2010 +/-20 months) and robustness checks follow in subsequent rows. The first set of checks are standard for the regression discontinuity design: including an indicator variable for the cut-off month, including polynomials of the assignment variable, extending and reducing bandwidth and employing a ‘donut hole’ strategy where June-August are excluded from the analyses. In addition, we test whether our results are robust to inclusion

of observations for children who turn 14 after the minimum age of criminal responsibility was re-established at 15 (reform implemented 1<sup>st</sup> of March, 2012). Results are robust to these specification changes. The second set of checks study potential announcement effects. First, we exclude individuals turning 14 years between the announcement of the reform and the actual implementation of the reform, and then we investigate whether the real response happened already when the media debate took off on October 1<sup>st</sup>, 2009 (see Figure 1). We find no evidence that youths react to these announcements.

**Figure 2. Monthly prevalence rates for reported (as if) charges of penal code offenses for 13-, 14- and 15-year-olds**



Data source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993-1999.

Note: The 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 in Denmark 20 months (March 2008) pre reform of the minimum age of criminal responsibility in Denmark (July 2010) to 19 months post reform (February 2012).

We proceed to investigate whether the reform had spillover effects on 13-year-olds, using the same set of model specifications. Table 3 presents our results. We find no evidence that the reform had any impact on the group of younger children. We similarly study 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 crime rates of 15-year-olds changed because of the reform.

The upper panel of Table 4 next investigates whether effects vary by subgroups. 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 for individuals who committed crime prior to age 14, which point towards effects on recidivism. The lower panel of Table 4 distinguishes between different types of penal code offenses, and reveals no significant effects.

As a final robustness analyses, we perform simpler OLS regressions where we pool information for each individual into one single outcome (any offense/more than one offense before/at a given age). Results are shown in Table A5 and support the finding reported in Table 2 that there is no general deterrent effect of the reform on crime committed up until age 15. However, at the bottom of the table, we see that individuals exposed to the reform (when they were 14 years old) have significant *higher* probability of a penal code offense at age 15. Table A6 reveals that this effect is also significant when we single out individuals without prior offenses by age 14. We interpret this as a potential indication of higher rates of reoffending among 14-year old offenders whose criminal cases were handled by the criminal justice system rather than the social authorities due to the reform.<sup>24</sup> We investigate recidivism in detail in the next section of the paper.

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<sup>24</sup> This is consistent with the small positive (though insignificant) point estimate of the reform effect in Table 2.

**Table 2. Effects of the reform on monthly reported offending rates (penal code offenses), population: 14-year-olds**

	I	II	III	IV	V	VI
Reform effects: July 2010 - February 2012	-0.00012 (0.00013)	0.00003 (0.00013)	0.00003 (0.00013)	0.00017 (0.00015)	0.00018 (0.00015)	0.00017 (0.00015)
Number of months prior the reform (20-1, otherwise 0)	0.00001 (0.00001)	0.00002* (0.00001)	0.00002* (0.00001)	0.00003** (0.00001)	0.00002** (0.00001)	0.00002** (0.00001)
Number of months during the reform (1-19, otherwise 0)	-0.00001 (0.00001)	-0.00002** (0.00001)	-0.00002* (0.00001)	-0.00003** (0.00001)	-0.00002* (0.00001)	-0.00002* (0.00001)
Controls:						
Age month specification	No	Linear	Dummies	Dummies	Dummies	Dummies
Calendar month dummies	No	No	No	Yes	Yes	Yes
Child background	No	No	No	No	Yes	Yes
Parents background	No	No	No	No	Yes	Yes
Child crime history	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

Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.

Note: The 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 from November 2008 to February 2012. The 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, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Control variables: number of months relative to reform, age, calendar month, gender, ethnicity, birth weight, parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), child ADHD diagnosis, child using prescriptive drugs, child and parents' criminal history, police district.

**Table 3. Effects of the reform on monthly reported offending rates (penal code offenses), population: 13- and 15-year-olds**

	I	II	III	IV	V	VI
13-year-olds: reform effects	-0.00036*** (0.00009)	-0.00019** (0.00009)	-0.00019** (0.00009)	-0.00014 (0.00011)	-0.00010 (0.00011)	-0.00010 (0.00011)
Observations	1,903,320	1,903,320	1,903,320	1,903,320	1,903,320	1,903,320
Individuals	158,610	158,610	158,610	158,610	158,610	158,610
15-year-olds: reform effects	-0.00053*** (0.00015)	-0.00043*** (0.00016)	-0.00043*** (0.00016)	-0.00024 (0.00018)	-0.00023 (0.00018)	-0.00023 (0.00018)
Observations	1,972,224	1,972,224	1,972,224	1,972,224	1,972,224	1,972,224
Individuals	164,352	164,352	164,352	164,352	164,352	164,352
Controls:						
Age month specification	No	Linear	Dummies	Dummies	Dummies	Dummies
Calendar month dummies	No	No	No	Yes	Yes	Yes
Child background	No	No	No	No	Yes	Yes
Parents background	No	No	No	No	Yes	Yes
Child crime history	No	No	No	No	Yes	Yes
Police district fixed effects	No	No	No	No	No	Yes

Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.

Note: The upper part of this table shows results from analyses of spill-over effects of the reform to 13-year-olds and the lower part shows results from placebo test of reform effects to 15-year-olds. The estimates are coefficients from linear panel models on the probability of an (as if) charge in a given month for the population of 13- or 15-year-olds from November 2008 to February 2012. Each column represents a gradually richer conditioning set. Standard errors are clustered at the individual level and reported in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Control variables: number of months relative to reform, age, calendar month, gender, ethnicity, birth weight, parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), child ADHD diagnosis, child using prescriptive drugs, child and parents' criminal history, police district.

**Table 4. Robustness analyses on monthly reported offending rates (penal code offenses), population: 14-year-olds**

	I	II	III	IV	V	VI
<i>Baseline result: reform effects to 14-year-olds (obs.= 1,955,508)</i>	-0.00012 (0.00013)	0.00003 (0.00013)	0.00003 (0.00013)	0.00017 (0.00015)	0.00018 (0.00015)	0.00017 (0.00015)
<i>Different subpopulations:</i>						
Boys (obs.=1,004,484)	-0.00005 (0.00021)	0.00017 (0.00021)	0.00017 (0.00021)	0.00025 (0.00024)	0.00021 (0.00024)	0.00021 (0.00024)
Girls (obs.=951,024)	-0.00018 (0.00015)	-0.00011 (0.00015)	-0.00011 (0.00015)	0.00009 (0.00016)	0.00013 (0.00016)	0.00013 (0.00016)
Without prior offenses by age 14 (obs.=1,935,828)	-0.00021* (0.00012)	-0.00009 (0.00012)	-0.00009 (0.00012)	0.00004 (0.00013)	0.00008 (0.00014)	0.00006 (0.00015)
With prior offenses by age 14 (obs.=19,680)	0.00878* (0.00527)	0.01009* (0.00522)	0.01016* (0.00524)	0.01137* (0.00608)	0.00962 (0.00614)	0.01157* (0.00662)
<i>Different outcomes (subcategories of penal code offenses):</i>						
Violent offense (obs.= 1,955,508)	-0.00003 (0.00005)	0.00002 (0.00005)	0.00002 (0.00005)	0.00008 (0.00006)	0.00007 (0.00006)	0.00007 (0.00006)
Burglary (obs.= 1,955,508)	-0.00004 (0.00004)	-0.00002 (0.00004)	-0.00002 (0.00004)	-0.00001 (0.00004)	0.00000 (0.00004)	0.00000 (0.00004)
Shoplifting (obs.= 1,955,508)	-0.00008 (0.00007)	-0.00004 (0.00007)	-0.00004 (0.00007)	0.00005 (0.00008)	0.00004 (0.00008)	0.00004 (0.00008)
Theft of vehicles (obs.= 1,955,508)	0.00000 (0.00005)	0.00003 (0.00005)	0.00003 (0.00005)	0.00001 (0.00005)	0.00001 (0.00005)	0.00001 (0.00005)
Vandalism (obs.= 1,955,508)	-0.00006 (0.00004)	-0.00004 (0.00004)	-0.00004 (0.00004)	-0.00005 (0.00005)	-0.00006 (0.00005)	-0.00006 (0.00005)
<i>Controls:</i>						
Age month specification	No	Linear	Dummies	Dummies	Dummies	Dummies
Calendar month dummies	No	No	No	Yes	Yes	Yes
Child background	No	No	No	No	Yes	Yes
Parents background	No	No	No	No	Yes	Yes
Child crime history	No	No	No	No	Yes	Yes
Police district fixed effects	No	No	No	No	No	Yes

Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.



Note: The table shows result from robustness analyses including reform effects to different subpopulations of 14-year-olds and different outcomes (selected subcategories of penal code offenses). The reported estimates are coefficients from linear panel models on the probability of an (as if) charge in a given month from November 2008 to January 2012 and each column represents a gradually richer conditioning set. Standard errors are clustered at the individual level and reported in parentheses, <sup>\*</sup>  $p < 0.10$ , <sup>\*\*</sup>  $p < 0.05$ , <sup>\*\*\*</sup>  $p < 0.01$ . Control variables: number of months relative to reform, age, calendar month, gender, ethnicity, birth weight, parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), child ADHD diagnosis, child using prescriptive drugs, child and parents' criminal history, police district.

## 6. Effects on recidivism: Individual deterrence?

The analysis above showed little effects of the reform on general deterrence. Yet if anything, there was actually a slight increase in crime rates. That new offenders drive these results would be against theoretical predictions since the reform uniformly increased the costs of committing crime. It may be, however, that the observed slight increase in crime rates among the 14-year-olds is due to higher reoffending rates. We therefore investigate whether the reform lowering the age limit for processing juveniles in the Danish criminal justice system affects young offenders' recidivism.

In theory, reform effects on recidivism may be either negative or positive.<sup>25</sup> Interactions with the criminal justice system at an earlier age may affect subsequent offending if such interactions change the offender's perception of the costs and benefits of crime (Becker 1968; Nagin, Cullen, and Jonson 2009). These experiences may influence either the expected probability of apprehension or the expected severity of punishments and thereby deter young people from committing criminal offenses.<sup>26</sup> Labeling theories in criminology argue that involvement with the criminal justice system can have a negative influence on offenders' future outcomes. First, interactions with the official system leading to public labeling of the young offender as deviant can cause him/her to change self-perception that in turn raise the likelihood of engaging in deviant behaviors (Lemert 1951). Second, institutions' responses to the official label may reduce offenders' opportunities in both the education system and labor market and thereby increase the risk of delinquency (Paternoster and Iovanni 1989; Sampson and Laub 1997). Third, the labeling of an offender can influence peer interactions by enhancing the risk of social exclusion from conventional groups and increasing contact with deviant groups (Lemert 1951). All three mechanisms imply that juveniles' involvement with the legal system is likely to increase the likelihood of subsequent criminal behavior. The net effect of juveniles' interactions with the criminal justice system on subsequent crime may be either negative or positive depending on which mechanisms dominate.

For this analysis, we select the 14-year-olds who were (as if) charged for a violation of the penal code at age 14, and estimate OLS regressions of reoffending 3, 6, 9, 12, 15 and 18 months after the first offense. We estimate the following regression equation:

$$y_j = \alpha Reform_j + X_j\beta + u_j \quad (2)$$

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<sup>25</sup> In criminology, the negative effect is denoted "specific deterrence", whereas the positive effect is denoted "labeling".

<sup>26</sup> Hjalmarsson (2009b) found evidence of changes in the perceived severity of punishment related to the age of majority, but not for offenders who had been arrested prior to reaching the age limit.

where  $y_j$  is the relevant outcome (indicators for whether child  $j$  is charged with a new penal code offense within 3, 6, 9, 12, 15, or 18 months along with educational outcomes).  $Reform_j$  is an indicator for whether the first offense of child  $j$  took place pre- or post-reform and thus whether the sanction was determined in the social service system or in the criminal justice system;  $X_j$  is a list of control variables: calendar month of first offense, offense age and type, child and family background variables, and police district fixed effects. Again,  $\alpha$  is the parameter of interest. Here,  $\alpha$  measures the effect of committing crime under the new, stricter regime on subsequent crime and educational outcomes. Standard errors are robust and clustered at the police district level. As a robustness check, we estimate simple Cox Proportional Hazard models of the time to next penal code offense. As an additional outcome, we also study educational achievement before age 17 measured by: school enrollment, exam participation, grades in language arts and math and school type.

Our estimation sample consists of the population of 14-year-olds (as if) charged with a penal code offense, who turned 14 twenty to thirteen months prior to the policy reform and who turned 14 in the first eight months after the introduction of the reform. In other words, we compare 14-year-old offenders who have their 14th year just prior to the reform with 14-year-old offenders who have their 14th year during the reform period. We restrict the sample to offenders with an (as if) charge of the penal code. For one, these are the offenses with potential detrimental effects on future outcomes because they result in a criminal record if the offender is found guilty. Second, we found no general deterrent effects in terms of reduction of such offenses and this limits the risk of selection bias. We compare observable background characteristics of the sample of 14-year-old offenders who were (as if) charged on either side of the reform. Table A7 shows only a few significant differences. However, they few significant differences suggest that the post-reform group is slightly negatively selected in terms of criminal history of parents, educational attainment of the mother and use of ADHD medicine. In view of the downward trend in crime over the observation period seen in Figures 2 and A1, this is not a surprising finding. We include a rich set of control variables in Eq. 2 to take account of potential selection between the pre- and post-reform group..

Table 5 shows recidivism rates at varying points in time after the first offense at age 14 and compares offenders pre-reform who had their criminal case handled by the social authorities and offenders post-reform who had their criminal case processed in the criminal justice system. There is a clear tendency that 14-year-olds affected by the reform recidivates faster than 14-year-olds who committed their

offense prior to the reform. The post-reform offenders have five-percentage points higher recidivism rates after 12 to 18 months.

**Table 5. Recidivism rates (penal code offenses) 14-year-old penal code offenders**

	Pre-reform (obs.=893)	Post-reform (obs.=676)	Difference and t-test
Recidivism after:			
3 months	0.17	0.18	0.01
6 months	0.22	0.24	0.02
9 months	0.26	0.29	0.04
12 months	0.29	0.34	0.05*
15 months	0.32	0.38	0.05*
18 months	0.36	0.41	0.05*

Data source: Administrative register data from Statistics Denmark and Police records for 14-year-old penal code offenders.

Note: The table shows recidivism rates for 14-year-old penal code offenders with their 14<sup>th</sup> year pre- or post-reform and the last column shows the difference between the two groups and t-test of difference in means \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Table 6 shows the formal results. Specification I mirrors the difference in the raw means seen in Table 5, whereas specifications II to IV gradually include a richer conditioning set. When all control variables are added in our preferred specification IV, we find that the probability of reoffending is around 4-percentage point higher for post-reform offenders compared to pre-reform offenders, and this gap is statistically significant 9 to 18 months after the first offense. This gap corresponds to 10 percent higher recidivism after 18 months for post-reform offenders. These results are robust to using the Cox Proportional Hazard model (see Table A8 in Appendix).

The results show that interaction with the criminal justice system at 14 *increases* reoffending. There are no individual deterrent effects of offenders experiencing formal sanctions in the criminal justice system when compared to having the case handled in the social system. Two potential explanations of these effects are, on one hand, that the perceived costs of crime are reduced (or benefits increased) after first interaction with the criminal justice system. In that, the offender experiences softer sanctions than he expected. On the other hand, an explanation may be that the official sanctions create a labeling effect by which the offenders experience social exclusion and/or institutional responses to the public label that enhance subsequent offending.

As mentioned earlier, there is a downward trend in juvenile crime over the relevant period (see Figure 2). Therefore, one concern may be whether a similar trend influences recidivism. In Table A9, we estimate the time (or cohort) trend in recidivism based on our pre-reform sample of 14-year-old offenders. We run OLS regressions of recidivism 3 to 18 months after the first offense on a linear birth month variable. The trend estimates are small in magnitude and not statistically significant.<sup>27</sup> However, the point estimates in specification I are negative and may suggest a weak downwards trend in recidivism, which could contaminate the estimated reform effect, which is not separately identified from other time or cohort influences. In Table A10, we re-estimate the coefficients in Table 6 including the time (or cohort) trend as a control variable, allowing this trend to counteract the effect of the reform. In this case, the parameters of main interest are roughly three times larger, although all the trend estimates are insignificant. Hence, we regard our main results in Table 6 as conservative estimates of the impact of processing 14-year-old offenders in the criminal justice system.

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<sup>27</sup> This is consistent with the conclusions by Danish Ministry of Justice (2014, 2016).

**Table 6. Effects of reform on recidivism (penal code offenses), population: 14-year-old penal code offenders**

	I	II	III	IV
Effects of reform on recidivism 3 months	0.0121 (0.0239)	0.0228 (0.0219)	0.0198 (0.0292)	0.0204 (0.0286)
Effects of reform on recidivism 6 months	0.0224 (0.0208)	0.0336* (0.0182)	0.0300 (0.0207)	0.0305 (0.0206)
Effects of reform on recidivism 9 months	0.0391** (0.0172)	0.0495*** (0.0161)	0.0365** (0.0165)	0.0377** (0.0164)
Effects of reform on recidivism 12 months	0.0535** (0.0192)	0.0673*** (0.0183)	0.0450*** (0.0132)	0.0471*** (0.0125)
Effects of reform on recidivism 15 months	0.0525** (0.0213)	0.0663*** (0.0199)	0.0414** (0.0158)	0.0428** (0.0148)
Effects of reform on recidivism 18 months	0.0507** (0.0215)	0.0650*** (0.0208)	0.0375** (0.0131)	0.0388*** (0.0122)
Controls:				
Calendar month dummies	No	Yes	Yes	Yes
Offense age and type	No	Yes	Yes	Yes
Child background variables	No	No	Yes	Yes
Family background variables	No	No	Yes	Yes
Police district fixed effects	No	No	No	Yes
Observations	1,569	1,569	1,569	1,569

Data source: Administrative register data from Statistics Denmark and Police records for 14-year-old penal code offenders pre- and post-reform.

Note: The reported estimates are coefficients from OLS regressions, rows represent separate regression models on the probability of recidivism at 3, 6, 9, 12, 15 and 18 months and each column represents a gradually richer conditioning set. Robust standard errors are clustered at police district and reported in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Control variables: offense month, offense age, type of the offense, child gender, ethnicity, birth weight, child ADHD diagnose, child using prescriptive drugs, child's criminal history (age 10-13), parents' income, occupation and education, family type, parents' criminal history, police district.

We perform a range of heterogeneity analyses, all reported in Table A11: We study effects on 14-year-old offenders with all types of offenses, divide the sample by gender and by prior reported offenses, exclude violent offenders and offenders who commit vandalism. Overall, the results from the robustness analyses are very similar to the reported findings. The background to and findings of two of these robustness checks are relevant to highlight. First, violent offenses are among the most severe criminal charges and could lead to an unsuspended prison sentence or to placement in a secured

institution. Hence, because juveniles who commit a criminal offense while being *under* the age of criminal responsibility have their case handled by the social authorities, the offenders with the most serious crimes (334 individuals in our sample) risk placement in secured institution with no upper time limit. To ensure that this potential incapacitation effect does not influence our results we run an analysis where the population is restricted to juveniles with non-violent offenses. The results are very similar to the results reported in Table 6. Second, we distinguish between different sub-groups defined by prior offenses. The effect size is negative and insignificant for individuals who have a criminal history already at ages 10-13. This is consistent with Hjalmarsson (2009b) who found evidence of changes in the perceived severity of punishment related to the age of majority, but not for offenders who had been arrested prior to reaching the age-limit.

The above analysis suggests that exposure to the formal criminal justice system increases recidivism, which could indicate some type of labeling effect. The next step is to explore to what extent these detrimental effects of the reform are also seen for educational outcomes. Table 7 shows that 14-year-old offenders charged in the criminal justice system are less likely to be enrolled in 9<sup>th</sup> grade, less likely to be enrolled in the ordinary lower secondary school (in 9<sup>th</sup> grade) and more likely to attend boarding schools when compared to 14-year-old offenders who committed their offense prior to the reform. Furthermore, offenders affected by the reform have lower grades conditional on participating in the 9<sup>th</sup> grade exit exam (participation rates are not statistically significantly different). Hence, the results show both higher recidivism rates and poorer educational outcomes for 14-year-old offenders charged in the criminal justice system during the reform period.

Recidivism within 18 months and educational achievement before age 17 are closely related, but it is not possible to disentangle the causal chain in this study. Instead, we present raw means of educational outcomes separately for 14-year-old offenders with and without recidivism within 18 months in order to get a sense of the mechanisms, at least descriptively (see Table A12). Unsurprisingly, individuals who recidivate generally have much poorer educational outcomes than those who do not recidivate. In addition, the group of recidivists affected by the reform are seven percentage points less likely to be enrolled in 9<sup>th</sup> grade. This suggests that - although the initial crime and subsequent sanction most often was relatively soft - the fact that the case was processed in the criminal justice system means that they are more likely to enter an unfortunate life course. On the other hand, the group of 14-year-old offenders who did not recidivate are equally likely to be enrolled in 9<sup>th</sup> grade, no matter whether the offense was committed before or after the reform. Instead, the type of school is different;

individuals who are affected by the reform are seven percentage points less likely to be enrolled in ordinary secondary school and correspondingly more likely to attend boarding schools. This suggests that some offenders are moved to another school environment with different codes of conduct, other adults and peers, and this may explain why no further offenses are registered within 18 months. However, these individuals do have lower grades (conditional on participating) compared to their counterparts before the reform.



**Table 7. Effects of reform on educational achievement, population: 14-year-old penal code offenders**

	I	II	III	IV	Observations
<i>Outcome</i>					
Enrolled in 9th grade	-0.0448*** (0.0153)	-0.0514*** (0.0155)	-0.0481*** (0.0172)	-0.0470*** (0.0170)	1,569
Exam participation (0/1)	0.0109 (0.0232)	0.0034 (0.0232)	0.0216 (0.0244)	0.0223 (0.0245)	1,569
<i>Type of school (if enrolled 9<sup>th</sup> grade):</i>					
Ordinary lower secondary schools	-0.0408 (0.0258)	-0.0452* (0.0261)	-0.0379 (0.0285)	-0.0388 (0.0284)	1,421
Boarding schools	0.0428** (0.0179)	0.0402** (0.0178)	0.0457** (0.0198)	0.0478** (0.0197)	1,421
Schools for children with special needs	0.0075 (0.0122)	0.0084 (0.0125)	0.0030 (0.0133)	0.0014 (0.0134)	1,421
<i>Grades (conditional on participation):</i>					
Language Arts (teacher assessment)	-0.0579 (0.0491)	-0.0651 (0.0484)	-0.0353 (0.0487)	-0.0366 (0.0493)	1,016
Language Arts (exit exam)	-0.1270*** (0.0424)	-0.1396*** (0.0424)	-0.1015** (0.0422)	-0.1017** (0.0425)	1,021
Math (teacher assessment)	-0.0512 (0.0536)	-0.0597 (0.0541)	-0.0211 (0.0541)	-0.0117 (0.0544)	1,008
Math (exit exam)	-0.1032** (0.0520)	-0.1045** (0.0528)	-0.0561 (0.0540)	-0.0581 (0.0540)	996
<i>Controls:</i>					
Calendar month dummies	No	Yes	Yes	No	
Offense age and type	No	Yes	Yes	No	
Child background variables	No	No	Yes	No	
Family background variables	No	No	Yes	No	
Police district fixed effects	No	No	No	Yes	

Data source: Administrative register data from Statistics Denmark and Police records for 14- year-old penal code offenders pre- and post-reform.

Note: The reported estimates are coefficients from OLS regressions, rows represent separate regression models with different educational outcomes (conditional on enrolment/participation) before age of 17 and each column represents a gradually richer conditioning set. Robust standard errors are reported in parentheses and \* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01. Control variables: offense month, offense age, type of the offense, child gender, ethnicity, child's birth weight, child ADHD diagnosis, child using prescriptive drugs, child's criminal history (ages 10-13), parents' income, occupation and education, family type, parents' criminal history, police district.

## 7. Conclusion and discussions

This study uses Danish administrative data to estimate the consequences of lowering the minimum age of criminal responsibility on crime rates. We also investigate effects on recidivism and educational outcomes. To do this, we exploit a reform in Denmark that lowered the minimum age of criminal responsibility from 15 to 14. Much against the political intentions, we find no evidence that the reform lowered crime rates. If anything, we detect a small uptick in crime among 14-year-olds after the implementation of the reform. We also see that youth who committed crime during the reform period and processed in the criminal justice system were more likely to recidivate at any given point in time just as they experienced worse schooling outcomes than 14-year-old offenders processed in the social system did.

The findings from the study suggest that the Danish policy reform that introduced more severe punishments by lowering the age-limit of criminal responsibility did not have the intended deterrent effects on criminal behaviors among 14-year-olds. These results from analyses of juveniles at the fringes of the criminal justice systems coincides with the findings from previous studies of age-limits within the criminal justice system where “[the] literature around the age of criminal majority produces little evidence of deterrence among young offenders.”(Chalfin and McCrary, 2017:30).

Several theoretical explanations prevail for why this policy did not reduce crime rates among juveniles. First, preconditions are that the change in the criminal law was known to the population of 14-year-olds and that this awareness of the reform increased their perception of the severity of the punishments for criminal behavior. We show that the reform of the minimum age of criminal responsibility was widely debated in the mass media; however, we cannot be sure that the information about the reform and its consequences also reached the 14-year-olds at that time. Moreover, the prevalence rates among 14-year-olds are low and therefore only few individuals in the cohorts have experience with the consequences of the reform, either directly or indirectly (e.g. through friends or classmates punished in the criminal justice system) (Stafford and Warr 1998). It is possible that legal reforms like ours actually affect the perceptions of the severity of the expected punishment more among law-abiding juveniles who would not have committed criminal acts in the first place. Second, the police must have enforced the new law so that the perceived certainty of the punishment (e.g. risk of apprehension or sanctions) was not at the same time reduced. We find no indications of the Danish police changing their enforcements of the criminal law for example by being more reluctant to book 14-year-olds during the reform. Third, the perceived severity of the punishments is only one element

in the decision making, so even though potential offenders are aware of the reform they may decide to engage in crime anyway if the expected benefits (e.g. money, thrills or peer approval) exceed the expected costs.

The results from the analyses of recidivism show that penal code offenders who were affected by the reform and processed in the criminal justice system at the age of 14 have higher recidivism rates. This finding has several possible explanations where the first one derives from the deterrence perspective. Within this theoretical work the experience with the criminal justice system can change the offenders' information of the perceived severity of the punishment and can lead to an increase in subsequent offending if the perceived cost is reduced, for example by the experienced sanction being more lenient than expected. Second, the results can also be explained with reference to labeling theories, which state that the public label of criminal justice system interactions can increase criminal behavior among juveniles. The official status as 'criminal' can increase future offending by formal (exclusion conventional opportunities) or informal reactions (exclusion from non-deviant groups) and the change of self-perception.

The latter theoretical explanation is substantiated by the results from analyses of their educational outcomes, which show that 14-year-olds processed in the criminal justice system are less likely to be enrolled in the 9th grade and have lower grades at exit exam, conditional on participating. These results coincides with previous studies that found negative effects of court appearance, arrest and incarceration to juveniles' educational attainments (e.g. Aizer and Doyle 2015; Hjalmarsson 2008; Sweeten 2006). Moreover, Aizer and Doyle (2015) find substantial effects of juvenile incarceration on high school completion, which relates to lower likelihood of ever returning to school after imprisonment and higher likelihood of receiving a classification of emotional or behavioral disorders among those who do return to the school system.

Finally, the 14-year-olds who committed a penal code offense will receive a criminal record for one to five years, depending on the sanction. If convicted, the information will be retained in the 'system' for ten years with an official record, which could influence future meetings with the police and as well as decisions on whether or not to press charges (Petrosino, Turpin-Petrosino, and Guckenburg, 2010). In itself, this could increase the *reported* recidivism rates in the group affected by the reform. Moreover, the results show higher enrollment rates in boarding schools, which also can be influenced by different official reactions to offenders with and without an official label, as boarding schools are used for both preventive measures and placements by the social authorities.

Of course, 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.

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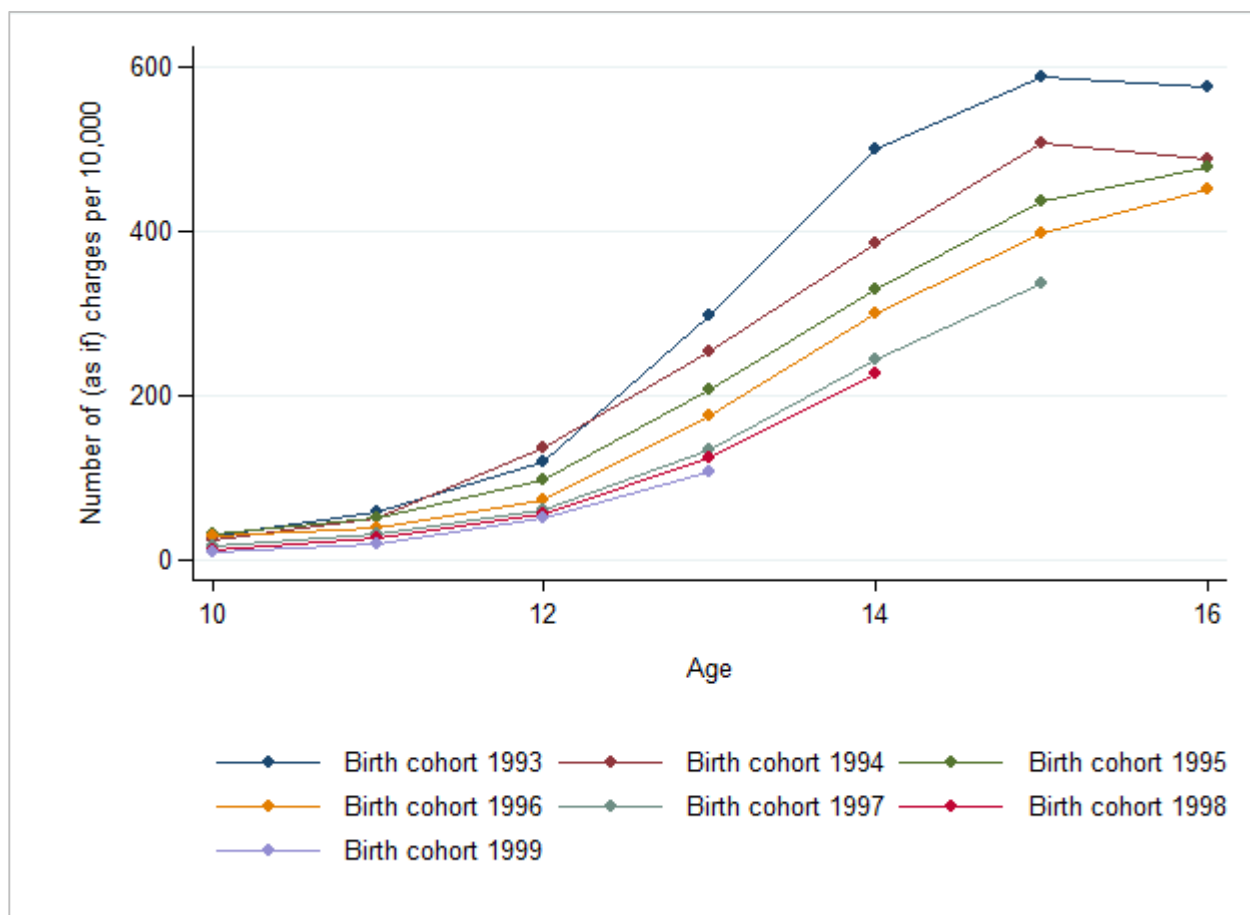
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## Appendix

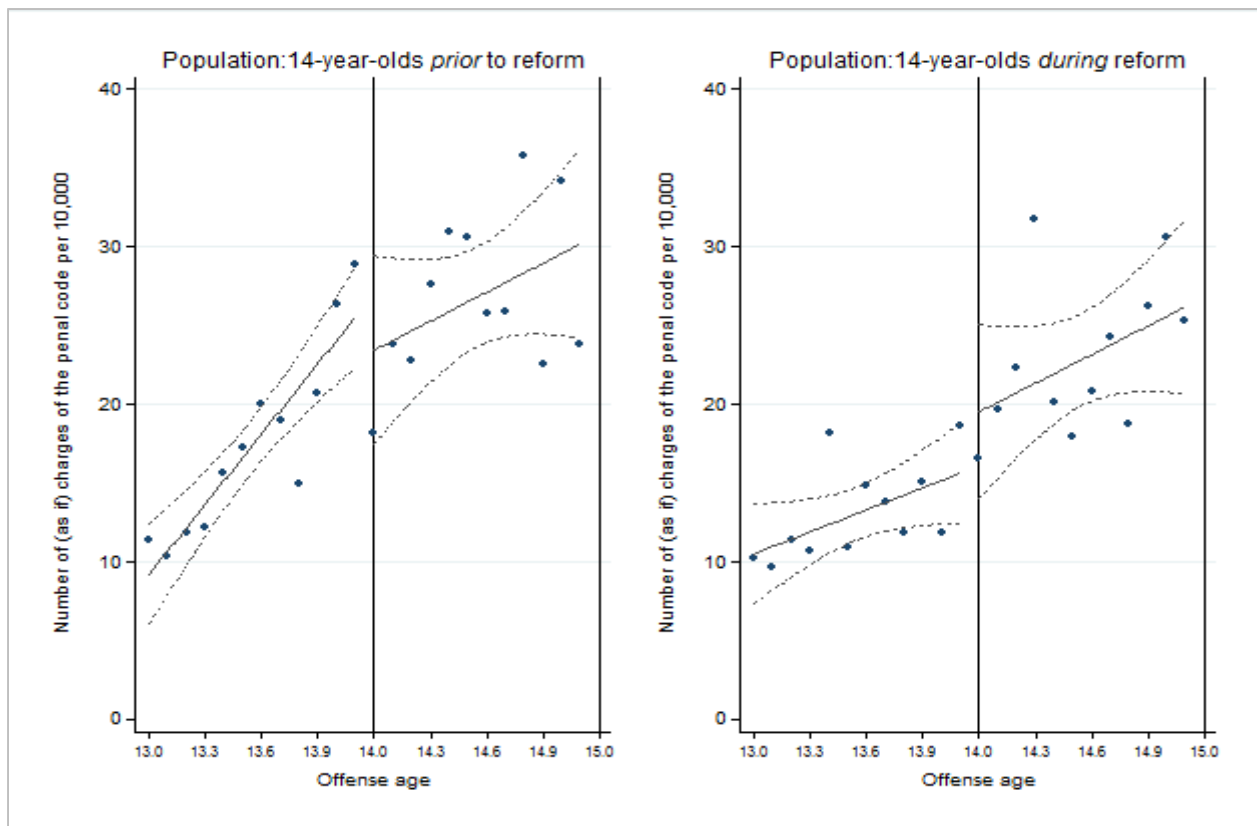
**Figure A1. Annual number of (as if) charges of penal code offenses per 10,000 by cohorts 1993 to 1999 over the age-interval 10-16**



Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.

Note: The figure shows the crime-age curves for seven Danish birth cohorts born in 1993 to 1999 based on the annual number of (as if) charges for a penal code offense per 10,000 in the cohort for age groups 10 to 16. The administrative records of (as if) charges for these birth cohorts include the years 2002 to 2013 and the crime-age curves are therefore end at ages 13 to 15 for the three youngest cohorts.

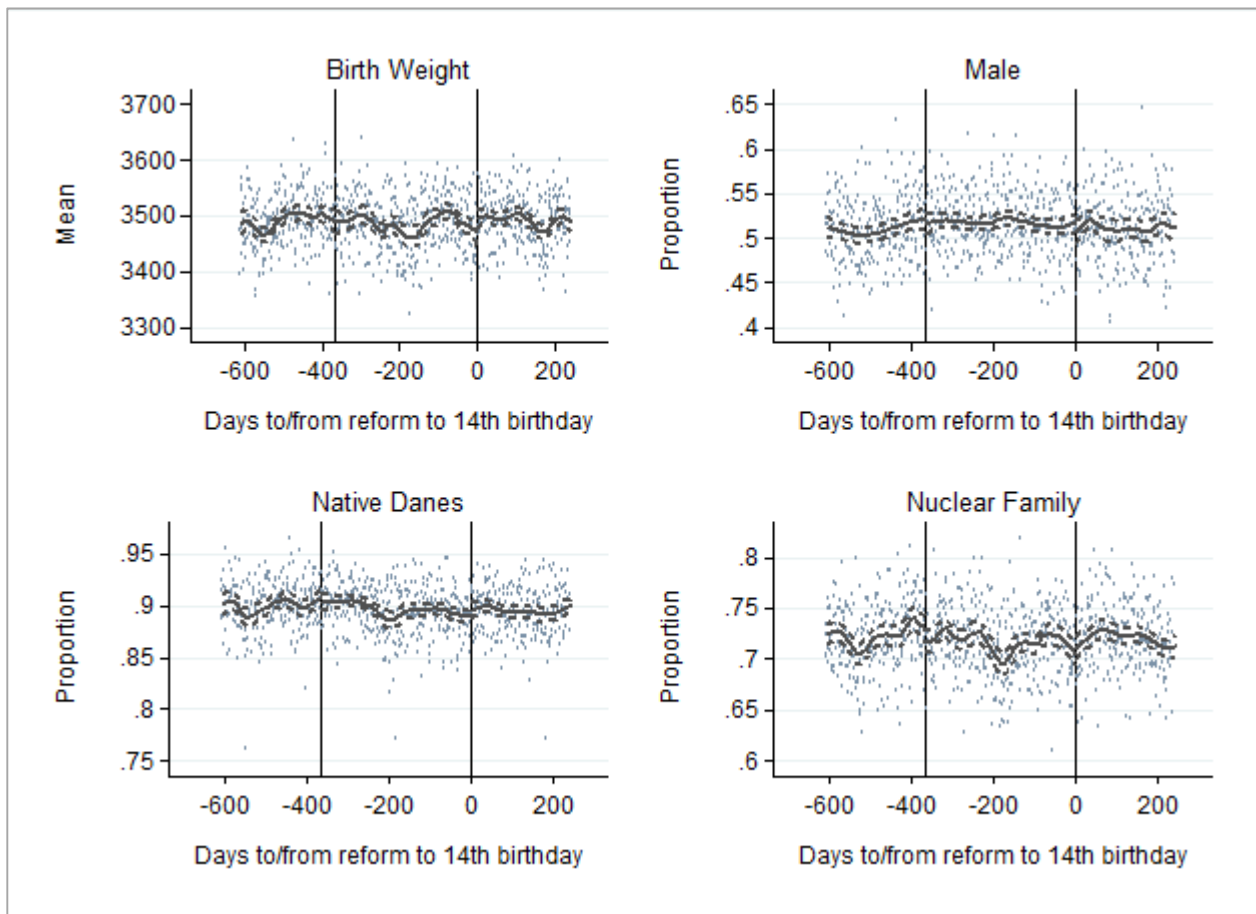
**Figure A2. Number of (as if) charges of penal code offenses per 10,000 by month ages 13 to 15 for children who have their 14<sup>th</sup> year pre or post reform**



Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.

Note: The figure shows scatterplots of the number of reported (as if) charges of the penal code per 10,000 in a given month between age 13 to 15 for children who have their 14<sup>th</sup> year prior to the reform of the minimum age of criminal responsibility and children who have their 14<sup>th</sup> year during the reform. The solid grey lines are a local linear trend lines and the dashed lines indicate 95% confidence intervals.

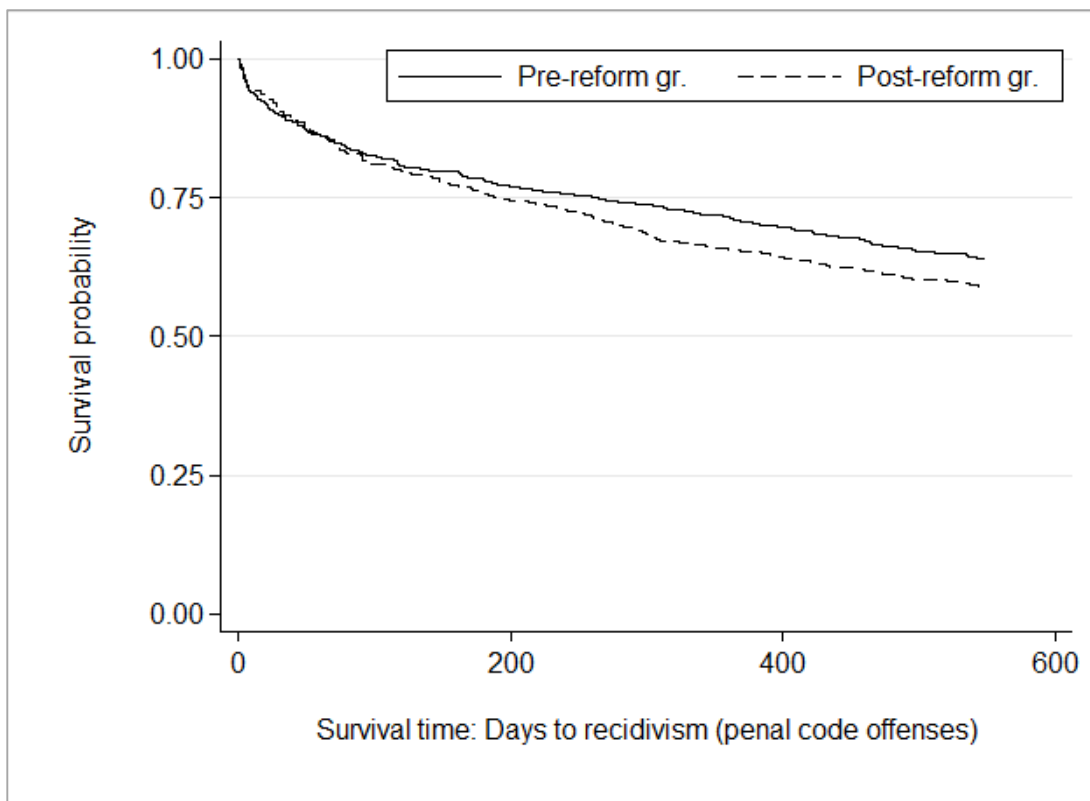
**Figure A3. Mean of selected control variable by distance to/from reform to 14<sup>th</sup> birthday**



Note: The figure shows scatterplots of selected variables by distance to/from reform date to 14<sup>th</sup> birthday, e.g. at the vertical line at 0, the plot shows mean of variable for individuals turning 14 years on July 1, 2010. The solid line is a local polynomial smoothed line and the corresponding dashed lines indicate 95% confidence intervals.

Data source: Administrative register data from Statistics Denmark and police records for birth cohorts 1993-1999.

**Figure A4. Survival plots: time to recidivism (penal code offenses) for 14- year-old penal code offenders who have their 14<sup>th</sup> year pre or post reform**



Data source: Administrative register data from Statistics Denmark and Police records for 14- year-old penal code offenders.

Note: The figure shows the survival probability from first reported penal code offense at the age of 14 and the number of days to recidivism to a new penal code offense within the first 18 months. The control group consist of 14- year-old penal code offenders who have their 14<sup>th</sup> year prior to the reform of the minimum age of criminal responsibility and the treatment group consist of 14- year-old penal code offenders who have their 14<sup>th</sup> year during the reform.

**Table A1.A: Variable definitions and primary data sources: Individual characteristics.**

Variable	Definition	Primary data source
Female	Dummy equals one if the child is female.	Population register, DST.
Age	Age based on birthday and measured in months.	Population register, DST.
Native Dane	Dummy equals one if the child is native Dane.	Population register, DST.
Western immigrant	Dummy equals one if the child is 1 <sup>st</sup> or 2 <sup>nd</sup> generation immigrant from a western country.	Population register, DST.
Non-western immigrant	Dummy equals one if the child is 1 <sup>st</sup> or 2 <sup>nd</sup> generation immigrant from a non-western country.	Population register, DST.
Birth weight	Weight of the child at birth in grams.	Medical Birth Register, DST.
Birth weight < 1500 g.	Dummy equals one if the birth weight of the child is less than 1500 grams.	Medical Birth Register, DST.
Birth weight < 2500 g.	Dummy equals one if the birth weight of the child is less than 2500 grams,	Medical Birth Register, DST.
Born premature	The length of the pregnancy in weeks.	Medical Birth Register, DST.
Born extremely premature	Dummy equals one if the pregnancy is shorter than 31 weeks.	Medical Birth Register, DST.
ADHD diagnose	Dummy equals one if the child has been diagnosed with ADHD at before his/her 10 <sup>th</sup> birthday.	Psychiatric Central Register, National Patient Register of Prescriptions of Medicinal Products, DST.
Ritalin	Dummy equals one if the child has been prescribed Ritalin (age 0-9).	Register of Prescriptions of Medicinal Products, DST.
Ritalin (180 dd min. 1 year)	Dummy equals one if the child has been prescribed Ritalin min. 180 accumulated daily doses) in a minimum of 1 year (age 0-9).	Register of Prescriptions of Medicinal Products, DST.
Other psychotropic drugs	Dummy equals one if the child has prescriptions of other psychotropic drugs (N-group: N05, N06 (excl. N06BA04) and N07) before his/her 10 <sup>th</sup> birthday.	Register of Prescriptions of Medicinal Products, DST.
Prior offense age 10-13	Dummy equals one if the child has at least one as if charge of a criminal offense before his/her 14 <sup>th</sup> birthday.	Central Police Register.
Number of prior offenses	Number of prior as if charges age 10-13.	Central Police Register.
Prior violence	Dummy for as if charge(s) of violent offense age 10-13.	Central Police Register.
Prior burglary	Dummy for as if charge(s) of burglary age 10-13.	Central Police Register.
Prior shoplifting	Dummy for as if charge(s) of shoplifting age 10-13.	Central Police Register.
Prior vehicle theft	Dummy for as if charge(s) of vehicle theft age 10-13.	Central Police Register.
Prior other theft	Dummy for as if charge(s) of another theft age 10-13.	Central Police Register.
Prior robbery	Dummy for as if charge(s) of robbery age 10-13.	Central Police Register.
Prior vandalism	Dummy for as if charge(s) of vandalism age 10-13.	Central Police Register.
Prior other property off.	Dummy for as if charge(s) of other property age 10-13.	Central Police Register.
Prior traffic offense	Dummy for as if charge(s) of traffic offense age 10-13.	Central Police Register.
Prior drug offense	Dummy for as if charge(s) of drug offense age 10-13.	Central Police Register.
Prior other offense type	Dummy for as if charge(s) of other offenses age 10-13.	Central Police Register.
Criminal debut age	Age of the first reported offense age 10-13.	Central Police Register.



**Table A1.B: Variable definitions and primary data sources: Family characteristics.**

Variable	Definition	Primary data source
Nuclear family	Dummy for living in a two-parent household at age 9.	Population register, DST.
Parent and new partner	Dummy for living with one parent and his/her new partner at age 9.	Population register, DST.
Single parent	Dummy for living in a single-parent household at age 9.	Population register, DST.
Not living with parents	Dummy equals one if the child is not living with any of the parents at age 9.	Population register, DST.
Mother's annual income	Mother's annual income in the year the child is age 9, deflated to 2004 prices and measured in 1000 DKK.	Income Register, DST.
Father's annual income	Father's annual income in the year the child is age 9, deflated to 2004 prices and measured in 1000 DKK.	Income Register, DST.
Mother working	Dummy equals one if mother is working in the year the child is age 9.	Integrated Database for Labor Market Research, DST.
Father working	Dummy equals one if father is working in the year the child is age 9.	Integrated Database for Labor Market Research, DST.
Mother primary and secondary school	Dummy equals one if mother has primary or secondary school as the highest education in the year child is age 9.	Education Register (annual registrations), DST
Mother vocational education	Dummy equals one if mother has vocational education as the highest education in the year child is age 9.	Education Register (annual registrations), DST
Mother general upper secondary education	Dummy equals one if mother has general upper secondary education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Mother short cycle higher education	Dummy equals one if mother has short cycle higher education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Mother medium cycle higher education	Dummy equals one if mother has medium cycle higher education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Mother long cycle higher education	Dummy equals one if mother has long cycle higher education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Father primary and secondary school	Dummy equals one if father has primary or secondary school as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Father vocational education	Dummy equals one if father has vocational education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Father general upper secondary education	Dummy equals one if father has general upper secondary education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Father short cycle higher education	Dummy equals one if father has short cycle higher education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Father medium cycle higher education	Dummy equals one if father has medium cycle higher education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST
Father long cycle higher education	Dummy equals one if father has long cycle higher education as the highest education in the year the child is age 9.	Education Register (annual registrations), DST

Variable	Definition	Primary data source
Mother convicted of criminal offense	Dummy equals 1 if mother is convicted and found guilty of criminal offense (any type).	Crime Statistics Register (Dispositions), DST.
Mother convicted of prison sentence	Dummy equals 1 if mother is convicted and found guilty of a suspended or unsuspended prison sentence.	Crime Statistics Register (Dispositions), DST.
Father convicted of criminal offense	Dummy equals 1 if father is convicted and found guilty of criminal offense (any type).	Crime Statistics Register (Dispositions), DST.
Father convicted of prison sentence	Dummy equals 1 if father is convicted and found guilty of a suspended or unsuspended prison sentence.	Crime Statistics Register (Dispositions), DST.
Missing identifier(mother)	Dummy equals one if the identifier for the mother is missing in the Medical Birth Register.	Medical Birth Register, DST
Missing identifier(father)	Dummy equals one if the identifier for the father is missing in the Medical Birth Register.	Medical Birth Register, DST
Missing register data (mother)	Dummy equals one if the income information for the mother is missing in the year the child is 9.	Income Register, DST.
Missing register data (father)	Dummy equals one if the income information for the father is missing in the year the child is 9.	Income Register, DST.

**Table A1.C: Variable definitions and primary data sources: specific to analysis of deterrence effects**

Variable	Definition	Primary data source
Calendar month	Dummies for the calendar month (1-12) in each year.	
Months prior to reform	Number of months prior to July 2010 (20-1, otherwise 0).	
Months during reform	Number of months after July 2010 (1-19, otherwise 0).	
Reform month	Dummy equals one if the month is July 2010.	
Distance to reform 1 (quadratic)	Number of months prior to July 2010 (second-degree polynomial)	
Distance to reform 2 (quadratic)	Number of months after July 2010 (second-degree polynomial)	
Distance to reform 1 (cubic)	Number of months prior to and after July 2010 (third-degree polynomial)	
Distance to reform 2 (cubic)	Number of months after July 2010 (third-degree polynomial)	
<i>Outcome variables:</i>		
Monthly offending rates (all penal code offenses)	Dummy equals one if the individual has at least one (as if) charge of a penal code offense in a given month (November 2008 to January 2012).	Central Police Register, Crime Statistics Register (Charges), DST.
Monthly offending rates (violent offenses)	Dummy equals one if the individual has at least one (as if) charge of a violent offense in a given month.	Central Police Register, Crime Statistics Register (Charges), DST.
Monthly offending rates (burglary)	Dummy equals one if the individual has at least one (as if) charge of burglary in a given month.	Central Police Register, Crime Statistics Register (Charges), DST.
Monthly offending rates (shoplifting)	Dummy equals one if the individual has at least one (as if) charge of shoplifting in a given month.	Central Police Register, Crime Statistics Register (Charges), DST.
Monthly offending rates (theft of vehicles)	Dummy equals one if the individual has at least one (as if) charge of theft of vehicles in a given month.	Central Police Register, Crime Statistics Register (Charges), DST.
Monthly offending rates (vandalism)	Dummy equals one if the individual has at least one (as if) charge of vandalism in a given month.	Central Police Register, Crime Statistics Register (Charges), DST.
Any penal code offense before 14	Dummy equals one if the individual has at least one (as if) charge of a penal code offense before his/her 14 <sup>th</sup> birthday.	Central Police Register, Crime Statistics Register (Charges), DST.
More than one penal code offense before 14	Dummy equals one if the individual has more than one (as if) charge of a penal code offense before his/her 14 <sup>th</sup> birthday.	Central Police Register, Crime Statistics Register (Charges), DST.
Any penal code offense at 14	Dummy equals one if the individual has at least one (as if) charge of a penal code offense in the month of his/her 14 <sup>th</sup> birthday.	Central Police Register, Crime Statistics Register (Charges), DST.
More than one penal code offense at 14	Dummy equals one if the individual has more than one (as if) charge of a penal code offense in the month of his/her 14 <sup>th</sup> birthday.	Central Police Register, Crime Statistics Register (Charges), DST.
Any penal code offense before 15	Dummy equals one if the individual has at least one (as if) charge of a penal code offense before his/her 15 <sup>th</sup> birthday.	Central Police Register, Crime Statistics Register (Charges), DST.
More than one penal code offense before 15	Dummy equals one if the individual has more than one (as if) charge of a penal code offense before his/her 15 <sup>th</sup> birthday.	Central Police Register, Crime Statistics Register (Charges), DST.
Any penal code offense at 15	Dummy equals one if the individual has at least one (as if) charge of a penal code offense in the month of his/her 15 <sup>th</sup> birthday.	Central Police Register, Crime Statistics Register (Charges), DST.
More than one penal code offense at 15	Dummy equals one if the individual has more than one (as if) charge of a penal code offense in the month of his/her 15 <sup>th</sup> birthday.	Central Police Register, Crime Statistics Register (Charges), DST.

**Table A1.D: Variable definitions and primary data sources: specific to analysis of recidivism**

Variable	Definition	Primary data source
Offense age	Dummies for offense age (14.0 to 15.0) when first penal code offense was committed at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense month	Dummies for the calendar month (1-12) of the first penal code offense committed at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: violence	Dummy equals one if the offender is (as if) charged of a violent offense at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: burglary	Dummy equals one if the offender is (as if) charged of burglary at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: shoplifting	Dummy equals one if the offender is (as if) charged of shoplifting at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: vehicle theft	Dummy equals one if the offender is (as if) charged of vehicle theft at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: other theft	Dummy equals one if the offender is (as if) charged of other types of theft at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: robbery	Dummy equals one if the offender is (as if) charged of robbery at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: vandalism	Dummy equals one if the offender is (as if) charged of vandalism at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: other property offense	Dummy equals one if the offender is (as if) charged of other types of a property offense at age 14	Central Police Register, Crime Statistics Register (Charges), DST.
Offense 14: other offense types	Dummy equals one if the offender is (as if) charged of other offense types at age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
<i>Outcome variables:</i>		
Recidivism 3 months	Dummy equals one if the offender recidivates to a penal code offense within 3 months from first offense age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Recidivism 6 months	Dummy equals one if the offender recidivates to a penal code offense within 6 months from first offense age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Recidivism 9 months	Dummy equals one if the offender recidivates to a penal code offense within 9 months from first offense age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Recidivism 12 months	Dummy equals one if the offender recidivates to a penal code offense within 12 months from first offense age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Recidivism 15 months	Dummy equals one if the offender recidivates to a penal code offense within 15 months from first offense age 14.	Central Police Register, Crime Statistics Register (Charges), DST.
Recidivism 18 months	Dummy equals one if the offender recidivates to a penal code offense within 18 months from first offense age 14.	Central Police Register, Crime Statistics Register (Charges), DST.

Variable	Definition	Primary data source
Time to recidivism	The number of days from the first penal code offense committed at age 14 to recidivism to a penal code offense within 18 months.	Central Police Register, Crime Statistics Register (Charges), DST.
Birth month	The number of months from 14 <sup>th</sup> birthday to reform month (July 2010).	Population register, DST.
Enrolled in 9 <sup>th</sup> grade	Dummy equals one if the offender has been enrolled in 9 <sup>th</sup> grade before his/her 17 <sup>th</sup> birthday.	Education Register (all entries), DST.
Exam participation	Dummy equals one if the offender has participated in 9 <sup>th</sup> grade exam (in one or more subject(s)) before his/her 17 <sup>th</sup> birthday.	Education Register (grades lower secondary education), DST.
Ordinary schools	Conditional on enrollment in 9 <sup>th</sup> grade dummy equals one if the offender was enrolled at an	Education Register (all entries and institution register), DST.
Boarding schools	Conditional on enrollment in 9 <sup>th</sup> grade dummy equals one if the offender was enrolled at a	Education Register (all entries and institution register), DST.
Schools special needs	Conditional on enrollment in 9 <sup>th</sup> grade dummy equals one if the offender was enrolled at a school for children with special needs.	Education Register (all entries and institution register), DST.
Language Arts (teacher assessment)	Average of the final teacher assessments in language arts (reading, writing, spelling, oral presentation and order) in 9 <sup>th</sup> grade. The test scores are standardized with national average for that specific test (e.g. reading) in a given school year.	Education Register (grades lower secondary education), DST.
Language Arts (exit exam)	Average of the exit exams in language arts (reading, writing, spelling, oral presentation and order) in 9 <sup>th</sup> grade. The test scores are standardized with national average for that specific test in a	Education Register (grades lower secondary education), DST.
Math (teacher assessment)	Average of the final teacher assessments in math (written test in skills, problem solving and oral presentation) in 9 <sup>th</sup> grade. The test scores are standardized with national average for that specific	Education Register (grades lower secondary education), DST.
Math (exit exam)	Average of the exit exams in math (written test in skills, and problem solving) in 9 <sup>th</sup> grade. The test scores are standardized with national average for that specific test in a given school year.	Education Register (grades lower secondary education), DST.

**Table A2. Summary statistics of sample of 14-year-olds used in analysis: Means (std. dev.).**

		N	Mean	Sd
<i>Child characteristics</i>	Male	162,959	0.51	0.50
	Female	162,959	0.49	0.50
	Native Dane	162,959	0.90	0.30
	Western immigrant 1st & 2nd generation	162,959	0.01	0.07
	Non-western immigrant 1st & 2nd generation	162,959	0.08	0.28
	Birth weight	154,029	3488.96	592.60
	Birth weight under 1500 g.	154,029	0.01	0.08
	Birth weight under 2500 g.	154,029	0.05	0.21
	Born premature	142,675	0.04	0.19
	Born extremely premature	142,675	0.01	0.09
	ADHD diagnose (age 0-9)	162,959	0.01	0.09
	Use of Ritalin (age 0-9)	162,959	0.01	0.08
	Use of Ritalin (180 dd min. 1 year) (age 0-9)	162,959	0.00	0.06
	Use of other psychotropic drugs (age 0-9)	162,959	0.04	0.19
<i>Criminal history (age 10-13)</i>	Charged of an offense before age 14	162,959	0.01	0.10
	Number of prior charges	1,640	1.55	1.52
	Charged of a violent offense	1,640	0.14	0.35
	Charged of burglary	1,640	0.06	0.24
	Charged of shoplifting	1,640	0.41	0.49
	Charged of vehicle theft	1,640	0.08	0.27
	Charged of theft	1,640	0.08	0.27
	Charged of robbery	1,640	0.02	0.15
	Charged of vandalism	1,640	0.24	0.43
	Charged of other property offenses	1,640	0.08	0.27
	Charged of a traffic offense	1,640	0.01	0.12
	Charged of a drug offense	1,640	0.00	0.03
	Charged of another offense	1,640	0.04	0.19
	Criminal debut age	1,640	11.26	0.78
<i>Family characteristics (age 9)</i>	Nuclear family	162,959	0.72	0.45
	Parent and new partner	162,959	0.09	0.28
	Single parent	162,959	0.18	0.38
	Not living parents	162,959	0.01	0.09
	Mother's annual income(1000 DKK, deflated)	161,321	193.58	142.90
	Father's annual income(1000 DKK, deflated)	156,438	297.99	247.71
	Mother working	162,161	0.79	0.41
	Father working	159,788	0.86	0.34

		N	Mean	Sd
<i>Family characteristics (age 9)</i>	Primary and secondary school - mother	162,959	0.24	0.44
	Vocational education - mother	162,959	0.38	0.48
	General upp. secondary edu. - mother	162,959	0.07	0.25
	Short cycle higher edu. - mother	162,959	0.04	0.20
	Medium cycle higher edu. - mother	162,959	0.19	0.39
	Long cycle higher edu. - mother	162,959	0.08	0.26
	Primary and secondary school - father	162,959	0.25	0.45
	Vocational education - father	162,959	0.40	0.49
	General upp. secondary edu. - father	162,959	0.05	0.22
	Short cycle higher edu. - father	162,959	0.08	0.26
	Medium cycle higher edu. - father	162,959	0.10	0.30
	Long cycle higher edu. - father	162,959	0.10	0.29
	Mother convicted of criminal offense	162,959	0.01	0.12
	Mother convicted of prison or suspended prison sentence	162,959	0.00	0.06
	Father convicted of criminal offense	162,959	0.05	0.21
	Father convicted of prison or suspended prison sentence	162,959	0.02	0.14
	Missing identifier(mother)	162,959	0.00	0.08
	Missing identifier(father)	162,959	0.02	0.17
	Missing register data child age 9(mother)	162,959	0.01	0.23
	Missing register data child age 9(father)	162,959	0.04	0.27
	Post-reform (age 14 after reform)	162,959	0.28	0.45
	Pre-/post reform (age 14 prior to and after reform)	162,959	0.43	0.49
	Pre-reform (age 14 prior to reform)	162,959	0.29	0.45
Observations		162,959		

Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.  
Note: The table shows summary statistics for the population of 14-year-olds from November 2008 to February 2012.

**Table A3. Summary statistics of sample used in analysis: Means, Differences and t-tests.**

		Pre-reform (1)	Pre-/post-reform (2)	Post-reform (3)	Difference & t-test (1-3)	Difference & t-test (2-3)
		Mean	Mean	Mean		
<i>Child characteristics</i>	Male	0.51	0.52	0.51	-0.00	0.01
	Female	0.49	0.48	0.49	0.00	-0.01
	Native Dane	0.90	0.90	0.90	0.00*	0.00
	Western immigrant 1st & 2nd generation	0.00	0.01	0.01	-0.00	-0.00
	Non-western immigrant 1st & 2nd generation	0.08	0.08	0.09	-0.00*	-0.00
	Birth weight	3490.90	3485.91	3491.59	-0.69	-5.68
	Birth weight under 1500 g.	0.01	0.01	0.01	0.00	0.00
	Birth weight under 2500 g.	0.05	0.05	0.05	-0.00*	0.00
	Born premature	0.03	0.04	0.04	-0.01***	-0.00
	Born extremely premature	0.01	0.01	0.01	-0.00	0.00
	ADHD diagnose (age 0-9)	0.01	0.01	0.01	-0.00***	-0.00
	Use of Ritalin (age 0-9)	0.01	0.01	0.01	-0.00**	-0.00
	Use of Ritalin (180 dd min. 1 year) (age 0-9)	0.00	0.00	0.00	-0.00**	-0.00*
	Use of other psychotropic drugs (age 0-9)	0.03	0.04	0.04	-0.01***	-0.00**
<i>Criminal history (age 10-13)</i>	Charged of an offense before age 14	0.01	0.01	0.01	0.00***	0.00*
	Number of prior charges	1.63	1.55	1.42	0.20*	0.13
	Charged of a violent offense	0.10	0.16	0.16	-0.06**	-0.01
	Charged of burglary	0.06	0.07	0.04	0.01	0.03
	Charged of shoplifting	0.39	0.40	0.45	-0.06	-0.05
	Charged of vehicle theft	0.08	0.08	0.09	-0.01	-0.01
	Charged of theft	0.08	0.08	0.07	0.01	0.01
	Charged of robbery	0.02	0.02	0.03	-0.01	-0.02
	Charged of vandalism	0.26	0.24	0.22	0.04	0.02
	Charged of other property offenses	0.08	0.09	0.06	0.02	0.03
	Charged of a traffic offense	0.02	0.02	0.01	0.01	0.01
	Charged of a drug offense	0.00	0.00	0.00	-0.00	-0.00
	Charged of another offense	0.05	0.03	0.02	0.03**	0.01
	Criminal debut age	11.29	11.23	11.26	0.03	-0.03
<i>Family characteristics (age 9)</i>	Nuclear family	0.72	0.72	0.72	0.00	-0.00
	Parent and new partner	0.09	0.09	0.09	-0.00	0.00
	Single parent	0.18	0.18	0.18	-0.00	0.00
	Not living parents	0.01	0.01	0.01	-0.00	-0.00



		Pre-reform (1)	Pre-/post-reform (2)	Post-reform (3)	Difference and t-test (1-3)	Difference and t-test (2-3)
		Mean	Mean	Mean		
<i>Family characteristics (age 9)</i>	Mother's annual income(1000 DKK, deflated)	193.17	193.18	194.64	-1.47	-1.46
	Father's annual income(1000 DKK, deflated)	294.04	298.30	301.61	-7.58***	-3.32*
	Mother working	0.79	0.79	0.80	-0.01***	-0.01***
	Father working	0.86	0.86	0.87	-0.01***	-0.01***
	Primary and secondary school - mother	0.24	0.24	0.23	0.01***	0.01***
	Vocational education - mother	0.38	0.38	0.37	0.01	0.00
	General upp. secondary edu. - mother	0.07	0.07	0.07	0.00	0.00
	Short cycle higher edu. - mother	0.04	0.04	0.05	-0.00	-0.00
	Medium cycle higher edu. - mother	0.19	0.19	0.19	-0.00	-0.01*
	Long cycle higher edu. - mother	0.07	0.08	0.08	-0.01***	-0.01***
	Primary and secondary school - father	0.26	0.25	0.25	0.01**	0.01**
	Vocational education - father	0.40	0.40	0.40	0.00	-0.00
	General upp. secondary edu. - father	0.05	0.05	0.05	-0.00	-0.00
	Short cycle higher edu. - father	0.08	0.08	0.08	-0.00	-0.00
	Medium cycle higher edu. - father	0.11	0.10	0.10	0.00	0.00
	Long cycle higher edu. - father	0.09	0.10	0.10	-0.01***	-0.00*
	Mother convicted of criminal offense	0.01	0.01	0.02	-0.01***	-0.00***
	Mother convicted of prison or suspended prison sentence	0.00	0.00	0.01	-0.00***	-0.00***
	Father convicted of criminal offense	0.04	0.05	0.06	-0.02***	-0.01***
	Father convicted of prison or suspended prison sentence	0.01	0.02	0.02	-0.01***	-0.01***
	Missing identifier(mother)	0.00	0.00	0.00	0.00	-0.00
	Missing identifier(father)	0.02	0.02	0.02	0.00	-0.00
	Missing register data child age 9(mother)	0.01	0.01	0.01	0.00	0.00
	Missing register data child age 9(father)	0.04	0.04	0.04	0.00	-0.00
Observations		47,441	69,785	45,733		

Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.

Note: The table shows summary statistics for the population of 14-year-olds from November 2008 to February 2012, divided into three groups according to whether they have their 14th year pre-reform, pre-and post reform or post reform. The last two column show the differences between the groups and t-tests of difference in means \* p<0.05, \*\* p<0.01, \*\*\* p<0.001.

**Table A4. Robustness analyses: Effects of the reform on monthly reported offending rates (penal code offenses), population: 14-year-olds**

<i>Baseline result:</i> Reform effect July 2010-February 2012 (obs.= 1,955,508)	0.00017 (0.00015)
<i>Different reform specifications:</i>	
Including dummy variable for reform month (obs.= 1,955,508)	0.00017 (0.00016)
Distance to reform (quadratic) (obs.= 1,955,508)	-0.00025 (0.00027)
Distance to reform (quadratic and cubic) (obs.= 1,955,508)	-0.00002 (0.00035)
Adding 14-year-olds after the minimum age of criminal responsibility was re-established at 15 (14 <sup>th</sup> birthday after 1 March, 2012) (obs.=3,449,100)	0.00020 (0.00013)
Excluding 14-year-olds closest to the reform (14 <sup>th</sup> birthday June, July and August 2010) (obs.=1,742,040)	0.00016 (0.00015)
Excluding 14-year-olds furthest away from the reform (14 <sup>th</sup> birthday November- December 2008 and January-February 2012) (obs.=1,816,104)	0.00010 (0.00016)
<i>Announcements effects:</i>	
Excluding 14-year-olds born 17 March -30 June 1996 (obs.= 1,715,076)	0.00014 (0.00016)
Effects of media debate October 2009 - June 2010 (obs.=1,030,623)	-0.00068 (0.00270)
<hr/> Controls:	
Age month specification	Dummies
Calendar month dummies	Yes
Child background	Yes
Parents background	Yes
Child crime history	Yes
Police district fixed effects	Yes

Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.

Note: The 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). The reported estimates are coefficients from linear panel models on the probability of an (as if) charge in a given month from November 2008 to January 2012. Standard errors are clustered at the individual level and reported in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Control variables: number of months relative to reform, age, calendar month, gender, ethnicity, birth weight, parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), child ADHD diagnosis, child using prescriptive drugs, child and parents' criminal history, police district.

**Table A5. OLS-models: Effects of the reform (penal code offenses), population: 14-year-olds**

	I	II	III	IV
<i>Outcomes (obs.=93,174):</i>				
Any penal code offense before 14	-0.00534*** (0.00092)	0.00458 (0.00416)	-0.00165 (0.00353)	-0.00176 (0.00352)
More than one penal code offense before 14	-0.00161*** (0.00050)	0.00123 (0.00222)	-0.00101 (0.00216)	-0.00104 (0.00216)
Any penal code offense at 14	-0.00396*** (0.00084)	-0.00128 (0.00379)	-0.00236 (0.00412)	-0.00248 (0.00412)
More than one penal code offense at 14	-0.00056 (0.00047)	-0.00071 (0.00212)	-0.00176 (0.00233)	-0.00178 (0.00233)
Any penal code offense before 15	-0.00861*** (0.00117)	0.00224 (0.00526)	-0.00326 (0.00498)	-0.00350 (0.00498)
More than one penal code offense before 15	-0.00246*** (0.00070)	0.00000 (0.00311)	-0.00297 (0.00316)	-0.00302 (0.00316)
Any penal code offense at 15	-0.00349*** (0.00090)	0.00913** (0.00397)	0.00731* (0.00439)	0.00731* (0.00439)
More than one penal code offense at 15	-0.00051 (0.00055)	0.00213 (0.00245)	0.00094 (0.00271)	0.00095 (0.00270)
Controls:				
Age specification	No	No	No	No
Calendar month dummies	No	No	No	No
Birth month relative to reform	No	Yes	Yes	Yes
Child background	No	No	Yes	Yes
Parents background	No	No	Yes	Yes
Police districts fixed effects	No	No	No	Yes

Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.

Note: The reported estimates are coefficients from OLS regressions for the population of 14-year-olds pre-reform (14<sup>th</sup> birthday November 2008 to June 2010) and post-reform (14<sup>th</sup> birthday July 2010 to February 2012). Rows represent separate regression models with different outcome specifications and each column represents a gradually richer conditioning set. Robust standard errors are reported in parentheses and \* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01. Control variables: number of months relative to reform, gender, ethnicity, birth weight, parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), child ADHD diagnosis, child using prescriptive drugs, child and parents' criminal history, police district.

**Table A6. OLS-models: Effects of the reform (penal code offenses), population: 14-year-olds by sub group**

	Subsample: without prior offense by age 14		Subsample: with prior offense by age 14	
<i>Outcomes:</i>				
Any penal code offense before 14	-0.00352*** (0.00067)	-0.00226 (0.00352)	0.03392*** (0.01024)	0.03066 (0.04962)
More than one penal code offense before 14	-0.00071** (0.00034)	-0.00160 (0.00172)	-0.01492 (0.03130)	-0.06129 (0.15166)
Any penal code offense at 14	-0.00375*** (0.00080)	-0.00198 (0.00396)	0.01747 (0.02641)	-0.05281 (0.13083)
More than one penal code offense at 14	-0.00044 (0.00043)	-0.00316 (0.00216)	0.00756 (0.01938)	0.11815 (0.09359)
Any penal code offense before 15	-0.00670*** (0.00099)	-0.00357 (0.00501)	0.02056** (0.00902)	-0.01196 (0.03831)
More than one penal code offense before 15	-0.00128** (0.00057)	-0.00308 (0.00285)	-0.02833 (0.03258)	-0.09227 (0.15790)
Any penal code offense at 15	-0.00312*** (0.00087)	0.00742* (0.00426)	-0.00131 (0.02606)	0.03291 (0.12481)
More than one penal code offense at 15	-0.00020 (0.00051)	0.00236 (0.00255)	-0.00786 (0.02063)	-0.10778 (0.09886)
Observations	92,249	92,249	925	925
Controls:				
Age specification	No	No	No	No
Calendar month dummies	No	No	No	No
Birth month relative to reform	No	Yes	No	Yes
Child background	No	Yes	No	Yes
Parents background	No	Yes	No	Yes
Police districts fixed effects	No	Yes	No	Yes

Data source: Administrative register data from Statistics Denmark and Police records for birth cohorts 1993-1999.

Note: The reported estimates are coefficients from OLS regressions. The sample of 14-year-olds pre-reform (14<sup>th</sup> birthday November 2008 to June 2010) and post-reform (14<sup>th</sup> birthday July 2010 to February 2012)(obs.=93,174) is divided into two groups according to their criminal history before age 14. Robust standard errors are reported in parentheses and \* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01. Control variables: number of months relative to reform, gender, ethnicity, birth weight, parents' income, occupation and education, family type (nuclear, single parent, new partner, child not living at home), child ADHD diagnosis, child using prescriptive drugs, child and parents' criminal history, police district.

**Table A7. Summary statistics of sample used in analysis of recidivism: Means and t-tests.**

		Pre-reform		Post-reform		Difference and t-test
		<i>Obs.</i>	<i>Mean</i>	<i>Obs.</i>	<i>Mean</i>	
<i>Child characteristics</i>	Male	893	0.65	676	0.64	0.01
	Female	893	0.35	676	0.36	-0.01
	Native Dane	893	0.77	676	0.75	0.02
	Western immigrant 1st & 2nd generation	893	0.01	676	0.01	-0.00
	Non-western immigrant 1st & 2nd generation	893	0.22	676	0.23	-0.01
	Birth weight	809	3455.77	610	3489.50	-33.72
	Birth weight under 1500 g.	809	0.00	610	0.00	0.00
	Birth weight under 2500 g.	809	0.04	610	0.04	-0.00
	Born premature	799	0.03	462	0.04	-0.01
	Born extremely premature	799	0.00	462	0.00	0.00
	ADHD diagnose (age 0-9)	893	0.02	676	0.02	-0.00
	Use of Ritalin (age 0-9)	893	0.01	676	0.03	-0.02***
	Use of Ritalin (180 dd min. 1 year) (age 0-9)	893	0.00	676	0.02	-0.02**
	Use of other psychotropic drugs (age 0-9)	893	0.04	676	0.03	0.01
<i>Family characteristics (age 9)</i>	Nuclear family	893	0.48	676	0.47	0.01
	Parent and new partner	893	0.13	676	0.14	-0.01
	Single parent	893	0.03	676	0.04	-0.01
	Not living with parents	893	0.01	676	0.01	0.00
	Mother's annual income(1000 DKK, deflated)	878	130.21	660	113.04	17.17**
	Father's annual income(1000 DKK, deflated)	817	202.33	613	189.88	12.45
	Mother working	888	0.57	668	0.56	0.01
	Father working	854	0.69	645	0.67	0.02
	Primary and secondary school - mother	893	0.47	676	0.48	-0.01
	Vocational education - mother	893	0.31	676	0.33	-0.02
	General upp. secondary edu. - mother	893	0.07	676	0.05	0.01
	Short cycle higher edu. - mother	893	0.02	676	0.03	-0.00
	Medium cycle higher edu. - mother	893	0.11	676	0.08	0.03*
	Long cycle higher edu. - mother	893	0.02	676	0.01	0.00
	Primary and secondary school - father	893	0.43	676	0.44	-0.01
	Vocational education - father	893	0.33	676	0.34	-0.01
	General upp. secondary edu. - father	893	0.06	676	0.05	0.00
	Short cycle higher edu. - father	893	0.04	676	0.06	-0.01
	Medium cycle higher edu. - father	893	0.05	676	0.04	0.01
	Long cycle higher edu. - father	893	0.04	676	0.03	0.02
	Mother convicted of criminal offense	893	0.03	676	0.06	-0.02*
	Mother convicted of prison or suspended prison sentence	893	0.01	676	0.03	-0.02**
	Father convicted of criminal offense	893	0.09	676	0.15	-0.06***
	Father convicted of prison or suspended prison sentence	893	0.04	676	0.07	-0.03**

		Pre-reform		Post-reform		Difference and t-test
		Obs.	Mean	Obs.	Mean	
	Missing identifier(mother)	893	0.01	676	0.01	-0.01
	Missing identifier(father)	893	0.04	676	0.05	-0.00
	Missing register data child age 9(mother)	893	0.02	676	0.02	-0.01
	Missing register data child age 9(father)	893	0.09	676	0.09	-0.01
<i>Crime history (age 10-13)</i>	Charged of an offense before age 14	893	0.11	676	0.12	-0.01
	Number of prior charges	98	2.01	82	2.20	-0.18
	Charged of a violent offense	98	0.14	82	0.20	-0.05
	Charged of burglary	98	0.03	82	0.07	-0.04
	Charged of shoplifting	98	0.35	82	0.38	-0.03
	Charged of vehicle theft	98	0.15	82	0.23	-0.08
	Charged of theft	98	0.14	82	0.10	0.05
	Charged of robbery	98	0.08	82	0.12	-0.04
	Charged of vandalism	98	0.29	82	0.24	0.04
	Charged of other property offenses	98	0.09	82	0.10	-0.01
	Charged of a traffic offense	98	0.02	82	0.02	-0.00
	Charged of a drug offense	98	0.01	82	0.01	-0.00
	Charged of another offense	98	0.09	82	0.04	0.06
	Criminal debut age	98	11.22	82	11.34	-0.12
<i>Offense at 14</i>	Offense_age	893	14.50	676	14.49	0.01
	Offense age 14.0	893	0.04	676	0.05	-0.02
	Offense age 14.1	893	0.12	676	0.09	0.02
	Offense age 14.2	893	0.10	676	0.12	-0.02
	Offense age 14.3	893	0.10	676	0.11	-0.01
	Offense age 14.4	893	0.11	676	0.08	0.03
	Offense age 14.5	893	0.10	676	0.07	0.02
	Offense age 14.6	893	0.10	676	0.13	-0.03
	Offense age 14.7	893	0.10	676	0.09	0.01
	Offense age 14.8	893	0.10	676	0.09	0.00
	Offense age 14.9	893	0.09	676	0.11	-0.02
	Offense age 15.0	893	0.06	676	0.05	0.01
	Charged of a violent offense	893	0.17	676	0.18	-0.01
	Charged of burglary	893	0.06	676	0.05	0.01
	Charged of shoplifting	893	0.33	676	0.37	-0.03
	Charged of vehicle theft	893	0.11	676	0.09	0.02
	Charged of other theft	893	0.08	676	0.08	0.00
	Charged of robbery	893	0.04	676	0.03	0.01
	Charged of vandalism	893	0.13	676	0.11	0.02
	Charged of other property offenses	893	0.05	676	0.06	-0.00
	Charged of other types of offenses	893	0.01	676	0.03	-0.01*

Data source: Administrative register data from Statistics Denmark and Police records for 14- year-old penal code offenders pre- and post-reform.

Note: The table shows summary statistics for the population of 14- year-old penal code offenders, divided into two groups according to whether they have their 14th year pre- or post-reform. The last column shows the difference between the groups and t-tests of difference in means \* p<0.05, \*\* p<0.01, \*\*\* p<0.001.

**Table A8. Effects of reform on time to recidivism (penal code offenses), population: 14-year-old penal code offenders**

	I	II	III	IV
Effects of reform	1.1735* (0.0961)	1.2447*** (0.1038)	1.1802* (0.1062)	1.1574 (0.1060)
Controls:				
Calendar month dummies	No	Yes	Yes	Yes
Offense age and type	No	Yes	Yes	Yes
Child background variables	No	No	Yes	Yes
Family background variables	No	No	No	Yes
Observations:	1,569	1,569	1,569	1,569

Data source: Administrative register data from Statistics Denmark and Police records for 14- year-old penal code offenders pre- and post-reform.

Note: The table shows results from supplementary analyses and the reported estimates are hazard ratios of recidivism within 18 months from Cox regressions for 14- year-old penal code offenders pre- and post-reform. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Control variables: offense month, offense age, type of the offense, gender, ethnicity, birth weight, child ADHD diagnosis, child using prescriptive drugs, child's criminal history (ages 10-13), parents' income, occupation and education, family type and parents' criminal history.

**Table A9. Time trend in recidivism rates: Effects of birth month on recidivism (penal code offenses), population: 14-year-old penal code offenders pre-reform**

	I	II	III	IV
Effects of birth month on recidivism 3 months	-0.0003 (0.0042)	-0.0005 (0.0042)	0.0001 (0.0047)	0.0004 (0.0046)
Effects of birth month on recidivism 6 months	-0.0020 (0.0037)	-0.0020 (0.0034)	-0.0011 (0.0043)	-0.0008 (0.0043)
Effects of birth month on recidivism 9 months	-0.0017 (0.0040)	-0.0018 (0.0035)	-0.0009 (0.0044)	-0.0006 (0.0043)
Effects of birth month on recidivism 12 months	-0.0008 (0.0041)	-0.0009 (0.0038)	-0.0004 (0.0044)	-0.0000 (0.0043)
Effects of birth month on recidivism 15 months	-0.0025 (0.0031)	-0.0025 (0.0033)	-0.0017 (0.0039)	-0.0013 (0.0039)
Effects of birth month on recidivism 18 months	-0.0014 (0.0032)	-0.0015 (0.0033)	-0.0011 (0.0040)	-0.0008 (0.0039)
Controls:				
Calendar month dummies	No	Yes	Yes	Yes
Offense age and type	No	Yes	Yes	Yes
Child background variables	No	No	Yes	Yes
Family background variables	No	No	No	Yes
Police district fixed effects	No	No	No	Yes
Observations:	1,383	1,383	1,383	1,383

Data source: Administrative register data from Statistics Denmark and Police records for 14- year-old penal code offenders pre- and post-reform.

Note: The table shows results from supplementary analyses of time trends in recidivism rates. The sample includes 14-year-old penal code offenders pre-reform from March 2008 to June 2010. The reported estimates are coefficients from OLS regressions of the effects of birth month on the probability of recidivism at 3, 6, 9, 12, 15 and 18 months and each column represents a gradually richer conditioning set. Robust standard errors are clustered at police district and reported in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Control variables: offense month, offense age, type of the offense, child gender, ethnicity, birth weight, child ADHD diagnose, child using prescriptive drugs, child's criminal history (age 10-13), parents' income, occupation and education, family type, parents' criminal history, police district.



**Table A10. Effects of reform on recidivism (penal code offenses), population: 14-year-old penal code offenders**

		Without cohort corrections	With cohort corrections
3 months	Effect of reform on recidivism	0.0204 (0.0286)	0.1197 (0.0988)
	Birth month to reform month		-0.0052 (0.0051)
6 months	Effect of reform on recidivism	0.0305 (0.0206)	0.0973 (0.1202)
	Birth month to reform month		-0.0035 (0.0061)
9 months	Effect of reform on recidivism	0.0377** (0.0164)	0.0740 (0.1101)
	Birth month to reform month		-0.0019 (0.0058)
12 months	Effect of reform on recidivism	0.0471*** (0.0125)	0.0824 (0.1051)
	Birth month to reform month		-0.0019 (0.0051)
15 months	Effect of reform on recidivism	0.0428** (0.0148)	0.0966 (0.0828)
	Birth month to reform month		-0.0028 (0.0041)
18 months	Effect of reform on recidivism	0.0388*** (0.0122)	0.1285 (0.0853)
	Birth month to reform month		-0.0047 (0.0043)
Observations		1,569	1,569
Controls:			
Calendar month dummies(offense)		Yes	Yes
Offense age and type		Yes	Yes
Child background variables		Yes	Yes
Family background variables		Yes	Yes
Police district fixed effects		Yes	Yes

Data source: Administrative register data from Statistics Denmark and Police records for 14- year-old penal code offenders pre- and post-reform.

Note: The reported estimates are coefficients from OLS regressions, rows represent separate regression models on the probability of recidivism at 3, 6, 9, 12, 15 and 18 months and the two columns represent models without/with cohort correction. Robust standard errors are clustered at police district and reported in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Control variables: offense month, offense age, type of the offense, child gender, ethnicity, birth weight, child ADHD diagnose, child using prescriptive drugs, child's criminal history (age 10-13), parents' income, occupation and education, family type, parents' crime history, police district.

**Table A11. Robustness analyses: Effects of reform on recidivism (penal code offenses), population: 14-year-old penal code offenders**

	3 months	6 months	9 months	12 months	15 months	18 months
<i>Different subpopulations:</i>						
Pre-/post reform same calendar months (obs.=1,597)	0.0200 (0.0212)	0.0203 (0.0171)	0.0255 (0.0184)	0.0347** (0.0140)	0.0315 (0.0188)	0.0343* (0.0189)
14-year-old offenders (all types of crimes obs.=1,716)	0.0096 (0.0213)	0.0092 (0.0205)	0.0167 (0.0168)	0.0291* (0.0154)	0.0249 (0.0154)	0.0237 (0.0136)
With prior offenses by age 14 (obs.=180)	0.0105 (0.0821)	0.0592 (0.0821)	-0.0128 (0.1121)	0.0042 (0.0974)	0.0506 (0.0680)	0.0421 (0.0702)
Without prior offenses by age 14 (obs.=1,389)	0.0259 (0.0225)	0.0319* (0.0168)	0.0453*** (0.0126)	0.0590*** (0.0135)	0.0548*** (0.0145)	0.0475*** (0.0146)
Boys (obs.=1,018)	-0.0055 (0.0385)	0.0139 (0.0326)	0.0182 (0.0294)	0.0283 (0.0257)	0.0305 (0.0252)	0.0361* (0.0191)
Girls (obs.=551)	0.0804** (0.0305)	0.0715* (0.0377)	0.0839* (0.0389)	0.0835* (0.0429)	0.0771* (0.0388)	0.0618 (0.0397)
Excluding offenders with violent off. (obs.=1,243)	0.0469 (0.0360)	0.0522* (0.0253)	0.0534** (0.0222)	0.0609** (0.0225)	0.0559** (0.0218)	0.0589** (0.0223)
Excluding offenders with vandalism (obs.=1,378)	0.0193 (0.0242)	0.0245 (0.0176)	0.0338* (0.0156)	0.0498*** (0.0140)	0.0427* (0.0198)	0.0455** (0.0192)
Controls:						
Calendar month dummies	Yes	Yes	Yes	Yes	Yes	Yes
Offense age and type	Yes	Yes	Yes	Yes	Yes	Yes
Child background variables	Yes	Yes	Yes	Yes	Yes	Yes
Family background variables	Yes	Yes	Yes	Yes	Yes	Yes
Police district fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Data source: Administrative register data from Statistics Denmark and Police records for 14- year-old penal code offenders pre- and post-reform.

Note: The table shows result from robustness analyses with different (sub-) populations of 14-year-old penal code offenders. Each column represents separate regression models on the probability of recidivism at 3, 6, 9, 12, 15 and 18 months including all control variable. Robust standard errors are clustered at police district and showed in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Control variables: offense month, offense age, type of the offense, gender, ethnicity, birth weight, child ADHD diagnosis, child using prescriptive drugs, child's criminal history (ages 10-13), parents' income, occupation and education, family type, parents' criminal history, police district.

**Table A12. Educational mean outcomes for 14-year-old penal code offenders by sub group**

	Subsample: with recidivism within 18 months			Subsample: without recidivism within 18 months		
	Pre- reform	Post- reform	Diff.	Pre- reform	Post- reform	Diff.
<i>Outcome:</i>						
Enrolled in 9th grade	0.87	0.80	-0.07*	0.96	0.95	-0.01
Exam participation (0/1)	0.58	0.62	0.03	0.77	0.79	0.02
<i>Type of school (if enrolled 9<sup>th</sup> grade):</i>						
Ordinary lower secondary schools	0.56	0.56	0.00	0.72	0.66	-0.06
Boarding schools	0.09	0.10	0.01	0.11	0.18	0.07**
Schools for children with special needs	0.10	0.09	-0.01	0.02	0.03	0.01
Production colleges	0.14	0.14	0.00	0.08	0.06	-0.03
Treatment institutions	0.11	0.11	-0.01	0.06	0.07	0.00
<i>Grades (conditional on participation):</i>						
Language Arts (teacher assessment)	-1.13	-1.04	0.09	-0.57	-0.65	-0.08
Language Arts (exit exam)	-0.91	-0.99	-0.08	-0.49	-0.60	-0.11*
Math (teacher assessment)	-1.23	-1.20	0.03	-0.74	-0.78	-0.04
Math (exit exam)	-1.04	-1.14	-0.10	-0.71	-0.78	-0.06

Data source: Administrative register data from Statistics Denmark and Police records for 14- year-old penal code offenders pre- and post-reform.

Note: The table shows means for different educational outcomes (conditional on enrolment/participation) before age of 17 for the sample 14- year-old penal code offenders pre- and post-reform (obs.=1,569). The sample is divided into two subgroups according to whether they recidivate or not within 18 months. The two columns labelled “Diff.” show the differences between the pre and post reform groups within each sub group, and t-tests of difference in means \* p<0.05, \*\* p<0.01, \*\*\* p<0.001.

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