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CHAPTER

3

The Development and Validation of an Actuarial Risk Assessment Tool for the Prediction of First-Time Offending (Y-ARAT-FO)

This chapter is adapted from:
Assink, M., Van der Put, C. E., & Stams, G. J. J. M. (2016).
The development and validation of an actuarial risk assessment
tool for the prediction of first-time offending.
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Abstract

For prevention purposes, it is important that police officers can estimate the risk for delinquency among juveniles who were involved in a criminal offense, but not in the role of a suspect. In the present study, the Youth Actuarial Risk Assessment Tool for First-Time Offending (Y-ARAT-FO) was developed based solely on police records with the aim to enable Dutch police officers to predict the risk for first-time offending. For the construction of this initial screening instrument, an Exhaustive CHAID analysis was performed on a dataset that was retrieved from the Dutch police system. The Y-ARAT-FO was developed on a sample of 1,368 juveniles and validated on a different sample of 886 juveniles showing moderate predictive accuracy in the validation sample (AUC = .728). The predictive accuracy of the Y-ARAT-FO was considered sufficient to justify its use as an initial screening instrument by the Dutch police.

Keywords: actuarial risk assessment, screening, first-time offending, juvenile delinquency, CHAID analysis

3.1 Introduction

The most important goal of prevention strategies in the area of juvenile delinquency is to prevent onset of delinquent behavior rather than treating juvenile delinquents (DeMatteo & Marczyk, 2005). At least four different reasons can be put forward to the rationale of these prevention strategies. First, juvenile delinquency is a serious societal problem with detrimental physical and mental health effects for both victims and offenders (e.g., Krug, Dahlberg, Mercy, Zwi, & Lozano, 2002; McGuw, & Iacono, 2005; Piquero, Daigle, Gibson, Leeper Piquero, & Tibbets, 2007). Second, a considerable amount of literature shows that signs of chronic antisocial behavior, which are predictive of later delinquency, can already be recognized early in the juvenile's life (Dishion & Patterson, 2006; Loeber, Farrington, Stouthamer-Loeber, & White, 2008) and can therefore be targeted by early prevention efforts. Third, as children and adolescents grow older, problem behavior tends to become more stable, which makes it more difficult to change (Bernazzani, Cothe, & Tremblay, 2001). Fourth, since delinquency is associated with significant monetary costs to society, investing in early prevention efforts can have substantial financial benefits (e.g., Nores, Belfield, Barnett, & Schweinhart, 2005).

Prevention programs are often characterized by broad-based and systemic efforts targeting juveniles at high risk for delinquent behavior. To identify these high risk children and adolescents, it is important that valid and reliable screening instruments be available, that can predict the likelihood of becoming a delinquent. To date, numerous risk assessment tools have been developed and reported on in scientific literature, but most of these instruments were designed for estimating the likelihood of recidivism among juveniles who already have committed one or more offenses. To our knowledge, no valid and reliable instrument is yet available for predicting the onset of general delinquency among juveniles. Therefore, the current study describes the development of a risk screening instrument for predicting the risk for onset of general delinquency among juveniles. The psychometric quality of this instrument will be considered by examining its predictive validity.

In the Netherlands, the police is an important link in the chain of youth care because police officers do not only deal with juvenile offenders, but also with a substantial number of juvenile non-offenders who are in some way involved in a criminal offense, but not in the role of a suspect. For example, from a large sample of juveniles who came into contact with the Dutch police in 2007 ($N = 9,531$), we could derive that 66.4% ($n = 6,331$) of these juveniles was an offender (i.e., having the role of a suspect) and 33.6% ($n = 3,200$) of these juveniles was a non-offender (i.e., having any role other than that of a suspect). Although the juveniles in the latter group have never been recorded by the Dutch police as being suspected of an offense, they may be at risk for future

delinquency. Previous research has shown that juveniles involved in a criminal offense as a witness or a victim are at elevated risk for delinquency (e.g., Hurt, Malmud, Brodsky, & Giannetta, 2001; Loeber, Kalb, & Huizinga, 2001; Patchin, Huebner, McClusky, Varano, & Bynum, 2006). These juveniles should have the opportunity to benefit from preventive strategies that increase their well-being in the long term by preventing the onset of delinquency.

For this preventive effort to be effective, it is essential that the police be able to identify which juvenile non-offenders are at high risk for delinquency, so that they can be timely referred to other specialized agencies in the chain of youth care for a more thorough assessment and, if necessary, treatment to counteract the risk for first-time offending. Hence, the aim of the present study was to examine whether a risk screening instrument based on official police records could be developed, enabling Dutch police officers who lack significant clinical experience to make an initial screening of the risk for onset of general delinquency among juvenile non-offenders. In the development of this instrument, we only used information available in operational police systems so that an automatic assessment process would be possible within limited time and resources available to Dutch police officers.

Today, different methods are being used in the field of forensic risk assessment. One of the dominant contemporary approaches to risk assessment is actuarial prediction (Singh, 2012). Actuarial (or statistical) risk assessment instruments estimate the likelihood of future delinquency through the assignment of numerical values to factors that are empirically associated with delinquency. A statistical algorithm is then used to calculate a probabilistic estimate of future delinquency from a total test score. In this actuarial approach, each individual is appraised using the same criteria so that individuals can be directly compared to others who have had the same tool administered regardless of who conducted the assessment (Singh, Grann, & Fazel, 2011).

A large body of literature showed that the actuarial method for risk assessment performs as well as clinical methods or is even more accurate (e.g., Ægisdóttir et al., 2006; Dawes, Faust, & Meehl, 1989; Fazel, Singh, Doll, & Grann, 2012; Grove & Meehl, 1996; Grove, Zald, Lebow, Snitz, & Nelson, 2000; Meehl, 1954; Hanson & Morton-Bourgon, 2009). On the other hand, actuarial models have been criticized, for instance because purely actuarial predictions do not sufficiently take into account individual differences (Sreenivasan, Kirkish, Garrick, Weinberger, & Phenix, 2000). In addition, Scott and Resnick (2006) stated that actuarial instruments are rigid, lacking sensitivity to change and cannot be generalized to populations other than the sample that was used to construct the instrument. Furthermore, it should be noted that actuarial methods are less suitable for making decisions about effective treatment.

Despite these critical comments, an actuarial approach to risk assessment seemed most appropriate to us in the present study, for several reasons. First, Dutch police officers will only conduct an *initial* screening of risk with the aim to identify those juveniles who are at high risk for onset of delinquency and who are in need of further assessment by a more specialized agency in the chain of youth care. Second, an actuarial approach to risk screening reduces unwarranted disparities in decision making (e.g., racial and gender biases) relative to professional judgment approaches (Young, Moline, Farrell, & Bierie, 2006). Third, an actuarial risk assessment instrument was preferred above other instruments because of the ease of use, the relatively low costs for training and materials and the possibility of a rapid risk screening. These are important issues, because Dutch police officers do not have the time, resources and expertise to engage in thorough clinical assessment, meaning that only information on juveniles derived from the Dutch police system is available to police officers. Finally, previous research suggests that developing a risk screening tool using only data derived from a police system can be a fruitful approach. For an elaborate discussion on the potential of data mining in the criminal justice context, see the work of Berk (2012).

In sum, the aim of the present study was to develop a valid and reliable actuarial risk screening instrument for predicting the risk for onset of general delinquency among juvenile non-offenders. This instrument will be further referred to as the Youth Actuarial Risk Assessment Tool for First-Time Offending (Y-ARAT-FO). In developing this instrument, the same procedure was used as in the development of the Youth Actuarial Risk Assessment Tool (Y-ARAT), which is a risk screening instrument for the prediction of general offense recidivism among juvenile offenders and which was also solely based on Dutch police records (Van der Put, 2014). The construction and validation of the Y-ARAT-FO comprised several steps. First, we examined the extent to which police records were related to delinquency. Second, we examined whether an actuarial risk screening instrument could be developed with a sufficiently high predictive value, using only police records with a history of ten years. Third, we examined whether the instrument was suitable for predicting specific types of delinquent behavior.

3.2 Methods

3.2.1 Sample

The sample consisted of 2,254 juveniles between the ages of 12 and 18 years ($M = 15.5$, $SD = 1.7$), who were registered in official Dutch police records in 2007 because they were involved in an offense, but not in the role of a suspect. These juveniles were selected at random from all juveniles who came into contact with the Dutch police in 2007 in

the police regions “Hollands-Midden” and “Rotterdam-Rijnmond”. To construct and validate the model, the sample was split randomly into a construction sample (60%, $n = 1,368$) and a validation sample (40%, $n = 886$). The size of the full sample ($N = 2,254$) was sufficiently large for splitting this sample into a construction and validation sample and to perform an Exhaustive CHAID analysis in which the total group is divided into a number of smaller subgroups. No significant differences were found between the construction and validation sample in terms of gender ($\chi^2(1) = .035, p = .829$), country of birth ($\chi^2(1) = .000, p = 1.000$), and age ($t(2,252) = .514, p = .607$).

3.2.2 Data Collection

The random sample of juveniles registered in official police records was drawn from two regional computer systems of the Dutch police. Juveniles who were involved in an incident that took place in 2007 were selected, meaning that the incident in 2007 was taken as the index incident. The juveniles involved in these incidents had any role other than that of a suspect (i.e., victim, witness, reporter of an offense, missing person, a juvenile attracting police attention or a juvenile having any role not otherwise defined by the Dutch police) and had never been recorded by the police as a suspect of an offense. The records of these juveniles were retrieved from the police system for a period of ten years prior to the date on which the index incident took place (i.e., from 1997 to 2007). Data about delinquent behavior were also retrieved from the system in the form of official records. Onset of delinquency was defined as a juvenile being suspected by the police of committing an offense within a period of three years after the index incident took place (i.e., from 2007 to 2010). The juvenile was recorded in the police registration system as having the role of a suspect in these offenses. In the Netherlands, a juvenile being registered as a suspect means either that the juvenile was caught by the police in the act of committing an offense (after which the juvenile was arrested) or that a juvenile was summoned to the police station because the police was convinced that the juvenile had committed an offense. In both situations, there is a temporal deprivation of liberty for the juvenile.

Prior to the construction of an assessment instrument, it is important to determine which predictor variables should be included in the analysis. The designated predictor variables were based on both information from literature reviews of risk factors for the onset of juvenile delinquency (e.g., Loeber, 1990; Smith, 2004; Youth Justice Board, 2005) as well as expertise of the Dutch police gained in the development of ProKid, which is a risk screening instrument for juvenile offenders younger than 12 years of age (Abraham, Buysse, Loef, & Van Dijk, 2011). Information on police records of co-occupants at the juvenile's living address was also retrieved. Table 3.1 presents the predictor variables that were established from the police records.

3.2.3 Analyses

We developed the risk screening instrument by conducting a tree classification method designated as Exhaustive Chi-squared Automatic Interaction Detector (Exhaustive CHAID) analysis. Tree classification methods like CHAID are very useful for gaining insight into profiles of youth with a high and low probability for delinquency (Steadman et al., 2000; Thomas & Leese, 2003). The purpose of CHAID is to create homogenous groups based on the value of a specific outcome variable (in the present study, onset of delinquent behavior among juveniles) by splitting cases into two or more groups on the basis of several predictor variables (Biggs, De Ville, & Suen, 1991; Kass, 1980). This technique is particularly useful if a study is exploratory rather than confirmatory, if the analysis involves relations between a number of independent variables and a single dependent variable, if these independent variables interact with each other, and if there is no strong theory about the relative importance of the independent variables in predicting the dependent variable (Boslaugh, Kreuter, Nicholson, & Naleid, 2005). A limitation of this analysis is that the time period within which a juvenile commits the first offense cannot be taken into account. However, we preferred CHAID analysis above logistic regression since the results are visually presented and therefore easily interpretable, which is of high importance for practical use by, for instance, police officers or youth care workers without substantial clinical expertise. Although CHAID and Exhaustive CHAID are very similar algorithms, the latter was preferred in the current study because Exhaustive CHAID performs a more thorough merging and testing of predictor variables than the regular CHAID algorithm (Biggs, De Ville, & Suen, 1991).

The CHAID algorithm as applied in the current study involved dividing the total group of juveniles into a number of subgroups on the basis of the independent variables most strongly associated with delinquent behavior. The procedure for this analysis comprises a number of steps in which the first step is to divide the total group into a number of subgroups on the basis of the variable most strongly associated with delinquent behavior. In the next step, the subgroups are split again on the basis of the variable that is second most strongly associated with delinquent behavior. This stepwise procedure is repeated until there are either no more variables that have a significant association with delinquent behavior or until the subgroups have reached a minimum size ($n = 25$ in the current study). The result is a visual tree model in which each terminal node represents a "risk group" in which juveniles have similar police records and thus a similar risk for committing a first offense. When interpreting the tree model from top to bottom one can identify how the juveniles in each risk group score on the predictor variables that are part of the instrument. To build the CHAID tree model, the total group of juveniles was randomly divided into two groups; about 60% of the sample was used to build the model (construction sample) and about 40% of the sample was used to validate the model (validation sample).

Table 3.1. Background Characteristics and Types of Police Records: Descriptives and Association with Delinquent Behavior (Total Sample; N = 2,254)

Categorical independent variables	M	SD	Range	ϕ
Male (0 = No; 1 = Yes)	.547	.498	0 – 1	.173***
Born outside the Netherlands (0 = No; 1 = Yes)	.069	.253	0 - 1	.041
Continuous independent variables				r_b
Current age	15.499	1.660	12 – 18	-.155***
Age at first incident (all roles other than suspect)	14.109	1.986	4 – 17	-.222***
Number of incidents (all roles other than suspect)	2.177	2.018	1 – 25	.256***
Number of incidents (involved as victim)	.550	.799	0 – 7	-.039
Number of incidents (involved as witness)	.191	.472	0 - 4	-.121***
Number of incidents (involved as witness of violence)	.067	.277	0 - 3	-.033
Number of incidents (involved as aggrieved person or reporter of an offense)	.208	.490	0 - 4	-.012
Number of incidents (recorded by the police, not having a specific role)	.021	.155	0 - 2	.089**
Number of incidents (involved in all roles other than suspect), type of incident:				
Non-violent property offense	.311	.562	0 - 4	-.020
Violent property offense	.043	.215	0 – 2	.057
Public order offense without violence	.559	1.034	0 – 13	.274***
Public order offense with violence	.039	.221	0 - 2	-.015
Sex offense without violence	.029	.185	0 – 2	.017
Sex offense with violence	.042	.229	0 – 3	-.032
Other offense without violence	.921	1.279	0 – 21	.160***
Other violent offense	.235	.559	0 - 6	.066*
Number of incidents in which weapons were involved at the juvenile's living address (the juvenile does not need to be involved in this incident)	.012	.167	0 – 3	-.036
Number of incidents involving domestic violence at the juvenile's living address (the juvenile does not need to be involved in this incident)	.096	.610	0 - 9	-.042
Number of incidents of sexual offenses at the juvenile's living address (the juvenile does not need to be involved in this incident)	.087	.949	0 - 17	-.032
Number of incidents of child abuse at the juvenile's living address (the juvenile does not need to be involved in this incident)	.004	.067	0 - 2	-.008

Table 3.1. Background Characteristics and Types of Police Records: Descriptives and Association with Delinquent Behavior (Total Sample; $N = 2,254$) (Continued)

Continuous independent variables				r_b
Number of incidents in which a co-occupant at the juvenile's living address was a suspect	4.169	27.581	0 - 481	.077*
Number of incidents of child abuse in which a co-occupant at the juvenile's living address was involved (in any role)	.026	.275	0 - 7	.026
Number of incidents of neglect in which the juvenile and/or a co-occupant at the juvenile's living address was a victim	0	0	0 - 0	-. ^a
Number of incidents of conflicts in which a co-occupant at the juvenile's living address was a victim	.342	3.443	0 - 122	.039
Number of incidents of domestic strife in which the juvenile and/or a co-occupant at the juvenile's living address was a victim	.051	0.529	0 - 21	.056

Note. Delinquent behavior was defined as a juvenile being suspected by the police of committing an offense within a period of three years after the index incident took place.

Correlations $\geq .20$ and $\leq -.20$ are in boldface to highlight the strongest associations.

ϕ = phi-coefficient; r_b = biserial correlation.

^a The biserial correlation could not be calculated, since this variable was a constant.

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

The sensitivity, specificity, false positive and false negative rates, positive and negative predictive value, overall accuracy and diagnostic odds ratios were examined in the validation sample and at different cut-off scores to assess the predictive validity of the instrument. Several researchers recommend reporting area under the receiver operating characteristic curve (AUC) values as the preferred statistic of predictive or diagnostic accuracy (e.g., Rice, & Harris, 2005; Mossman, 1994) and therefore AUC values were also calculated in the present study. Moreover, by reporting AUC values, the results of our study can be more easily compared to results of other risk assessment studies.

3.3 Results

3.3.1 Prevalence of Offenses

An overview of the prevalence of offenses within the three-year period after the index incident can be found in Table 3.2 for both the construction and validation sample. In total, the percentage of juveniles that started offending was 15.79% ($n = 216$) and 15.91% ($n = 141$) respectively. No statistical significant differences were found in the prevalence of (different types of) offenses between the construction and validation sample.

Table 3.2. *Prevalence of Different Offense Types within Three Years after the Index Offense*

	Total sample (N = 2,254)		Construction sample (n = 1,368)		Validation sample (n = 886)		$\chi^2(1)^b$
	n ^a	%	n ^a	%	n ^a	%	
Total number of juveniles that committed an offense	357	15.84	216	15.79	141	15.91	.000
Specific type of offense:							
Violent offense	59	2.60	34	2.50	25	2.80	.125
Property offense ^c	203	9.01	127	9.28	76	8.58	.246
Public order offense ^c	148	6.57	84	6.14	64	7.22	.859
Sexual offense ^c	4	.18	2	.15	2	.23	.000
Other offense ^c	198	8.78	118	8.63	80	9.02	.065

^a Number of unique juveniles in the sample that committed the offense.

^b Chi-square tests with Yates' correction were conducted to determine significant differences between the construction and validation sample. No significant Chi-square test results were found.

^c Either violent or non-violent in nature.

3.3.2 Risk Factors for Delinquency

Table 3.1 shows the association between the variables that were retrieved from the police system and delinquent behavior. The variables most strongly associated with delinquent behavior were (1) age at first recorded incident in which the juvenile was involved (not in the role of a suspect); (2) total number of recorded incidents in which the juvenile was involved (not in the role of a suspect) and (3) number of recorded public order offenses without violence in which the juvenile was involved (not in the role of a suspect).

3.3.3 Development of the Y-ARAT-FO

To develop the Y-ARAT-FO, we conducted an Exhaustive CHAID analysis. The variables from Table 3.1 were included as independent variables and the dependent variable was whether or not juveniles were registered in the Dutch police system as a suspect in the three-year period after the index incident. Figure 3.1 presents the CHAID output for the validation sample. To validate the CHAID model, the tree nodes that were derived by the CHAID algorithm in the construction sample were specified a priori in the validation sample, rather than allowing the algorithm to run new analyses using the same variables. When the CHAID algorithm ended, the following five variables were part of the CHAID model: (1) the total number of previously recorded incidents in which the juvenile had any role other than that of a suspect, (2) the gender of the juvenile, (3) the total number of recorded incidents in which a co-occupant at the juvenile's living address was a suspect, (4) whether or not the juvenile was born in the Netherlands, and

(5) the current age of the juvenile. As can be seen in Figure 3.1, the tree classification diagram consists of ten end nodes that represent ten different “risk groups”. In each risk group, juveniles have similar scores on the variables that comprise the Y-ARAT-FO and thus a similar risk for committing a first offense. The risk for delinquent behavior ranged from .05 in the lowest risk group to .43 in the highest risk group, meaning that 5% of the juveniles in the lowest risk group and 43% of the juveniles in the highest risk group will become an offender. For each new case that Dutch police officers are confronted with, the predicted probability of offending equals the proportion of offenders in one of the risk groups (i.e., one of the grey-shaded end nodes in Figure 3.1), into which each case is classified depending on the sequence of the variables that are part of the tree classification diagram.

3.3.4 Predictive Power of the Y-ARAT-FO

To assess the predictive power of the Y-ARAT-FO, AUC values were calculated for both the construction and validation sample. The AUC values were .724 ($p < .001$, 95% CI [.700, .748]) in the construction sample and .728 ($p < .001$, 95% CI [.697, .757]) in the validation sample, and were not statistically different ($Z = .004$, $p = .903$). The sensitivity, specificity, false positive and false negative rates, predictive values, overall accuracy and diagnostic odds ratio of the Y-ARAT-FO are presented in Table 3.3. These test performance outcomes were all calculated for the performance of the Y-ARAT-FO in the validation sample. Since these measures are dependent on a cut-off score above which the test result of the Y-ARAT-FO is considered positive, the test performance outcomes were calculated for different cut-off scores. These cut-off scores equal the risk for offending behavior of the different ‘risk groups’ that were produced by the CHAID analysis in the construction sample (i.e., the proportion of juveniles that start offending of every end node in the tree diagram that was produced in the construction sample). The sensitivity of the test refers to the proportion of juveniles who start offending and test positive, while the specificity refers to the proportion of juveniles who will not start offending and test negative. Ideally, a test should have high sensitivity and high specificity. However, sensitivity and specificity are inversely related, meaning that when sensitivity is high, specificity is low and vice versa.

In Table 3.3, the false positive rate is the chance of testing positive among juveniles who do not start offending and the false negative rate is the chance of testing negative among juveniles who do start offending. The positive predictive value refers to the probability that a juvenile scoring above a particular cut-off score is correctly identified as someone who will start offending, whereas the negative predictive value refers to the probability that a juvenile scoring below a particular cut-off score is correctly identified as someone who will not start offending.

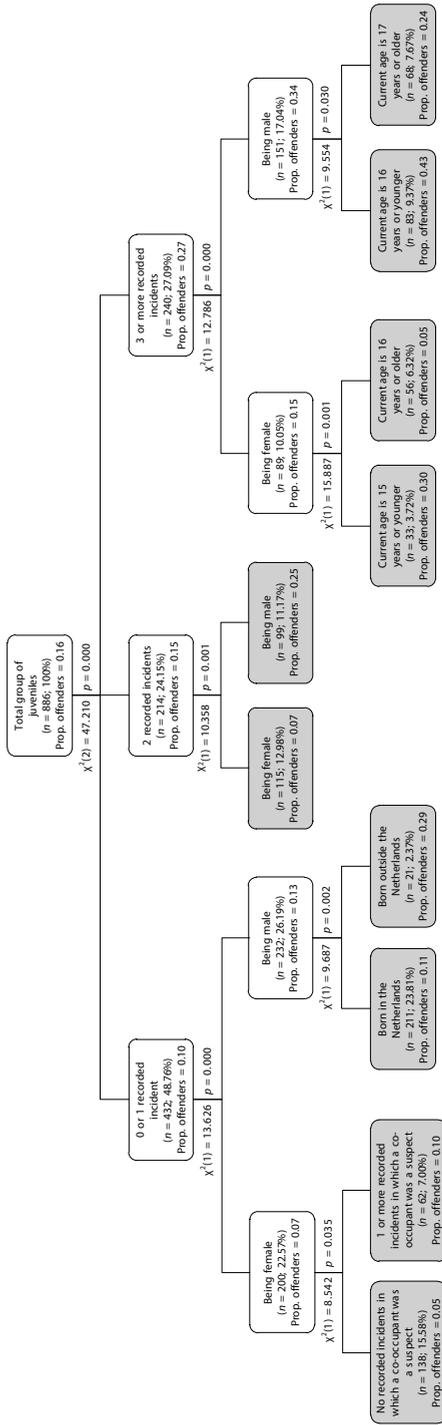


Figure 3.1. Classification Tree for the Validation Sample

Note. The ten grey-shaded terminal nodes represent the “risk groups” in which juveniles have similar scores on the variables that comprise the Y-ARAT-FO, and thus a similar risk for committing a first offense. Y-ARAT-FO = Youth Actuarial Risk Assessment Tool for First-Time Offending; n (%) = number of juveniles that are classified in each tree node and the percentage of the total group of juveniles; Prop. offenders = proportion of offending juveniles in each tree node.

Table 3.3. Estimates (and 95% Confidence Intervals) of Performance Measures for Different Cut-off Scores of the Y-ARAT-FO

Cut-off score (>) ^a	Sensitivity (95% CI)	Specificity (95% CI)	False Positive Rate (95% CI)	False Negative Rate (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)	Overall Accuracy (95% CI)	Diagnostic Odds Ratio (95% CI)
.032	.950 (.900 - .980)	.176 (.149 - .205)	.824 (.797 - .852)	.050 (.014 - .086)	.179 (.152 - .209)	.949 (.898 - .979)	.299 (.269 - .329)	4.084 (1.867 - 8.936)
.080	.894 (.831 - .939)	.320 (.286 - .354)	.681 (.647 - .714)	.106 (.056 - .144)	.199 (.169 - .232)	.941 (.904 - .966)	.411 (.378 - .443)	3.943 (2.259 - 6.883)
.089	.872 (.806 - .923)	.391 (.355 - .427)	.609 (.574 - .644)	.128 (.073 - .165)	.213 (.180 - .249)	.942 (.909 - .965)	.467 (.434 - .500)	4.380 (2.614 - 7.338)
.112	.830 (.757 - .888)	.466 (.429 - .502)	.534 (.498 - .570)	.170 (.108 - .209)	.227 (.192 - .266)	.935 (.905 - .958)	.524 (.491 - .557)	4.250 (2.677 - 6.748)
.124	.660 (.575 - .737)	.717 (.683 - .749)	.283 (.251 - .316)	.340 (.262 - .379)	.306 (.255 - .361)	.918 (.892 - .939)	.708 (.678 - .738)	4.903 (3.343 - 7.192)
.213	.482 (.397 - .568)	.816 (.786 - .843)	.184 (.156 - .212)	.518 (.435 - .555)	.332 (.268 - .401)	.893 (.867 - .915)	.763 (.735 - .791)	4.134 (2.831 - 6.038)
.225	.369 (.289 - .454)	.886 (.861 - .908)	.114 (.091 - .137)	.631 (.552 - .666)	.380 (.298 - .467)	.881 (.856 - .903)	.804 (.778 - .830)	4.537 (3.011 - 6.836)
.355	.326 (.250 - .410)	.906 (.883 - .926)	.094 (.073 - .115)	.674 (.596 - .707)	.397 (.307 - .492)	.877 (.851 - .899)	.814 (.788 - .839)	4.669 (3.039 - 7.175)
.370	.255 (.186 - .336)	.937 (.917 - .953)	.063 (.046 - .081)	.745 (.673 - .775)	.434 (.325 - .548)	.869 (.844 - .892)	.828 (.804 - .853)	5.092 (3.150 - 8.230)

Note: The presented measures pertain to the performance of the Y-ARAT-FO in the validation sample. Y-ARAT-FO = Youth Actuarial Risk Assessment Tool for First-Time Offending; 95% CI = 95% confidence interval.

^a If a test score on the Y-ARAT-FO (i.e., the probability of committing a first offense) is greater than the cut-off score, the test result is considered positive, otherwise, it is considered negative.

The overall accuracy refers to the proportion of offending and non-offending juveniles correctly classified by the instrument. Finally, the diagnostic odds-ratio is a measure for the discriminative power of the test, which is base rate resistant and refers to the ratio of a true positive result relative to the odds of a false positive result. A higher diagnostic odds ratio indicates a good test performance and unlike the AUC value, it can take into account different cut-off values.

3.3.5 Predictive Power of the Y-ARAT-FO for Predicting Specific Types of Offenses

Finally, it was examined whether the Y-ARAT-FO can be used for the prediction of specific types of delinquent behavior (see Table 3.4). The Y-ARAT-FO showed an acceptable predictive accuracy for the prediction of violent (AUC = .702), property (AUC = .737), public order (AUC = .751) and other offenses (AUC = .731) in the validation sample. A somewhat less optimal predictive accuracy was found for the prediction of property offenses in the construction sample (AUC = .682), but this did not differ significantly from the predictive accuracy for property offenses in the validation sample ($Z = 1.283$, $p = .200$).

3.4 Discussion

The aim of the current study was to examine whether a valid and reliable actuarial risk screening instrument could be developed for predicting the risk for onset of delinquent behavior among juvenile non-offenders, which is based solely on information derived from the Dutch police system and can be used by Dutch police officers without substantial clinical experience. The Youth Actuarial Risk Assessment Tool for First-Time Offending (Y-ARAT-FO) was developed by conducting an Exhaustive CHAID analysis, which yielded a risk classification scheme that can be used to classify new cases into one of ten different risk groups from which the predicted probability for delinquent behavior can be derived. The Y-ARAT-FO consists of the following five variables that together determine the risk for onset of delinquent behavior: (1) the total number of previously recorded incidents in which the juvenile had any role other than that of a suspect, (2) the gender of the juvenile, (3) the total number of recorded incidents in which a co-occupant at the juvenile's living address was a suspect, (4) whether or not the juvenile was born in the Netherlands and (5) the current age of the juvenile. Since the data that are needed as input for the Y-ARAT-FO can be extracted electronically from the computer database of the Dutch police, the risk value can be calculated quickly and consistently for large groups of juveniles without the need to retrieve or examine additional information about these juveniles.

Table 3.4. AUC Values (and 95% Confidence Intervals) for the Prediction of Specific Types of Offenses

Specific type of offense	Construction sample (n = 1,368)	Validation sample (n = 886)	Z ^a
	AUC (95% CI)	AUC (95% CI)	
Violent	.779 (.756 - .801)***	.702 (.671 - .732)***	-1.015
Property ^b	.682 (.656 - .706)***	.737 (.707 - .766)***	1.283
Public order ^b	.735 (.711 - .759)***	.751 (.721 - .779)***	.333
Other offenses ^b	.751 (.727 - .774)***	.731 (.701 - .760)***	-.471

Note. AUC = Area under the receiver operating characteristic curve; 95% CI = 95% confidence interval.

^a Hanley-McNeil tests were conducted to determine significant differences between AUC values in the construction and validation sample. No significant test results were found.

^b Either violent or non-violent in nature.

*** $p < 0.001$.

The observed AUC value of the Y-ARAT-FO was .728 in the validation sample and is equivalent to a Cohen's d of .858 (see the formulas of Ruscio, 2008), which can be interpreted as a large effect (Cohen, 1988). This AUC value compares favorably with AUC values of other actuarial risk assessment instruments. For instance, Schwalbe (2007) reported an average AUC value of risk instruments for predicting general recidivism of .640 ($SD = .042$), and Fazel, Singh, Doll and Grann (2012) found a median AUC value of .66 (interquartile range = .58 - .67) for instruments assessing the risk for general offending. Because the current AUC value equals a large effect size and meets the lower bound of .70 as reported by Swets (1988) and Hosmer and Lemeshow (2000), we consider the predictive validity of the Y-ARAT-FO as acceptable. In addition, we believe that the Y-ARAT-FO showed an acceptable predictive accuracy for the prediction of violent, property, public order and other offenses. However, the predictive accuracy for specific type of offenses may be improved by developing separate models and this is recommended for future studies.

The choice of a suitable cut-off score depends largely on the consequences of false positive and false negative test results. When the aim is to identify the largest proportion of juveniles who are at risk for becoming delinquent, the test should be highly sensitive. On the other hand, if further assessment is costly to society or may have unwanted (psychological) side effects, the test should be highly specific. Since sensitivity and specificity are inversely related, a cut-off score should be chosen that best meets the desired ratio between false positive and false negative test results. If the aim is to minimize the total number of erroneous decisions, a cut-off value should be chosen that maximizes both sensitivity and specificity. Erroneous decisions include both false positives (i.e., a juvenile not at risk for delinquency is referred to further assessment) and false negatives (i.e., a juvenile at high risk for delinquency is not referred to further assessment). A true high risk juvenile not referred to further assessment may be a more

negative outcome than a low risk juvenile who is referred to further assessment. In the first case, a juvenile in need of further assessment is not referred to a youth worker with clinical experience and/or an appropriate behavioral intervention. The last case has serious implications for both available resources (i.e., time and money) and for juveniles and their parents who will be assessed too often. Actuarial instruments have the advantage that the number of false positives and false negatives can be calculated for different cut-off values so that an informed choice can be made about the appropriate cut-off value that best meets the requirements of the situation in which the instrument is used.

Regarding the Y-ARAT-FO, the cut-off score at which the total number of false results is minimized was .370, with a total of 16.95% false results (calculated as $[(\text{false positives} + \text{false negatives}) / \text{total number of test results}] * 100$). At this cut-off score the percentage of false positives was 56.41 (calculated as $[\text{false positives} / \text{total number of positives}] * 100$), and the percentage of false negatives was 13.21 (calculated as $[\text{false negatives} / \text{total number of negatives}] * 100$). If a reduction in false negatives is desirable, it is possible to choose a lower cut-off score, but this will increase the percentage of false positives. For instance, a cut-off score of .124, yielded 69.88% false positives, 8.76% false negatives and 29.02% false decisions in total. Although the percentages of false positives seem high at every cut-off score, the actual number of juveniles that will be referred for further investigation seems acceptable at several cut-off scores. For instance, a cut-off score of .225 yielded 60.43% false positives, but when looking at all juveniles in the sample, only 14.46% tested positive on the Y-ARAT-FO. We therefore believe that the number of false positives produced by the Y-ARAT-FO will not be very problematic for the capacity of youth welfare agencies.

The Y-ARAT-FO can only be used by Dutch police officers as a preliminary screening instrument in the initial stage of risk assessment. If police officers come into contact with a juvenile non-offender because of involvement in an incident (but not in the role of a suspect), police officers can use the test result of the Y-ARAT-FO to support their decision about referring the juvenile for further assessment. It is important to point out that the Y-ARAT-FO should be used in addition to, and not instead of, the judgment of police officers because the current instrument is not able to perfectly predict future delinquent behavior. There are numbers of false positive and false negative test results at each cut-off score of the instrument, meaning that test results of the Y-ARAT-FO should not be regarded as a gold standard. A possible explanation for these false test results is that the Y-ARAT-FO is constrained by the availability of data that can be retrieved from the Dutch police system, meaning that other variables that have a significant influence on the risk for delinquency (e.g., mental health and cognitive functioning) are not taken into account in calculating the risk for onset of delinquent behavior. In practice, this can

mean that when a police officer interviews a juvenile non-offender that tests positive on the Y-ARAT-FO, the optimal decision may be to refrain from referring the juvenile for further assessment if youth care is already involved in the juvenile's life. On the other hand, if the test result of the Y-ARAT-FO is negative, but a police officer has suspicions of cognitive or mental health problems, the optimal decision may be to refer the juvenile for further assessment. These examples illustrate that appropriate judgments of Dutch police officers remain important, even when instruments are available that support police officers in their decisions about referring juveniles for further assessment by more specialized youth care agencies.

Regarding the practical use of the Y-ARAT-FO, there is also an important ethical aspect that needs to be mentioned. False positive test results (i.e., low risk juveniles testing positive on the Y-ARAT-FO) may imply a considerable risk of stigmatizing juveniles, leading in turn to an adverse effect on juvenile's well-being and behavior. Therefore, the risk of stigmatizing juveniles should be weighed against the advantages of implementing the Y-ARAT-FO. It is interesting to point out here that false positives in criminal justice settings are often seen as more problematic than false negatives (e.g., because of ethical implications of putting someone in detention unnecessarily), whereas the reverse may be true for predicting the risk of first-time offending. Although a stigma may be associated with referring juveniles based on false positive test results, further assessment is in general not particularly intrusive or harmful. In contrast, false negatives imply that high risk juveniles who need further assessment (and perhaps treatment) will not be referred, which may be regarded as more problematic and unethical. However, it remains an ethical challenge to screen large groups of juvenile non-offenders without stigmatizing them by labelling the juveniles as possible offenders. This ethical consideration also underlines that the Y-ARAT-FO should be used to support a police officer's decision about referral of a juvenile for further assessment, and not as a single criterion. In this manner, possible negative aspects of the practical use of the Y-ARAT-FO can be reduced.

Several limitations of the current study should be noted. First, the sample used in the present study consisted of juveniles who were randomly selected from only two adjacent police regions in the Netherlands. These regions slightly differ from other regions in the Netherlands in terms of ethnicity, cultural background, household income and number of committed offenses (CBS, 2013), which might affect the generalizability of the results to other Dutch police regions. However, the Y-ARAT-FO was based on rather common predictor variables and it is therefore not to be expected that the current instrument is far less accurate when administered in other police regions. Second, although developing a risk screening tool based solely on police records does have several advantages, it must also be noted that the number of official recorded incidents is an

underestimation of the actual base rate. The willingness of victims to report an incident and police discretion (e.g., the decision not to lay charges) are examples of factors that directly contribute to the underreporting of incidents in official records (Alvi, 2012), and this can indirectly influence the validity of an actuarial risk screening tool that is based on official records. Third, data about official documented convictions could not be used in defining the onset of delinquency, since convictions are not registered in the Dutch police system. We therefore measured onset of delinquency by using the proxy of committing an offense as suspected by the Dutch police. Consequently, a problem that may arise in this definition is the conflation of suspected and actual offending, which, in turn, can produce bias in assessing the onset of delinquency. Perhaps, a more objective test result would be obtained when the dependent variable of the Y-ARAT-FO was based on an official outcome variable, such as whether or not a juvenile is convicted. On the other hand, a drawback of using official convictions is a possible underestimation of the actual delinquent behavior of juveniles, for instance, in juvenile cases where the available evidence does not meet the quality standards for obtaining a criminal conviction.

We believe that forensic risk assessment research is extended by the present study because it addresses risk assessment within early prevention of juvenile delinquency. To our knowledge, the Y-ARAT-FO is the first actuarial instrument that predicts the risk for onset of general delinquent behavior among juveniles. The Y-ARAT-FO can be administered by police officers without a clinical background, and it can easily be implemented in the Dutch police system. The instrument provides a quick, consistent, well interpretable and cost-effective initial screening of the risk for onset of juvenile delinquency. At a broader policy level, the Y-ARAT-FO may facilitate juvenile justice organizations and affiliated child and youth care organizations operating within early prevention in concentrating their time and resources more effectively on juveniles who have the highest risk for becoming a delinquent.

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Authors' Contributions

Mark Assink participated in the design of the study, conducted all statistical analyses, and drafted the manuscript. Claudia E. Van der Put participated in the design of the study and critically reviewed the manuscript. Geert Jan J. M. Stams critically reviewed the manuscript.