



# Unraveling the Sequences of Risk Factors Underlying the Development of Criminal Behavior

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Received: 19 October 2023 / Revised: 20 March 2024 / Accepted: 9 April 2024 /  
Published online: 25 April 2024  
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## Abstract

This work aims to investigate the role of sequences of risk factors from childhood to young adulthood in predicting subsequent criminal convictions. This study uses the Cambridge Study in Delinquent Development (CSDD) dataset, a prospective longitudinal research study that followed 411 males from South London from the age of 8 to 61 years. Temporal sequences of risk factors at ages 8–10, 12–14, and 16–18 were analyzed as predictors of subsequent criminal convictions up to the age of 61. Risk factors related to poverty, parenting problems, and children’s risk-taking predisposition at ages 8–10 emerged as prevalent starting points for the most highly predictive developmental sequences leading to convictions. The risk of a criminal conviction significantly increased if these risk factors were followed by low IQ scores or association with delinquent friends at ages 12–14, and by school and professional problems or drug addiction during late adolescence (ages 16–18). At each developmental stage, specific risk factors intricately combine to form chains of risk during development, subsequently predicting criminal convictions. A trajectory-of-risk-need-responsivity approach that identifies and breaks chains of risk factors that generate and enhance favorable conditions for criminal convictions is discussed.

**Keywords** Sequences · Offending · Risk factors · Longitudinal · Crime prevention

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## Introduction

Loeber et al. (1993) were pioneer researchers to explore developmental sequences as a means to examine the emergence and progression of criminal behavior. According to Loeber (2018), studying developmental sequences of behavior facilitates the exploration of an individual's progression from various forms of oppositional behavior, to conduct problems, delinquency, and, ultimately, criminal behavior. In fact, due to the advances in developmental criminology, Le Blanc and Loeber (1998) stated that: we can no longer be satisfied with a myopic view of the causes of individual offending, rooted in a specific moment in time, all of which are assumed to be invariant with developmental stages; rather, there is a need to adopt a system view in which numerous facilitators operate and interact along the developmental timeline. (p. 182).

Indeed, various theoretical approaches propose that, more than focusing on situational factors (e.g., circumstances, contexts), criminal behavior develops and is maintained through a chain of strengths and vulnerabilities in interaction with (and in some cases eliciting) subsequent risk factors that dynamically affect and are affected by individual traits. Such is the case of the Integrated Cognitive Antisocial Potential (ICAP) theory developed by Farrington (2003, 2005, 2020). Based on the analysis of long-term prospective studies, and particularly the Cambridge Study in Delinquent Development (CSDD; Farrington & West, 1981), the ICAP theory introduced the concept of Antisocial Potential (AP) which translates to an individual's likelihood to engage in antisocial or criminal behavior (Farrington, 2020). In this context, risk factors related to long-term energizing processes, such as the need for material goods but no legitimate methods to achieve them (e.g., due to unemployment, low income), early attachment and socialization problems (e.g., poor child rearing, disrupted families), impulsiveness, and antisocial models (e.g., criminal parents, delinquent peers), play a pivotal role for the development of long-term between-individuals AP (Farrington, 2020). In turn, short-term energizing influences, such as boredom, drug intoxication, or peer-driven instigation, affect short-term antisocial potential and, along with the presence of opportunities or victims, can increase the risk of criminal behavior at a particular moment (Farrington, 2020).

Furthermore, the ICAP theory suggests that developmental risk factors could have differential importance at different ages and could dynamically affect each other (Farrington, 2020). For example, disrupted families could impair an individual's attachment and socialization mechanisms, and increase the likelihood of socialization with delinquent peers, thus impacting academic performance and increasing the likelihood of school desistance and unemployment. Hence, an individual's AP and the emergence of criminal behavior are not solely due to a set of distinct risk factors. Instead, it is the result of a sequential and dynamic interplay among factors related to individual characteristics, social context, and life events throughout the life course.

Adopting a developmental perspective can be advantageous, as it allows researchers to focus on the study of sequential processes involved in the characteristics and patterns of maintenance and desistance of crime (Day & Wiesner,

2019). The focus, therefore, is on assessing frequent chains of events that lead to antisocial behavior, through the systematic examination of the dynamic interplay and evolving influence of relevant explanatory mechanisms. This approach emphasizes the assessment of patterns of change and continuity in a person-centered approach, taking into consideration age-graded developmental factors and their age-conditioned role (Day & Wiesner, 2019). Moreover, it underlines the dynamic transactions between the life history of an individual and current social contexts (Day & Wiesner, 2019). Thus, crime can be “conceptualized as the functioning of, and transactions across and within, biological, psychological, and social systems, with constant feedback and interaction over time” (Capaldi & Wiesner, 2009, p. 376).

Although a few studies have investigated lifelong trajectories of criminal convictions (Basto-Pereira & Farrington, 2019, 2020; Huizinga & Miller, 2013), surprisingly, we were not able to find a single study addressing the lifelong developmental sequences of factors leading to overall criminal behavior. And even though a great deal is known about risk factors that predict antisocial behavior and crime, little is known about the dynamic and sequential relations between different risk factors, in different ages and developmental stages, that will impact offending and different criminal pathways. In fact, prior research examining more than two temporally ordered risk factors is scarce, and the most robust studies address only a very limited array of pre-established and theoretically guided sequences of explanatory factors (e.g., Bishop et al., 2017), often assessed over short time periods. Thus, their aim is typically to examine the presence of specific mechanisms (or sequences) proposed for a certain theoretical framework. This might be due to the fact that quantitatively analyzing a large number of sequences of life events poses multiple methodological challenges. Moreover, there is also a scarcity of lifelong longitudinal data addressing numerous and significant risk factors associated with offending (Basto-Pereira et al., 2015).

Consequently, the current understanding of criminal behavior in the developmental literature suffers from a substantial knowledge gap. In fact, current central features in many assessment and intervention models in the criminal field, such as the Risk-Need-Responsivity (RNR) models, only target current static and dynamic evidence-based risk factors (i.e., criminogenic needs) and tailor interventions accordingly to reduce the risk of recidivism (Andrews et al., 1990).

In this scope, the application of sequential analysis in developmental criminology, as an exploratory data mining method, represents an advancement in understanding the complex interplay of developmental risk factors that lead to criminal behavior. This methodological approach is relevant for unraveling the complex dynamics of developmental risk factors, providing a deeper insight into the pathways and developmental mechanisms leading to criminal behavior. It surpasses traditional methods by enabling in-depth analysis of risk factor sequences over time, allowing a nuanced examination of how these factors evolve and interact with other risk factors over time, and shedding light on their cumulative impact on criminal convictions. In other words, studying crime etiology by independently examining risk factors only lets researchers contemplate a single *frame* of a complex process, while studying the sequences of events makes it possible to see more of the entire *movie*.

## The Current Study

The present study aims to offer insights into this under-researched area of criminology, by identifying and mapping the complex chains of multisystemic factors that contribute to the development and persistence of criminal behavior. To the best of our knowledge, this is the first study to analyze the sequences of events of an individual's life, from childhood to adulthood, that predict antisocial and criminal behavior. We believe that identifying the chain of multisystemic factors underlying the development and persistence of antisocial behavior holds significant importance when considering crime prevention and intervention. Firstly, it aids in comprehending why individuals with similar life trajectories may exhibit distinct criminal outcomes. Secondly, expanding our knowledge about the most important developmental sequences of risk factors heightening the risk of adult criminal convictions is relevant for future endeavors aimed at successfully targeting and preventing developmental-graded risk factors, according to a previous trajectory of risk factors.

Therefore, we aim to (1) examine the impact of the most predominant sequences of risk factors from childhood up to adolescence and young adulthood on adult criminal convictions and (2) investigate the existence of risk factors that have a high likelihood of explaining, or promoting other risk factors in subsequent developmental stages, leading to a crime-predicting sequence.

## Methods

### Data and Procedures

This study analyzed the Cambridge Study in Delinquent Development (CSDD) dataset. The CSDD is a prospective longitudinal study of 411 males originally residing in a working-class area of South London. These males were assessed face-to-face for the first time in 1961–1962, when they were children at ages 8–9, and the last time in 2000–2003, at the average age of 48. Additionally, criminal convictions were assessed up to the age of 61. Most of the boys were selected based on their enrollment at ages 8–9 in one of the six state primary schools within a 1-mile radius of a research office in a deprived area of South London.

Most of the sample belonged to two-parent working-class families (i.e., parents employed as skilled, semi-skilled, or unskilled manual workers) and were of Caucasian and British origin (357, or 87%). Within the remaining 13% of boys, 12 had African-Caribbean origins, 14 had at least a father or a mother from Ireland, 12 had at least one parent from Cyprus, and 16 were of Caucasian ethnicity, and at least one of their parents originated from another Western industrialized nation.

Almost the entire sample of boys were interviewed face to face at different time points spanning various phases of their development. These time points included childhood (ages 8 and 10), adolescence (age 14), the transition from adolescence to early adulthood (ages 16 and 18), and adulthood (ages 32 and 48). This is a multi-informant study, as the boys' parents, peers, female partners, and teachers were also interviewed. School records were searched during childhood and adolescence.

Criminal convictions were examined from the age of 10 up to 61 years old. The age at which each crime was committed was recorded, rather than the age at which the criminal conviction occurred. Criminal records were searched every few years from 1964 to 2017, enabling the retrieval of all convictions from the age 10 up to the age of 61 years old. The last search conducted in the Police National Computer (PNC) was completed in April 2017, thus ensuring the collection of all convictions committed up to the age of 61.99 (Farrington, 2019b). Less serious convictions, such as most of the motoring offenses, are not registered in the PNC and, therefore, were not included. All participants were informed about the CSDD study objectives and implications (and their parents when they were minors), and written informed consents were obtained at each interview. At the age of 48, on the last face-to-face interview, the attrition rate remained remarkably low, with 93% of the males being assessed. The CSDD study received approval from several ethic committees, including those of the Cambridge Institute of Criminology, the Institute of Psychiatry, King's College London, and the Home Office.

A comprehensive description of this study can be found in various books (Farrington et al., 2013, 2023; Piquero et al., 2007; West, 1969, 1982; West & Farrington, 1973, 1977) and articles (Farrington, 1995, 2003, 2019a, 2021; Farrington et al. 2009; Farrington & Jolliffe, 2022; Farrington et al., 2021; Farrington & West, 1981, 1990). In addition, comprehensive details on all the measures are freely available online in Farrington (1999) for consultation.

## **Risk Factors for Antisocial Behavior**

Our study focuses on sequences of explanatory predictors of crime during three key developmental periods: childhood (8–10 years old), adolescence (12–14 years old), and youth/teenage (16–18 years old) periods. These risk factors were designed to address parental, family, socioeconomic, attainment, personality, and behavioral/lifestyle domains that are theoretically expected to be explanatory predictors or indicators of antisocial behavior at each developmental phase.

### **Childhood Predictors (at Ages 8–10)**

Parental domain: (1) having a convicted father or (2) a convicted mother (based on criminal record searches); (3) having a young mother (giving birth to the first child before the age of 20); (4) low parental interest in the boy's education (parental knowledge of school activities, school problems, and other related aspects, assessed in interviews by psychiatric social workers); (5) depressed mother (a combination of ratings from interviews, scores on the neuroticism dimension assessed through the Mother's Health Questionnaire (Gibson et al., 1967), combined with information about current psychiatric treatments); and (6) authoritarian attitudes towards parenting based on Parental Attitude Schedules (Gibson, 1968).

Family domain: measures from this domain are based on structured assessments conducted by psychiatric social workers for each parent, and included: (7) harsh parental attitude and discipline (parents who are harsh, cruel, and often

use physical punishment as a parenting strategy); (8) poor parental supervision defined as a lack of knowledge about the boys' activities outside the house or characterized by permissive parenting strategies; (9) parental conflict, referring to persistent conflicts and tensions between parents; and finally, (10) disrupted family, which referred to separation (not caused by death or medical reasons) of the boy from the mother or father before the boy's tenth birthday.

Socioeconomic domain: most of the measures from this domain were obtained from structured assessments conducted by psychiatric social workers, and these risk factors included: (11) poor housing (very dilapidated premises); (12) low family income; (13) large family size (five or more children); (14) low socioeconomic status (boys whose fathers had unskilled manual jobs); and (15) high delinquency-rate schools. The last risk factor was obtained from official information provided by the local education authority.

Attainment domain: (16) low nonverbal IQ (Progressive Matrices Test, Raven, 1960); (17) low verbal IQ (vocabulary and verbal comprehension tests); (18) low junior school attainment (school records of tests based on a combination of English, arithmetic, and verbal reasoning scores).

Personality domain: (19) high daring, which referred to ratings by parents and peers regarding boys who displayed risky behavior (e.g., in traffic, climbing); (20) high hyperactivity, based on ratings by teachers regarding boys who were restless in class or lacked concentration; (21) high impulsivity, based on the Porteus Maze (Gibbens, 1958), the Spiral Maze (Gibson, 1969a), and the Tapping tests (Gibson, 1969b); (22) low popularity among peers (peer ratings); (23) nervous-withdrawn boys (rated by parents); (24) high neuroticism; and (25) high extraversion, which was based on the New Junior Maudsley Inventory (Furneaux & Gibson, 1966).

### Adolescent Risk Factors (at Ages 12–14)

Parenting/family domain: this was assessed through social worker ratings from interviews with parents, and the following risk factors were evaluated: (1) poor child rearing (based on neglectful, cruel, or harsh parenting styles) and (2) parental conflict (refers to constant conflicts and tensions between the parents).

Socioeconomic domain: this was assessed through social worker ratings from the interviews and includes: (3) low family income (based on the primary provider's income); (4) unemployed father (father temporarily or continuously unemployed in the past 2 years); (5) low SES (based on job of the father); and (6) poor housing (living in a dilapidated house).

Attainment domain: (7) low nonverbal IQ (assessed using the Progressive Matrices test); (8) low verbal IQ (assessed with the Mill Hill Vocabulary test, see Raven, 1981); and (9) frequent truancy (based on teachers' report).

Personality domain: (10) high neuroticism; (11) high extroversion (both based on the New Junior Maudsley Inventory completed by the boys; Furneaux & Gibson, 1966); (12) high daring; and (13) hyperactivity, related to lack of concentration and/or restlessness in class, both based on teacher's ratings.

Behavioral/Lifestyle domain: This was evaluated through self-report questionnaires and includes (14) early sex (had sex before 16 years old) and (15) association with delinquent friends.

### Youth/Teenage Risk Factors (at Ages 16–18)

Parenting/family domains: (1) poor relationship with the boy's parents (as determined through interviews at age 18).

Socioeconomic domain: this was assessed through an interview conducted at age 18 and included the following risk factors: (2) low take-home pay (based on income from a full-time job); (3) low socioeconomic status (SES) defined by boys with unskilled manual jobs; (4) unstable job record, referring to an inconsistent employment history characterized by short durations in multiple jobs.

Attainment domain: (5) no examinations passed, indicating that the boy reported not attempting or achieving success in any school examinations up to age 18.

Personality domain: (6) high neuroticism and (7) high extroversion personality traits (based on the Eysenck Personality Inventory at age 16; Eysenck & Eysenck, 1964); (8) high impulsiveness (Attitude Questionnaire administered at age 18; see Farrington, 1991).

Behavioral/Lifestyle domain: (9) habitual drug use, defined as self-reported drug misuse occurring five times or more; (10) binge drinking, referring to individuals who consumed seven or more pints of beer or the equivalent in other alcoholic drinks in a single evening in an average week; (11) heavy gambling, based on self-reports of significant amounts lost or won in gambling activities; (12) heavy smoking, characterized by smoking more than 20 cigarettes per day; (13) high debts, indicating a substantial amount of debt at age 18 (excluding mortgages); (14) promiscuous sex (referring to boys who had intercourse with two or more partners in the last 6 months); (15) hanging about, denoting frequent presence on the streets; (16) antisocial group members, referring to boys involved in group vandalism or violence with four or more males; and lastly, (17) injured in fighting or in a road accident (requiring hospital treatment).

Regarding the nature of the measures assessed in this study, a limited number of risk factors (as presented above) were inherently dichotomous (e.g., no exams passed, convicted father, convicted mother), and most of the risk factors were initially assessed as ratings on 2- to 4-point scales. Therefore, in order to standardize all risk factors to a common scale, factors assessed in ordinal scales were dichotomized into the "highest-risk" quartile versus the remaining three quartiles. This strategy appears as particularly pertinent, taking into account that distributions of our measures are neither normally distributed nor characterized by equal intervals. In addition, due to the limited range of ordinal scales (2- to 4-point scale), the dichotomization represents a mitigated risk of significant information loss from the original variables. Lastly, the application of dichotomization to the variables associated with predictors and outcomes, using similar strategies, has been implemented and/or examined in various contemporary cohorts. These include the Cambridge Study in Delinquent Development (Farrington, 2020) and the Pittsburgh Youth Study (e.g.,

Farrington & Loeber, 2000). These previous studies demonstrate minimal impact in terms of information loss or reduced power.

## Analytic Strategy

Regarding the statistical analysis, our work is divided into four parts. Firstly, we examined the prevalence and predictive ability of the most important risk factors measured at three time points: (1) ages 8–10; (2) ages 12–14; and (3) ages 16–18, in predicting criminal convictions from age 18 up to the age of 61. Secondly, we investigated the temporal sequences of two risk factors, each one measured at (1) ages 8–10 and 12–14; or (2) ages 12–14 and 16–18; or (3) ages 8–10 and 16–18, with the aim of identifying two-risk-factor sequences that best predict criminal convictions between the ages of 18 and 61. Thirdly, we examined the sequences of three risk factors, containing one risk factor measured at each one of the aforementioned three age groups, in predicting criminal convictions from 18 to 61.

Most of the risk factors have been produced taking into account the “worst” quartile (25%). Thus, an approximation to the expected proportion of a simultaneous sequence of two unrelated risk factors would be  $0.25^2$  or 6.25% (binomial test for proportions: 95% upper bound CI is 0.09 or 9%), and  $0.25^3$  or 1.56% for three unrelated risk factors (binomial test for proportions: 95% upper bound CI is 0.03 or 3%). Since we are interested in identifying sequences of risk factors that are simultaneously prevalent and tend to be associated across males more than expected by chance, in both cases, we established prevalences that are above the respective confidence intervals. Therefore, in Table 2, we have mapped sequences of two risk factors with a prevalence higher than 10%, while in Table 3, a prevalence of 5% was established for sequences of three risk factors.

The sequences that met the aforementioned pre-established criteria were mapped and cross-tabulated against the presence of criminal convictions in the subsequent ages and up to the age of 61. The odds ratio, chi-square tests, and descriptive statistics for the relationship between each sequence and the convictions status in subsequent ages were calculated. Sequences were ordered by odds ratio, and the 20 sequences with largest effect sizes predicting subsequent criminal careers were described. Sequences of two risk factors in different age periods are presented as “Factor 1 → Factor 2” and sequences of three risk factors are presented as “Factor 1 → Factor 2 → Factor 3.”

Participants without a minimum of 14 consecutive years of data (due to death or emigration) regarding convictions after the last risk factor was measured (at age 18) were excluded from the analysis, resulting in a sample of 367 males. Missing data across risk factors were replaced by the most frequent value for each risk factor, since this is the only available option in *TraMineR* for mapping sequences. In order to minimize bias associated with this imputation strategy, five risk factors that had more than 10% of missing data were excluded from the analysis (excluded at ages 8–10: authoritarian parents and illnesses and accidents; and excluded at ages 12–14: parental conflict, low income, and unemployed father).

In the fourth and last part of our analyses, we aimed to evaluate how each risk factor, present within prevalent sequences of three risk factors, that include one risk factor at each age period (ages: 8–10; 12–14; 16–18), contributes to the development of crime-predictive sequences. Each one of these sequences was cross-tabulated with the presence of convictions in subsequent ages up to age 61, and inferential statistics were calculated as described in the previous sections. Then, across all the aforementioned conditions, we described (1) the number of statistically significant sequences where each risk factor is integrated ( $n$ ); (2) the proportional representation of each risk factor at each age across all the statistically significant sequences of risk factors (% and % Cum for cumulative percentage); (3) the likelihood of a risk factor being part of a predictive sequence (% Sig. = Number of predictive sequences where  $X$  risk factor is presented divided by the total number of predictive and non-predictive sequences where  $X$  risk factor is presented); and (4) the median odds ratio (MOR) predicting subsequent convictions across all sequences where each risk factor is integrated.

To enhance the interpretability of the results, we introduced three new concepts related to the temporal position of each risk factor within the sequences. Firstly, the *magnetic risk factors*, which are described as risk factors that demonstrate a high likelihood of explaining or promoting various other risk factors leading to crime-predicting sequences. In our study, the magnetic ability of a risk factor will be evaluated at ages 8–10. Secondly, the *mixed risk factors*, which are risk factors that are in the middle of a sequence of risk factors. These risk factors are simultaneously influenced (or attracted) by risk factors at ages 8–10 and are also evaluated as magnetic risk factors for vulnerabilities at age 16–18. Therefore, in our study, the mixed ability of a risk factor can be evaluated only at ages 12–14. Thirdly, the *attracted risk factors*, which are risk factors caused or predicted by numerous preceding risk factors, contributing to predictive sequences leading to criminal conviction. In our study, the attracted ability of a risk factor will be evaluated at ages 16–18. As previously explained, a risk factor attracts or is attracted by other risk factors when the probability of a sequence of two or more risk factors substantially exceeds the multiplication of their individual probabilities.

A theorized example of a magnetic risk factor is poor supervision at ages 8–10, since besides its direct consequences for future antisocial behavior, this risk factor may contribute to children being more susceptible to associating with antisocial peers during adolescence, experiencing school failure and being more vulnerable to alcohol and drug consumption. Consequently, it attracts a constellation of risk factors that actively contribute to criminal convictions. In contrast, an example of an attracted risk factor might be school failure during the transition to adulthood. Theoretical perspectives suggest that several preceding risk factors during childhood or adolescence (e.g., poor supervision, low IQ, antisocial peers) can lead to, or indeed attract, school failure. Additionally, both the attracted risk factor and the preceding risk factors that explain it, form sequences of risk factors perceived as potential explanations for criminal behavior.

Since we are particularly interested in understanding how each risk factor can amplify the risk for criminal convictions within the developmental sequences of risk factors, we also introduce the concept of *Influential Power*. The *Influential Power* is

how each risk factor affects the predictive capability in the sequences of risk factors where it is inserted. The MOR (median odds ratio) provides a particularly relevant estimation of the Influential Power. For instance, a MOR of 4.00 for a particular risk factor means that in half of the sequences containing that risk factor there is a risk of conviction with an odds ratio of 4.00 or higher. Thus, while the % RF (previously described) estimates the ability of a risk factor to attract or be attracted by other risk factors, the MOR estimates the strength of each risk factor's influence on the predictive capacity of a sequence leading to criminal behavior.

Sequences of risk factors were calculated in *TraMineR*, *TraMineRextra* packages implemented in the *R* software (R Core Team, 2005; Gabadinho et al., 2016) and MOR and other additional calculations were performed in Excel 2016 software and IBM SPSS Statistics v.29.0 software.

## Results

### Risk Factors Predicting Criminal Convictions

Table 1 presents the prevalence of the top 20 risk factors measured at three time points: (1) ages 8–10, (2) ages 12–14, and (3) ages 16–18. These risk factors were assessed for their predictive ability for convictions between the ages of 18 and 61. Odds ratios (OR) were calculated to evaluate their predictive capability, with statistically significant OR values highlighted in bold. The large majority of the measured risk factors emerge as statistically significant predictors of adult criminal convictions, with the highest proportion of statistically significant results occurring for risk factors measured at ages 8–10. The risk factor that exhibited the strongest predictive ability for adult convictions was association with delinquent friends at ages 12–14 (OR = 5.24), followed by socioeconomic status at ages 16–18 (OR = 4.08), and, at ages 8–10, having a father who was convicted (OR = 3.76).

### Sequences of Two Risk Factors Predicting Criminal Convictions

Table 2 presents the top 20 temporal sequences of two risk factors that best discriminate criminal convictions between ages 18 and 61. The predictive capacity of these sequences was calculated for all possible combinations of risk factors measured at different time points, specifically sequences of risk factors measured at (1) ages 8–10 and 12–14; (2) ages 12–14 and 16–18; and (3) ages 8–10 and 16–18.

All top 60 temporal sequences of risk factors were statistically significant, with ORs ranged between 2.64 and 10.33. The sequence of two risk factors that exhibited the most significant difference between convicted and non-convicted males was “Low nonverbal IQ at ages 12–14 → Unstable job record at ages 16–18” (OR = 10.33). Among males without adult convictions, only 2.65% exhibited this temporal sequence of risk factors, while this sequence had a prevalence of 21.99% among males with adult convictions. This was followed by “High daring at ages 8–10 → Delinquent friends at ages 12–14” (OR = 9.34). Among males without adult

**Table 1** Top 20 risk factors at ages 8–10, 12–14 to 16–18, discriminating between convictions from ages 18 to 61 ordered by odds ratios

Rk	Risk factors (ages 8–10)				Risk factors (ages 12–14)				Risk factors (ages 16–18)				OR				
	n	RF	% RF	% NC RF	n	RF	% RF	% NCRF	n	RF	% RF	% NCRF		% CRF			
1	86	23.43	14.16	38.3	3.76	Delinquent friends	88	23.98	12.39	42.55	5.24	Low SES	60	16.35	8.85	28.37	4.08
2	83	22.62	14.6	35.46	3.21	Truancy	67	18.26	10.18	31.21	4.00	Unstable job record	88	23.98	15.93	36.88	3.08
3	35	9.54	5.75	15.6	3.03	Hyperactivity	94	25.61	16.81	39.72	3.26	Binge drinking	75	20.44	13.27	31.91	3.06
4	88	23.98	16.37	36.17	2.89	Early sex	108	29.43	21.68	41.84	2.60	No exams passed	189	51.5	41.59	67.38	2.90
5	82	22.34	15.93	32.62	2.56	Low verbal IQ	84	22.89	16.37	33.33	2.55	Hangs about	58	15.8	10.62	24.11	2.67
6	67	18.26	12.83	26.95	2.51	Low nonverbal IQ	108	29.43	23.01	39.72	2.20	Heavy smoking	97	26.43	19.03	38.3	2.64
7	73	19.89	14.16	29.08	2.49	Poor child rearing	102	27.79	23.01	35.46	1.84	Group activity	64	17.44	11.95	26.24	2.62
8	74	20.16	14.6	29.08	2.4	Daring	47	12.81	10.62	16.31	1.64	Heavy gambling	82	22.34	15.93	32.62	2.56
9	77	20.98	15.49	29.79	2.32	Low SES	106	28.88	25.66	34.04	1.49	Habitual drug use	115	31.34	23.89	43.26	2.43
10	95	25.89	19.91	35.46	2.21	Neuroticism	87	23.71	21.24	27.66	1.42	Sexual promiscuity	109	29.7	22.57	41.13	2.40
11	138	37.6	30.53	48.94	2.18	Poor housing	74	20.16	18.58	22.7	1.29	Poor relation w/ parents	83	22.62	17.26	31.21	2.17
12	111	30.25	23.89	40.43	2.16	Extraversion	95	25.89	25.22	26.95	1.09	Impulsiveness	95	25.89	20.35	34.75	2.08
13	86	23.43	18.14	31.91	2.12							Injured in fight/accident	60	16.35	13.72	20.57	1.63
14	58	15.8	11.95	21.99	2.08							Extraversion	84	22.89	20.35	26.95	1.44
15	77	20.98	16.81	27.66	1.89							High debts	86	23.43	21.24	26.95	1.37
16	93	25.34	20.8	32.62	1.84							Low take-home pay	81	22.07	24.34	18.44	0.70
17	73	19.89	16.37	25.53	1.75							Neuroticism	93	25.34	23.45	28.37	1.29
18	93	25.34	21.24	31.91	1.74												
19	99	26.98	23.01	33.33	1.67												
20	111	30.25	26.11	36.88	1.65												

% RF, % males with this Risk Factor; % MC, % of non-convicted males with this risk factor; % C, % of convicted males with this risk factor; Y, years old; OR, odds ratio. Bold values are statistically significant ( $p < .05$ )

**Table 2** Top 20 sequences at ages 8–10 to 12–14, 12–14 to 16–18, and 8–10 to 16–18, discriminating between convictions from ages 18 to 61 ordered by odds ratios

RR	Sequences (ages 8–10 to 12–14)	n	% RF	% NC RF	% C RF	OR	Sequences (ages 12–14 to 16–18)	n	% RF	% NC RF	% C RF	OR	Sequences (ages 8–10 to 16–18)	n	% RF	% NC RF	% C RF	OR
1	High darning → Delinquent friends	44	11.99	3.54	25.53	<b>9.34</b>	Low nonverbal IQ → Unstable job record	37	10.08	2.65	21.99	<b>10.33</b>	Convicted father → No exams passed	62	16.89	7.96	31.21	<b>5.24</b>
2	Large family size → Low verbal IQ	37	10.08	3.98	19.86	<b>5.97</b>	Delinquent friends → No exams passed	66	17.98	6.64	36.17	<b>7.97</b>	Disrupted family → No exams passed	50	13.62	6.19	25.53	<b>5.19</b>
3	Large family size → Poor childrearing	39	10.63	4.42	20.57	<b>5.59</b>	Delinquent friends → Sexual promiscuity	39	10.63	3.54	21.99	<b>7.68</b>	Poor housing → Poor relation w/parents	41	11.17	5.31	20.57	<b>4.62</b>
4	Poor housing → Truancy	39	10.63	4.42	20.57	<b>5.59</b>	Hyperactivity → Heavy smoking	40	10.90	4.42	21.28	<b>5.84</b>	Poor housing → Habitual drug use	44	11.99	5.75	21.99	<b>4.62</b>
5	High darning → Early sex	46	12.53	5.75	23.40	<b>5.01</b>	Hyperactivity → Sexual promiscuity	38	10.35	4.87	19.15	<b>4.63</b>	High darning → Heavy smoking	39	10.63	5.31	19.15	<b>4.22</b>
6	Poor housing → Delinquent friends	39	10.63	4.87	19.86	<b>4.84</b>	Early sex → Heavy smoking	44	11.99	5.75	21.99	<b>4.62</b>	Parental conflict → No exams passed	52	14.17	7.52	24.82	<b>4.06</b>
7	Low attainment → Low verbal IQ	51	13.90	6.64	25.53	<b>4.82</b>	Hyperactivity → No exams passed	68	18.53	9.73	32.62	<b>4.49</b>	Poor housing → Heavy smoking	46	12.53	6.64	21.99	<b>3.96</b>
8	High darning → Hyperactivity	42	11.44	5.31	21.28	<b>4.82</b>	Hyperactivity → Unstable job record	37	10.08	4.87	18.44	<b>4.42</b>	Large family size → No exams passed	69	18.80	10.62	31.91	<b>3.95</b>
9	Convicted father → Early sex	43	11.72	5.75	21.28	<b>4.43</b>	Truancy → No exams passed	53	14.44	7.52	25.53	<b>4.22</b>	Depressed mother → Habitual drug use	43	11.72	6.19	20.57	<b>3.92</b>
10	Low income → Low verbal IQ	42	11.44	5.75	20.57	<b>4.24</b>	Early sex → Habitual drug use	52	14.17	7.52	24.82	<b>4.06</b>	Depressed mother → Heavy smoking	42	11.44	6.19	19.86	<b>3.75</b>
11	High delinq. school → Low nonverbal IQ	39	10.63	5.31	19.15	<b>4.22</b>	Hyperactivity → Habitual drug use	38	10.35	5.31	18.44	<b>4.03</b>	Poor housing → Unsta- ble job record	46	12.53	7.08	21.28	<b>3.55</b>
12	Low attainment → Low nonverbal IQ	47	12.81	6.64	22.70	<b>4.13</b>	Extraversion → Habitual drug use	37	10.08	5.31	17.73	<b>3.84</b>	Poor supervision → No exams passed	51	13.90	7.96	23.40	<b>3.53</b>
13	Low income → Low nonverbal IQ	44	11.99	6.19	21.28	<b>4.09</b>	Poor child rearing → Habitual drug use	37	10.08	5.31	17.73	<b>3.84</b>	High delinq. school → No exams passed	60	16.35	9.73	26.95	<b>3.42</b>
14	Poor housing → Hyperactivity	41	11.17	5.75	19.86	<b>4.06</b>	Early sex → Impulsiveness	41	11.17	6.19	19.15	<b>3.59</b>	High darning → No exams passed	76	20.71	12.83	33.33	<b>3.40</b>

**Table 2** (continued)

Risk factor	n	% RF	% NC RF	% C RF	OR	Sequences (ages 12–14 → 16–18)	n	% RF	% NC RF	% C RF	OR	Sequences (ages 8–10 → 16–18)	n	% RF	% NC RF	% C RF	OR
15 High neuroticism → Hyperactivity	37	10.08	5.75	17.02	<b>3.36</b>	Low verbal IQ → No exams passed	63	17.17	10.18	28.37	<b>3.50</b>	Depressed mother → No exams passed	69	18.80	11.50	30.50	<b>3.38</b>
16 Low nonverbal IQ → Hyperactivity	37	10.08	5.75	17.02	<b>3.36</b>	Poor child rearing → No exams passed	63	17.17	10.18	28.37	<b>3.50</b>	Low attainment → No exams passed	62	16.89	10.18	27.66	<b>3.37</b>
17 High extraversion → Low nonverbal IQ	39	10.63	6.19	17.73	<b>3.26</b>	Early sex → No exams passed	73	19.89	12.83	31.21	<b>3.08</b>	Harsh discipline → relation w/parents	37	10.08	5.75	17.02	<b>3.36</b>
18 Poor housing → Poor child rearing	49	13.35	7.96	21.99	<b>3.26</b>	Poor child rearing → Poor relation w/parents	41	11.17	7.08	17.73	<b>2.83</b>	Low verbal IQ → Hyperactivity	38	10.35	6.19	17.02	<b>3.11</b>
19 Poor housing → Low verbal IQ	46	12.53	7.52	20.57	<b>3.18</b>	Low nonverbal IQ → Heavy smoking	45	12.26	7.96	19.15	<b>2.74</b>	Young mother → No exams passed	50	13.62	8.41	21.99	<b>3.07</b>
20 Poor housing → Early sex	48	13.08	7.96	21.28	<b>3.12</b>	Low nonverbal IQ → No exams passed	83	22.62	15.93	33.33	<b>2.64</b>	Low income → No exams passed	66	17.98	11.50	28.37	<b>3.05</b>

%, % males with this sequence of risk factors; % NC, % of non-convicted males with this sequence; % C, % of convicted males with this sequence; Y, years old; OR, odds ratio. Bold values are statistically significant ( $p < .05$ )

convictions, the prevalence of this sequence was 3.54%, while among males with adult convictions, the percentage increased for 25.53% of the sample. The most predictive sequence of risk factors, combining the age ranges “8–10” and “16–18,” was having a convicted father followed by no exams passed. Almost one-third of males with adult convictions exhibited this sequence, while among non-convicted males, this figure is reduced to 7.96%.

### Sequences of Three Risk Factors Predicting Criminal Convictions

Table 3 presents the 20 combinations of risk factors measured between the ages 8 and 18, with at least one risk factor measured at each time point (8–10, 12–14, and 16–18 years old), that best predicted non-convicted versus convicted males between ages 18 and 61. The sequence of risk factors that exhibited the strongest differentiation consisted of parental conflict at ages 8–10, followed by delinquent friends at ages 12–14, and no exams passed at age 16–18. This sequence of risk factors also exhibited a very large effect size in predicting subsequent convictions (OR = 41.60; % convicted males = 15.60% versus % non-convicted males = 0.44%). Less than one in 200 non-convicted males displayed this exact sequence of risk factors, while this sequence was observed in approximately one in six to seven males with convictions after the age of 18. The most prevalent risk factors observed among these top 20 sequences were, at ages 8–10, high daring, at ages 12–14, association with delinquent friends, and, at ages 16–18, no exams passed. Coincidentally, the most prevalent sequence of risk factors (9.81%) in this list was “High daring 8–10 → Delinquent friends 12–14 → No exams passed 16–18.”

### Magnetic, Mixed, and Attracted Risk Factors in Sequences Leading to Criminal Convictions

Table 4 analyzes risk factors involved in sequences at ages 8–10, 12–14, and 16–18, leading to criminal convictions between ages 18 and 61. Specifically, it examines, through a set of statistical indicators, the relative contribution of each risk factor to crime-predictive sequences.

At ages 8–10, *magnetic risk factors* are displayed. These risk factors demonstrate a high likelihood of promoting other risk factors leading to crime-predicting sequences. Six out of 24 risk factors represent approximately 50% of the risk factors measured at ages 8–10 and identified within the aforementioned sequences of risk factors. These risk factors are as follows: poor housing (12.40%; MOR = 4.78), high daring (9.69%; MOR = 6.99), low nonverbal IQ (8.91%; MOR = 4.24), convicted father (6.20%; MOR = 5.68), low income (6.20%; MOR = 5.12), and low verbal IQ (6.20%; MOR = 4.78). At ages 8–10, poor housing is the most frequently involved risk factor in sequences of risk factors leading to crime. High daring is the second most frequently involved risk factor in these predictive sequences and exhibits the third largest influential power (MOR = 6.99), surpassed only by disrupted family (MOR = 7.11) and poor parental supervision (MOR = 7.10).

At ages 12–14, *mixed risk factors* are displayed. These risk factors are attracted by risk factors at age 8–10 and are also evaluated as *magnetic risk factors* for vulnerabilities at age 16–18. They are in the middle of sequences of risk factors from ages 8 to 18 leading to subsequent criminal convictions. Four out of 12 risk factors are represented in almost 60% of the significant sequences (58.14%) at ages 12–14. These risk factors are as follows: low nonverbal IQ (18.60%; MOR=4.69), early sex (14.34%; MOR=4.95), low verbal IQ (13.95%; MOR=5.03), and delinquent friends (11.24%; MOR=9.53). Low (verbal or nonverbal) IQ appears in almost one-third of predictive sequences (32.55%). Delinquent friends have the greatest influential power, with half of the sequences including delinquent friends at ages 12–14 having an OR equal to or greater than 9.53.

Regarding the *attracted risk factors*, more than 90% of predictive sequences are formed by one of the following five risk factors at ages 16–18: no exams passed (63.18%; MOR=4.66), unstable job record (10.08%; MOR=6.75), heavy smoking (7.75%; MOR=5.66), habitual drug use (5.04%; MOR=5.37), and low socioeconomic status (4.26%; MOR=6.47). In particular, no exams passed is present in more than half of the sequences (63.18%; MOR=4.24) and unstable job record is the second most important attracted risk factor ( $n=26$ ; 10.08%) and showed the strongest influential power (MOR=6.61). Over half of the 27 sequences of risk factors including unstable job record (26 of those sequences are statistically significant) have an ability to predict crime after 18 with an OR larger than (or equal to) 6.61.

## Discussion

This research aims to provide a renewed understanding of how each risk factor, at various stages of life, may precipitate, interact with, or contribute to specific subsequent events, particularly those conducive to criminal behavior. This study introduces a novel framework for conceptualizing, analyzing, and summarizing the role of risk factors in longitudinal studies. We also introduce the concepts of *magnetic*, *attracted*, and *mixed risk factors*. The analytical strategy behind these concepts offers a renewed perspective for comprehending the long-term impact of life events contributing to the development of antisocial behavior.

In this study, poor housing during childhood emerged as the most magnetic risk factor, that is, the most prevalent shared origin for crime-predictive developmental sequences. Children in impoverished environments are likely to be exposed to multiple other risks (e.g., Yoshikawa et al., 2012), giving rise, in our study, to the largest number of developmental chains of risk factors from childhood to emerging adulthood that led to adult criminal convictions. In addition, sequences of risk factors from childhood to early adulthood encompassing family disruption, poor supervision, and high risk-taking at ages 8–10 displayed the largest MOR for predicting crime from 18 to 61 years of age. We refer to these as risk factors exerting strong influential power, given that sequences from ages 8–18 that begin with any one of these risk factors tend to unfold into the most crime-predictive developmental sequences.

**Table 3** Top 20 sequences from ages 8–10, 12–14 to 16–18, discriminating between convictions from ages 18 to 61 ordered by odds ratios

Rank E.F.	Sequence	n	RF	% RF	% NC RF	% C RF	OR
1	Parental conflict 8 10y → Delinquent friends 12 14y → No exams passed 16 18y	23		6.27%	0.44%	15.60%	<b>41.60</b>
2	High daring 8 10y → Delinquent friends 12 14y → Heavy smoking 16 18y	21		5.72%	0.44%	14.18%	<b>37.19</b>
3	Convicted father 8 10y → Low nonverbal IQ 12 14y → Unstable job record 16 18y	20		5.45%	0.44%	13.48%	<b>35.04</b>
4	Low attainment 8 10y → Low nonverbal IQ 12 14y → Unstable job record 16 18y	19		5.18%	0.44%	12.77%	<b>32.93</b>
5	Low SES 8 10y → Delinquent friends 12 14y → No exams passed 16 18y	19		5.18%	0.44%	12.77%	<b>32.93</b>
6	Disrupted family 8 10y → Delinquent friends 12 14y → No exams passed 16 18y	29		7.90%	0.88%	19.15%	<b>26.53</b>
7	Low income 8 10y → Low nonverbal IQ 12 14y → Unstable job record 16 18y	23		6.27%	0.88%	14.89%	<b>19.60</b>
8	Poor supervision 8 10y → Delinquent friends 12 14y → No exams passed 16 18y	23		6.27%	0.88%	14.89%	<b>19.60</b>
9	Lacks concentration 8 10y → Delinquent friends 12 14y → No exams passed 16 18y	22		5.99%	0.88%	14.18%	<b>18.51</b>
10	Harsh discipline 8 10y → Delinquent friends 12 14y → Sexual promiscuity 16 18y	21		5.72%	0.88%	13.48%	<b>17.44</b>
11	High daring 8 10y → Delinquent friends 12 14y → Unstable job record 16 18y	20		5.45%	0.88%	12.77%	<b>16.39</b>
12	Low verbal IQ 8 10y → Low nonverbal IQ 12 14y → Unstable job record 16 18y	20		5.45%	0.88%	12.77%	<b>16.39</b>
13	Parental conflict 8 10y → Hyperactivity 12 14y → No exams passed 16 18y	20		5.45%	0.88%	12.77%	<b>16.39</b>
14	High daring 8 10y → Delinquent friends 12 14y → No exams passed 16 18y	36		9.81%	1.77%	22.70%	<b>16.29</b>
15	Depressed mother 8 10y → Delinquent friends 12 14y → Heavy smoking 16 18y	19		5.18%	0.88%	12.06%	<b>15.35</b>
16	High daring 8 10y → Early sex 12 14y → Low SES 16 18y	19		5.18%	0.88%	12.06%	<b>15.35</b>
17	High daring 8 10y → Low nonverbal IQ 12 14y → Unstable job record 16 18y	19		5.18%	0.88%	12.06%	<b>15.35</b>
18	Poor housing 8 10y → Truancy 12 14y → Poor relation w/ parents 16 18y	19		5.18%	0.88%	12.06%	<b>15.35</b>
19	High daring 8 10y → Delinquent friends 12 14y → Sexual promiscuity 16 18y	21		5.72%	1.33%	12.77%	<b>10.88</b>
20	High daring 8 10y → Truancy 12 14y → No exams passed 16 18y	26		7.09%	1.77%	15.60%	<b>10.26</b>

%, % males with this sequence of risk factors; % NC, % of non-convicted males with this sequence; % C, % of convicted males with this sequence; y, years old; OR, odds ratio. Bold values are statistically significant

**Table 4** Analysis of the magnetic (mixed and attracted) risk factors in trajectories of risk factors from 8–10 to 16–18 predicting crime from ages 18–61

Magnetic risk factors at 8–10 years old	12–14 years old				16–18 years old				MOR						
	n	%	Cum %	% Sig.	MOR	n	%	Cum %		% Sig.					
Poor housing	32	12.40	12.40	91.43	4.78	48	18.60	18.60	94.12	4.69	163	63.18	63.18	88.11	4.24
High darning	25	9.69	22.09	96.15	6.99	37	14.34	32.95	97.37	4.95	26	10.08	73.26	96.30	6.61
Low nonverbal IQ	23	8.91	31.01	92	4.24	36	13.95	46.90	97.30	5.03	20	7.75	81.01	90.91	5.07
Convicted father	16	6.20	37.21	100	5.68	29	11.24	58.14	100	9.53	13	5.04	86.05	100	5.37
Low income	16	6.20	43.41	94.12	5.12	28	10.85	68.99	100	5.66	11	4.26	90.31	100	6.47
Low verbal IQ	16	6.20	49.61	94.12	4.78	26	10.08	79.07	100	5.23	9	3.49	93.80	81.82	5.66
Depressed mother	14	5.43	55.04	93.33	4.50	25	9.69	88.76	78.13	4.04	9	3.49	97.29	90	4.01
Low attainment	14	5.43	60.47	100	5.94	13	5.04	93.80	86.67	3.31	3	1.16	98.45	100	4.69
Large family size	12	4.65	65.12	100	5.53	8	3.10	96.90	50	2.61	2	0.78	99.22	100	6.50
Harsh discipline	11	4.26	69.38	61.11	3.38	7	2.71	99.61	87.50	3.72	1	0.39	99.61	100	4.04
High delinq. school	10	3.88	73.26	90.91	4.04	1	0.39	100	50	2.61	1	0.39	100	100	3.72
Unpopular	9	3.49	76.74	90	2.91	0	0	100	0	2.14	0	0	100	0	1.07
Disrupted family	8	3.10	79.84	100	7.11	0	0	100	0	2.14	0	0	100	0	0.67
High impulsivity	8	3.10	82.95	80	3.60	0	0	100	0	2.14	0	0	100	0	-
Poor supervision	8	3.10	86.05	100	7.10	0	0	100	0	2.14	0	0	100	0	-
Lacks concentration	7	2.71	88.76	87.50	5.54	0	0	100	0	2.14	0	0	100	0	-
Young mother	7	2.71	91.47	100	4.04	0	0	100	0	2.14	0	0	100	0	-
High extraversion	6	2.33	93.80	60	2.93	0	0	100	0	2.14	0	0	100	0	-
Parental conflict	6	2.33	96.12	85.71	5.32	0	0	100	0	2.14	0	0	100	0	-
Low SES	4	1.55	97.67	100	4.65	0	0	100	0	2.14	0	0	100	0	-
High neuroticism	3	1.16	98.84	50	2.33	0	0	100	0	2.14	0	0	100	0	-
Interest in education	3	1.16	100	75	4.56	0	0	100	0	2.14	0	0	100	0	-
Nervous boy	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-
All Sequences - % Sig.	258/288														

Cum %, cumulative %. % Sig. = (Total n of statistically significant sequences including this risk factor / Total n of sequences including this risk factor). MOR, median odds ratio

According to our findings, counteracting the effects of impoverished settings during early childhood might help prevent many of the longitudinal sequences predictive of crime. Moreover, targeted interventions to prevent or mitigate the effects of family disruption, poor supervision, and high risk-taking (or high daring) during childhood may interrupt some of the most detrimental sequences of risk factors. This is pivotal, as these specific developmental challenges seem to serve as triggers of key risk factors leading to adult criminal convictions.

During adolescence, children with a high-risk-taking propensity are more likely to be affiliated with delinquent friends, and the sequence of these risk factors at these specific ages creates one of the most high-risk developmental sequences for both juvenile delinquency and adult offending. High daring during childhood is present in seven out of the top ten sequences predicting criminal convictions during adulthood, and in all these cases, it is consistently followed by association with delinquent friends during the teenage years. McGloin and Shermer (2009) state that “self-control does influence peer involvement, which has a direct effect on offending behavior” (p. 59). In the same vein, our results suggest that, among youths with a high-risk-taking propensity, it might be crucial to prevent affiliation to delinquent peers. Therefore, our work indicates that, for children exhibiting an early high-risk-taking predisposition, it is essential to encourage interaction with prosocial groups (e.g., promoting structured leisure activities) and break sequences leading to multiple affiliations with deviant peers.

Low (verbal and nonverbal) IQ appear as the most important risk factors at ages 12–14. In sequences including low IQ, this risk factor often emerges after family socioeconomic disadvantage at ages 8–10, such as large family size, low family income, or poor housing. As many studies have found (e.g., Hanscombe et al., 2012), IQ is not a static variable, and it is plausible that an impoverished family environment influences children’s intelligence levels. In fact, low IQ might have been exacerbated by the effects of extreme poverty, and, in some instances, by dysfunctional parenting styles during childhood (Jensen et al., 2017). Therefore, for children in socioeconomically disadvantaged settings, it is important to address and mitigate its potential consequences on cognitive development and academic success. This can be achieved by enhancing conditions for cognitive and intellectual stimulation and supporting academic success among impoverished neighborhoods.

In the transition between late adolescence and young adulthood (16–18 years old), almost all paths appear to lead to educational and occupational failure, as well as, in some cases, addictive behavior. According to the proposed conceptualization, these are the most attracted risk factors by crime predictive sequences. Particularly, three-quarters of crime predictive sequences ended with either no exams passed or an unstable job record. From the remaining one-quarter of these sequences, approximately 14% led, at ages 16–18, to habitual drug use and/or heavy smoking. Consequently, for adolescents with these previous risk factors transitioning to adulthood, it is important to promote social integration and a structured lifestyle, through professional and vocational programs. It is also important to prevent addictive behavior.

Our findings support several fundamental predictions of the ICAP theory. The critical risk factors identified by this theoretical framework are central to the most relevant crime-predicting sequences. Furthermore, our work corroborates the ICAP

theory in emphasizing the sequential and dynamic interplay among these factors in promoting long-term antisocial potential. Additionally, this framework proposes that the impact of a specific risk factor can vary over time, potentially intensifying or diminishing during different developmental periods. Our work also adds to ICAP predictions that impulsivity and attachment and socialization processes are particularly relevant in earlier ages, while the role of antisocial peers emerges as particularly important across sequences during adolescence. Risk factors enhancing long-term energizing processes are important throughout the entire developmental process, but they are even more relevant in the transition to adulthood. Our findings suggest that enhancers of long-term energizing processes leading to adult convictions change their form across different developmental stages (childhood: impoverished settings; early adolescence: low IQ; transition to adulthood: school failure; unstable job record). These enhancers not only change in form; many of them contribute to long-term energizing processes in the next developmental stages leading to the most concerning crime-predictive sequences.

To sum up, according to our findings, at each developmental stage, specific risk factors intricately intertwine to establish chains of risk that underlie criminal behavior. Childhood vulnerabilities, exemplified by daring conduct, and familial challenges, such as family poverty (e.g., poor housing) or dysfunctional parenting, increase the likelihood of forming bonds with delinquent peers during early adolescence. Whether in isolation or in conjunction with diminished IQ, this convergence leads to academic and professional underachievement, fostering long-term chains of risk (e.g., unstructured routines, difficulty achieving success and acquiring money through legal means, exposure to antisocial models) for criminal convictions.

It is valuable to acknowledge the limitations of this study. Firstly, the CSDD sample comprises only males, and a limited number of assessments were conducted between the ages of 8 and 18. While the 8–18 risk factors were measured with a considerable level of accuracy according to present research standards, and have been providing invaluable insights into the lifelong impact of sequences of risk factors, it is important to acknowledge that these measurements were taken at a time when the social and economic landscape of the United Kingdom were different. For example, at that time, there were fewer ethnic minorities, fewer divorced parents, and less awareness of and mechanisms against domestic violence.

Secondly, the implementation of this statistical strategy required the dichotomization of variables. Other statistical methodologies, more suited for handling continuous predictors, are used to explore more nuanced and graduated relationships in data, such as age or salary. However, the rationale of this work does not focus on, nor theoretically assumes, a linear and equivalent impact of each level of the predictor on the measured outcome. For instance, while we anticipate that a dilapidated house may impact convictions, we do not expect that a very minor change in housing structure would result in any change in the risk of convictions. Instead, our attention is directed towards identifying a subgroup significantly affected by the risk factor, which is also significantly prevalent. Whereas we argue that the inherent nature of how these predictors were assessed, and the objectives of this study, justifies this methodological decision, it is important to highlight that dichotomizing variables can involve some relevant limitations, including information loss or reduced

power, although these are not very important in this specific case (for a review, see Iselin et al., 2013).

Thirdly, the exclusion of participants lacking a minimum of 14 consecutive years of data following the measurement of the last risk factor (at age 18) resulted in a sample of 367 males (almost 90% of the original sample). This criterion, required due to the absence of follow-up data from early mortality and emigration, may slightly increase the risk of selection bias. In addition, the approach of imputing missing data across risk factors using the most frequent value, while necessary, it can lead to reduced variability, particularly in risk factors with a large proportion of missing data. To mitigate the impact of this imputation strategy, we excluded a small proportion of risk factors (five risk factors) with more than 10% missing data. This targeted exclusion aimed to balance the integrity of our analysis with the inherent limitations of the data available.

Lastly, the limited age range of 8 to 18 years fails to capture the dynamic and evolving nature of criminogenic influences that manifest during adulthood. Additionally, while the extensive period of follow-up, assessed from ages 18 to 61 years, offers invaluable longitudinal insights, the binary assessment of conviction status it may oversimplify the nuanced complexity inherent in the development of criminal careers.

Therefore, it is essential to replicate our research using more contemporary longitudinal datasets that include more accurate measures, shorter assessment intervals, and ethnically and gender-diverse samples. Moreover, future studies could benefit from a longitudinal approach that spans a wider range of life stages and explores more refined measures of criminal outcomes to capture the dynamic nature of criminal careers. These considerations would contribute to more comprehensive insights in criminological research.

Research about the developmental sequences of antisocial behavior is still in its preliminary stages. Nonetheless, this study presents compelling evidence of predictive sequences of risk factors for offending, enabling the prevention of subsequent risk factors through tailored interventions. Particularly, the study of *magnetic, mixed, and attracted factors* aims to enhance our understanding of how risk factor interactions and evolution through developmental stages increase the risk of criminal convictions. For instance, *magnetic risk factors* are of particular interest for early-targeted interventions, considering that they are, by definition, followed more than expected by chance, by multiple risk factors in later stages of life, leading to crime-predicting sequences. Thus, identifying and addressing these age-graded risk factors could be pivotal in preventing the chain of risk factors promoting criminal careers.

Simultaneously, *attracted factors* were preceded by multiple risk factors, culminating in high-risk sequences. Therefore, if an adolescent displays numerous risk factor sequences from childhood through adolescence that, according to evidence-based knowledge, culminate in the same attracted risk factor, this specific attracted risk factor represents a potential and particularly relevant future criminogenic need that should be targeted for prevention. In this context, this work represents an exploratory step towards transitioning from a risk-need-responsivity approach to a *trajectory-of-risk-need-responsivity* approach. In other words, the development of this area and the replication of this study across multiple cohorts may contribute to robust evidence-based knowledge, enabling the development of assessment tools.

These tools can identify specific future high-risk criminogenic needs anticipated in an individual's risk sequence and facilitate early prevention.

**Acknowledgements** We would like to express our gratitude to the reviewers for their insightful comments and recommendations.

**Funding** Open access funding provided by FCTIFCCN (b-on). This work is part of the research project “ChainPrevent - The chain of events underlying the development and persistence of antisocial behaviour: Moving forward in Tailored Crime Prevention Strategies” and is funded by the FCT – Foundation for Science and Technology, I.P. (Fundação para a Ciência e a Tecnologia, I.P.), under the project reference: «2022.03898.PTDC». This work is also funded with national funds from FCT – Fundação para a Ciência e Tecnologia, I.P., in the context of the project UID/04810/2020.

## Declarations

**Informed Consent** Informed consent was obtained from all participants involved in this research.

**Conflict of Interest** The authors declare no competing interests.

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