



Deadly violence in Sweden: Profiling offenders through a latent class analysis

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ABSTRACT

Background: Sweden has in recent years witnessed increasing rates of firearm-related violence and homicide, which has contributed to increased rates of deadly violence. Attempts to profile offenders committing such crimes are of major importance, because such efforts may contribute to better preventive measures. We therefore aimed to study the characteristics of individuals convicted and/or suspected of homicide, attempted homicide, preparation to commit homicide as well as conspiracy to commit homicide (for simplicity called homicide+) in Sweden.

Methods: By using information from the Swedish Crime Register and the Swedish Criminal Suspect Register, individuals being 15–60 years old and convicted and/or suspected of homicide+ between 2000 and 2015 were included in the study. Using these registers and also other population and health care registers, information on previous criminality, substance abuse, and psychiatric disorders were added to the Latent Class Analysis (LCA) that was used to identify latent classes of individuals convicted and/or suspected for homicide+. In addition, several individual variables were added for validation purposes.

Results: A total of 14,466 individuals were included in the analysis. The majority were male ($n = 12,802$; 88.5%) and Swedish-born with Swedish-born parents ($n = 8247$; 57.0%). The LCA identified three classes where Conviction Class (CC) contained mostly convicted individuals whereas Mixed Class A (MCA) and Mixed Class B (MCB) contained almost equal rates of both convicted and suspected individuals. The CC was characterized by individuals with low rates of previous criminality, substance abuse and psychiatric disorders. The MCA and the MCB were characterized by individuals with higher rates of previous criminality, substance abuse, and psychiatric disorders as well as lower education and worse economy in comparison with the CC.

Conclusion: While MCA and MCB may be constituted by “traditional” criminals often well known by the police and/or the social authorities, the CC was mainly constituted by convicted offenders who may more easily escape the radar of the authorities.

1. Background

Homicide and attempted homicide are crimes causing significant harm on affected families and the whole society (Cohen & Piquero, 2009; Krug, Mercy, Dahlberg, & Zwi, 2002; Miller, Cohen, & Wiersema, 1996). According to the Small Arms Survey, located at the government-accredited Graduate Institute in Geneva, Switzerland, global homicide rates in 2015–2016 increased for the first time since 2004 (McEvoy & Hideg, 2018); that is unfortunately also the case in Sweden, which has witnessed increasing problems with firearm- and explosive-related violence (Khoshnood, 2017, 2018; Sturup, Gerell, & Rostami, 2019; Sturup, Rostami, Gerell, & Sandholm, 2018) during the same time period.

According to official statistics from the Swedish National Council for Crime Prevention (In Swedish: BRÅ) (BRÅ, 2018), deadly violence increased from 106 in 2016 to 133 in 2017. A newly published study shows that deadly violence has more than doubled in Sweden compared to 2012 when Sweden had its lowest number of deadly violence ($n = 68$) (Khoshnood, 2019). BRÅ defines deadly violence as homicide (murder and manslaughter), child homicide, causing another person's death without the intention to kill (in short: causing another's death) as well as death caused by terrorism (BRÅ, 2019).

Firearm-related violence as well as homicide has increased in Sweden and, in 2017, 35% of all homicides in the country were conducted with a firearm as Sweden witnessed 2.55 shootings per 100,000 inhabitants (Khoshnood, 2019). Today, the rates of firearm-related

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homicide among males aged 15–29 in Sweden is the highest among all Western European countries (Sturup et al., 2018).

With the increasing rates of deadly violence in Sweden and the highest rates of firearm-related homicides in Western Europe among young males, it is of vital importance to obtain more knowledge on the offenders committing these crimes. This is because identification of common offender characteristics for violent crimes like homicide can be used in crime prevention as well as risk assessments. In addition, these characteristics can further our understanding of which individuals may be at risk for committing violent crimes and contribute to more knowledge about what factors may be protective or detrimental in these individuals. Such knowledge may contribute to identify and prevent processes leading to deadly violence, which causes tremendous and irreversible harm to both the victim's and the offender's families as well as to the entire community.

Most previous studies on offender characteristics for violent crimes in which classes, clusters or profiles were created, were based on non-Swedish studies (Bijleveld & Smit, 2006; Gottlieb, Kramp, Lindhardt, & Christensen, 1990; Gruenewald & Pridemore, 2009; Haggerty, 2009; Holmes, De Burger, & Holmes, 1988; Holmes & Holmes, 2008; Langevin & Handy, 1987; Pridemore, 2006; Salfati & Canter, 1999; Vaughn, DeLisi, Beaver, & Howard, 2009; Zahn & Sagi, 1987). Only a few studies on offender characteristics and their respective crime characteristics were based on Swedish offenders (Belfrage & Rying, 2004; Caman, Howner, Kristiansson, & Sturup, 2017; Caman, Kristiansson, Granath, & Sturup, 2017; Corovic, 2013; Ebberline, 2008; Khoshnood & Väfors Fritz, 2017; Liem et al., 2013; Rajs, Lundstrom, Broberg, Lidberg, & Lindquist, 1998). Those studies were also limited to a small sample or only to a specific type of violent crime. To the best of our knowledge, there is no large study examining Swedish offender characteristics with respect to the most violent crimes: homicide, attempted homicide, preparation for homicide, and conspiracy to commit homicide. We therefore conducted the present study where we hypothesized an existence of specific, latent classes of offenders based on several variables (including other types of crime, substance use and psychiatric disorders) associated with violent crime in previous studies.

(Bijleveld & Smit, 2006; Brody & Kiehl, 2010; Cornell, 1990; Gottlieb et al., 1990; Howitt, 2009; Langevin & Handy, 1987; Pridemore, 2006; Rosenfeld, 2009).

The aim of the present study was thus to identify classes of individuals who were convicted or suspected of homicide, attempted homicide, preparation to commit homicide, and conspiracy to commit homicide, together termed homicide+, in Sweden.

2. Methods

We analyzed data on individuals from Swedish population-based registers with national coverage. These registers were linked using each individual's unique identification number replaced by a serial number to preserve confidentiality. The study is covered by ethical approval from the Regional Ethical Review Board in Lund (Dnr: 2012/795). The dataset for the Latent Class Analysis was created by selecting all individuals registered in our database with homicide+ between 2000 and 2015 and who were between 15 and 60 years old at the time of registration ($n = 17,922$). Furthermore, we required that individuals were registered in Sweden at age 15 (3456 individuals did not meet this criteria), so that previous crimes were included in the registers. In total we investigated 14,466 unique individuals.

Homicide+ was defined based on information from the Swedish Crime Register that includes nationwide almost complete data on all convicted individuals and the Swedish Criminal Suspect Register that includes nationwide data on all individuals suspected of a crime. The Swedish Law regulating the Criminal Suspect Register (1998:621) states that individuals suspected on reasonable grounds for a crime are to be registered in the Criminal Suspect Register (§1), and that they are to be removed from the register if the preliminary inquiry by the police has

been dropped (§13, point 1), if an indictment by the prosecutor has been dropped (§13, point 2), if a court of law has passed a sentence convicting or acquitting the accused (§13, point 3), or if an accused is requested to be extradited and this request has been refused or executed by the court of law (§13, point 4). The Criminal Suspect Register is thus continually changing. In this study we have used data from the register as available in 2015.

Homicide is an umbrella term for murder and manslaughter. Both these crimes, as well as the attempt, preparation, and conspiracy to commit homicide are all covered by the Swedish Penal Code chapter 3, §§ 1 (murder), 2 (manslaughter) and 11 (attempt, preparation and conspiracy).

The crime "causing another's death" was not included in the study since the intention of the offender is not to cause the death of another individual. In contrast, all the crimes included in the study, homicide+, are crimes in which the offender intends to kill another human being.

In the Criminal Suspect Register homicide is represented by the following codes; 0303, 0304: attempted homicide, preparation for homicide, and conspiracy to commit homicide, without a firearm, against a female (male); 0307, 0308: attempted homicide, preparation for homicide, and conspiracy to commit homicide, with a firearm, against a female (male); 0310, 0311: homicide, without a firearm, against a female (male); 0312, 0313: homicide, with a firearm, against a female (male).

We also included individual information on White Collar Crime, Property Crime, and Violent Crime. Based on information from other Swedish population-based registers, such as the Swedish nationwide health care registers, we included information on Drug Abuse, Alcohol Abuse and Psychiatric Disorders. Appendix 1 includes detailed information on these variables. The registration had to occur prior to the registration for homicide+ (i.e., from 1973 until the date of the homicide+) in order to be included in the dataset.

2.1. Latent class analysis

Latent Class Analysis (LCA) was used to identify homogeneous classes of homicide+ based on the variables selected for this purpose. We therefore entered, into the LCA, six dichotomous variables (yes/no) for each of the following registration types: White Collar Crime, Property Crime, Violent Crime (excluding homicide), Drug Abuse, Alcohol Abuse, and Psychiatric Disorder and a three-categorical variable defining the registration type of the studied crimes (only registered in the Criminal Suspect Register, 1 conviction, or 2 or more convictions during the study period). The rationale for choosing the six variables entered into the LCA was because many of these other crime types, substance use disorders and psychiatric disorders are correlated to violent crime as well as deadly violence (Bijleveld & Smit, 2006; Brody & Kiehl, 2010; Cornell, 1990; Gottlieb et al., 1990; Howitt, 2009; Langevin & Handy, 1987; Pridemore, 2006; Rosenfeld, 2009).

A limitation of LCA is that it depends on which variables that are selected. It is therefore essential to validate the LCA against other variables of relevance for the analysis. The number of latent classes indicated by the selected variables was determined by comparing model fit statistics between nested models. Improvement in model fit was indicated by smaller values of the log-likelihood, Akaike's Information Criterion (AIC), and the adjusted Bayesian information criterion. The number of classes is influenced by the number of included variables, so both empirical (improved model fit) and theoretical (model interpretability) aspects were also considered. Individuals were then assigned class membership based on their particular response profile's resemblance/fit to the latent class. The LCA was performed using PROC LCA in SAS v. 9.4 (Lanza, Dziak, Huang, Xu, & Collins, 2011; Lanza, Collins, Lemmon, & Schafer, 2007).

To investigate potential differences across LCA classes, we included several external validators at the individual level (year of birth, sex, low education (yes/no), age at first registration with homicide, country of

birth, resilience, IQ, school achievement, income, social welfare (yes/no) and neighborhood deprivation) and at the parental level (Homicide +, Psychiatric disorder, White collar crime, Property crime, Violent crime, Drug abuse, Alcohol abuse). These variables were selected to validate the LCA classes because many of them have been shown to be correlated to violent crimes (Bijleveld & Smit, 2006; Brody & Kiehl, 2010; Cornell, 1990; Gottlieb et al., 1990; Howitt, 2009; Langevin & Handy, 1987; Pridemore, 2006; Rosenfeld, 2009). Chi-square analyses were used to compare categorical variables and one-way ANOVA was used for continuous variables. Thereafter, we examined, by logistic regression, the patterns of the external validators when comparing the three LCA classes. For a description of the external variables/validators see Appendix 1.

In a further attempt to validate the LCA, we selected from the Swedish Multi-Generation Registry all Swedish-born full-sibling pairs born between 1950 and 1995. We linked this dataset to assigned class membership data from the LCA, treating those in other classes as unaffected. Tetrachoric correlations and odds ratios (ORs) were calculated for sibling pairs across LCA classes. As a validation we would assume that the within-class correlation for full siblings is stronger than the across-class correlation. All statistical analyses were performed using SAS 9.4 (SAS Institute, 2012).

3. Results

3.1. Descriptive data

A total of 14,466 individuals convicted ($n = 8709$; 60.2%) or only suspected ($n = 5757$; 39.8%) for homicide+ were included in the study population (Table 1). The age range was 15–60 years ($\bar{x} = 39$) and the majority of the included individuals were male ($n = 12,802$; 88.5%). The majority were also Swedish-born with Swedish-born parents ($n = 8247$; 57.0%) followed by Swedish-born individuals with at least one parent born outside Sweden ($n = 3356$; 23.2%) and individuals born outside Sweden ($n = 2860$; 19.8%). Overall, immigrants, defined as being born outside Sweden or being born in Sweden with at least one

Table 1
Descriptive data of the included individuals ($n = 14,466$).

Demographics	
Year of Birth [mean (SD)]	1976 (12.6)
Male sex [n (%)]	12,802 (88.5%)
Age at first registration [mean (SD)]	31.5 (11.8)
Low education [n (%)]	5946 (41.1%)
Country of birth	
Swedish born with Swedish born parents [n (%)]	8247 (57.0%)
Swedish born with one parent born outside Sweden [n (%)]	1562 (10.8%)
Swedish born with both parents born outside Sweden [n (%)]	1794 (12.4%)
Born outside Sweden [n (%)]	2860 (19.8%)
Socioeconomic status	
Neighborhood deprivation [SDI (SD)]	1.0 (2.3)
Income [mean (SD)]	0.0 (1.0)
Social Welfare [n (%)]	4687 (32.4%)
Conviction and suspicion	
Only suspicion [n (%)]	5757 (39.8%)
1 conviction [n (%)]	8434 (58.3%)
≥ 2 convictions [n (%)]	275 (1.9%)
Prior convictions	
White collar crime [n (%)]	4456 (30.8%)
Property crimes [n (%)]	7624 (52.7%)
Violent crime [n (%)]	7190 (49.7%)
Psychiatric ill-health	
Psychiatric disorders [n (%)]	3255 (22.5%)
Drug abuse [n (%)]	6003 (41.5%)
Alcohol abuse [n (%)]	3255 (22.5%)
Others	
Resilience ($n = 5916$) [mean (SD)]	-0.6 (1.1)
IQ ($n = 6774$) [mean (SD)]	-0.6 (1.0)
School achievement ($n = 7808$) [mean (SD)]	-1.03 (1.1)

Table 2

Descriptive data of the included individuals' parents ($n = 14,195$).

Prior convictions	
Homicide [n (%)]	369 (2.6%)
White collar crime [n (%)]	2782 (19.6%)
Property crimes [n (%)]	4330 (30.5%)
Violent crime [n (%)]	3180 (22.4%)
Psychiatric ill-health	
Psychiatric disorders [n (%)]	4031 (28.4%)
Drug abuse [n (%)]	1647 (11.6%)
Alcohol abuse [n (%)]	3634 (25.6%)

parent born outside Sweden, constituted a minority of the included individuals ($n = 6225$; 43.0%).

The most common modus operandi for homicide+ was the use of a firearm ($n = 5985$; 41.2%), and more than half of the included individuals had previously been convicted for property crime ($n = 7624$; 52.7%) and/or violent crime ($n = 7190$; 49.7%). A little over one-fifth ($n = 3255$; 22.5%) of the included individuals had a psychiatric disorder, and a large proportion had problems with alcohol ($n = 3255$; 22.5%) and/or drug ($n = 6003$; 41.5%) abuse.

A substantial part of the individuals had low education ($n = 5946$; 41.1%) and close to one-third received social welfare ($n = 4687$; 32.4%). Data for IQ, resilience and school achievement were available for a part of the individuals ($n = 6774$, $n = 5916$, and $n = 7808$, respectively) and showed low values for IQ (-0.6 ; SD 1.0), resilience (-0.6 ; SD 1.1), and school achievement (-1.03 , SD 1.1).

Table 2 present data of the included individuals' parents ($n = 14,195$; 98.1%). Few of the parents ($n = 369$; 2.6%) were previously convicted for homicide and more than one fifth of them had been convicted for violent crimes ($n = 3180$; 22.4%). Psychiatric disorders as well as alcohol and drug abuse were fairly common among the parents, ranging between 11.6% for drug abuse and 28.4% for psychiatric disorders.

3.2. Latent class analysis

The fit indices continued to improve with the number of classes (Table 3). However, the most substantial drop in both AIC and log-likelihood was observed when going from a model with two latent classes to a model with three classes. Furthermore, the additional classes that were the results from a four- or five class-model were small and rather similar to what we below call "mixed class A" and "mixed class B". The conviction class remained intact, however. Therefore, we used a model with three latent classes. Furthermore, in the models there are some indications of conditional dependence for some of the variables. This also strengthens the decision to restrict the number of classes to three as local independence between variables often leads to additional classes in the final model. Class 1 was constituted by the highest proportions of convicted individuals and was thus termed the "conviction class". Class 2 and Class 3 had almost equal proportions of convicted and suspected individuals why they were termed "mixed class A" and "mixed class B", respectively (Table 4).

The conviction class included 5189 individuals, i.e., 35.9% of the study population, and thus had a membership probability of 35.9%. A

Table 3
Fit indices for latent classes.

Number of latent classes	Log-likelihood	AIC	Adjusted BIC	Degrees of freedom
2	-58,430.37	2647.78	2731.41	364
3	-57,806.41	1419.85	1547.50	354
4	-57,470.3	767.71	939.37	344
5	-57,384.2	615.61	831.29	334
6	-57,264.7	396.46	656.1	324

Table 4
Assignment probabilities by class.

	Class 1	Class 2	Class 3
	Conviction class	Mixed class A	Mixed class B
Class membership probabilities	35.9%	37.0%	27.2%
Item response probabilities			
White collar crime	3.0%	22.5%	79.0%
Property crime	8.5%	60.7%	100%
Violent crime	7.2%	58.3%	94.1%
Drug abuse	3.4%	46.7%	84.8%
Alcohol abuse	0.0%	23.8%	80.0%
Psychiatric disorder	5.8%	21.7%	45.6%
Number of convictions for the studied crimes			
Only suspicion	18.4%	54.5%	48.0%
1 conviction	80.6%	43.7%	48.9%
≥ 2 convictions	1.0%	1.9%	3.1%

clear majority (81.6%) of the members of this class were convicted for homicide + . The proportions of individuals with previous convictions (range 3.0% to 8.5%), psychiatric disorder (5.8%), alcohol abuse (0%) and drug abuse (3.4%) were, however, low.

Membership probability for the mixed class A was 37.0% thus representing the largest class. More than half of the members in this class were only suspected (54.5%) and/or had previous convictions for property crimes (60.7%) and/or violent crimes (58.3%). Almost one fourth had alcohol abuse (23.8%), almost half had drug abuse (46.7%) problems, and more than one-fifth (21.7%) had psychiatric disorders.

The last class, mixed class B, had a membership probability of 27.2% and included thus more than one fourth of the individuals, representing the smallest class. More than half of the individuals were convicted (52.0%) and they also had by far the highest proportions of all other criminal behaviors, psychiatric disorders, alcohol abuse and drug abuse. For example, everyone in this class (100%) had previously been convicted for a property crime, and almost all were convicted previously for a violent crime (94.1%). A clear majority were also registered for alcohol abuse (80.0%), drug abuse (84.8%) as well as psychiatric disorders (45.6%).

The average individual posterior probabilities (SAS Institute, 2012) for each latent class membership were 84.5%, 82.2% and 85.3% for classes 1 to 3 respectively.

Some of the subjects in the LCA were not assigned to individual classes with high confidence. We repeated the analyses contained in Table 3 including only LCA assignments of greater than 70% probability (83% of the cases). Class membership declined mostly in classes 1 and 3 (21% and 18%), and slightly in class 2 (12%). Despite the reduction in numbers classified, neither the pattern of validators observed in Table 3 nor the sibling correlations hardly changed, enhancing the overall robustness of our findings (data not shown in tables).

3.3. Validation of latent classes

Table 5 shows a comparison between the classes based on the external validators. While individuals included in the conviction class and the mixed class A had almost the same mean age (the year of birth was 1977 and 1978, respectively), the mixed class B were older (year of birth = 1972). A higher proportion of those in the mixed class B received social welfare (57.7%) in comparison with the conviction class (11.6%) and the mixed class A (34.1%). Those in the mixed class B had the lowest resilience (-1.12 , SD 1.0) and IQ (-0.92 , SD 0.8) in comparison with the other classes. Individuals in the mixed class B had a considerably higher proportion of psychiatric disorders (38.7%) and alcohol abuse (37.9%) among their parents in comparison to both the conviction class (19.9% and 15.2%, respectively) and the mixed class A (29.0% and 26.6%, respectively).

The conviction class had individuals who were better educated (low education, 24.6%) in comparison with the mixed class A (low education 46.3%) and mixed class B (low education 55.5%). The conviction class also had the highest rate of Swedish-born individuals with Swedish-born parents. Overall, they had the most beneficial profile, considering every other variable in regard to parental registrations, income, social welfare, resilience, IQ as well as school achievement.

The highest proportions of individuals born outside Sweden or individuals born in Sweden with at least one parent born outside Sweden were found in the mixed class A (48.9%) followed by the mixed class B (43.4%).

Table 6 shows the results of the multivariate logistic regression model in which all the three classes were compared to each other in order to identify which variables that were able to distinguish the classes. Comparing the two mixed classes with each other, there were considerably more men and individuals with low education in mixed class B in comparison to mixed class A. Swedish-born individuals with one parent born outside Sweden as well as individuals receiving social welfare were at higher risk of being a member of mixed class B. Comparing the conviction class with the two mixed classes, the former had higher probability for females, lower odds for low educated individuals and a higher odds for Swedish-born individuals with Swedish-born parents.

We attempted to validate our classes by examining their aggregation and co-aggregation within 8,101,363 full siblings. The prevalence of homicide + in full siblings differed significantly ($p < .0001$) between our three classes and was highest in full siblings from the mixed class A ($6.5\% \pm 0.5\%$) and the mixed class B ($5.1\% \pm 0.6\%$) and lowest in full siblings from the conviction class ($2.9 \pm 0.4\%$) (data not shown in tables).

The tetrachoric correlations among all full siblings in the Swedish population born 1940–2000 are shown in Table 7. Some trends could be identified; a strong evidence for familial aggregation could be identified in each of our three classes with the mixed class A having the highest tetrachoric correlation (+0.42) and the conviction class having the lowest (+0.25). Second, all the cross-class correlations were positive, suggesting some general familial vulnerability to homicide + . Third, for the mixed classes A and B the correlation within the class was higher than the correlation across classes. For example, the correlation for class 2 across sibling pairs was +0.42 and was substantially higher than any of the correlations observed between class 1 and classes 1 and 3. Class 1 was the exception because the correlation within the class (+0.25) was slightly exceeded by the correlation between classes 1 and 2 (+0.27). This pattern of findings suggests some specificity in the familial factors influencing class membership. Fourth, the pattern of correlations provides a rough guide to the relationship of familial risk factors across classes. For example, our conviction class had lower correlation with the other classes. This suggest substantial independence for the familial factors predisposing different types of homicide.

We also aimed to validate our results from the LCA by randomly dividing our sample into two equally sized groups and testing for measurement invariance across the two groups. This was performed by comparing the G-square difference between the two models to a chi-square distribution with degrees of freedom equal to the difference in degrees of freedom. A significant p -value suggests that the null hypothesis of measurement invariance should be rejected (Lanza et al., 2007). We performed 100 replications of this, and in all replications the p -value was above 0.5, suggesting that there is equivalent meaning of the latent classes across the different samples.

4. Discussion

The current study aimed to identify classes of individuals who were convicted or suspected of homicide + using Latent Class Analysis. We also validated our analyses by adding other variables, i.e., external

Table 5
Comparison of covariates across classes.

	Class 1	Class 2	Class 3	P-value
Most probable class membership [n (%)]	5189 (35.9%)	5349 (37.0%)	3928 (27.2%)	
Demographics				
Year of birth [mean, median, (SD)]	1977, 1980 (13)	1978, 1981 (12)	1972, 1973 (11)	< 0.0001
Male sex [(%)]	84.6%	89.2%	92.7%	< 0.0001
Age at first registration [mean, median (SD)]	31.1, 27 (12.6)	29.5, 26 (11.1)	34.8, 34 (10.6)	< 0.0001
Low education [(%)]	24.6%	46.3%	55.5%	< 0.0001
Country of birth				
Swedish born with Swedish born parents [%]	63.3%	51.1%	56.6%	< 0.0001
Swedish born with one parent born outside Sweden [%]	9.0%	11.5%	12.3%	< 0.0001
Swedish born with both parents born outside Sweden [%]	10.1%	14.8%	12.3%	< 0.0001
Born outside Sweden [%]	17.6%	22.6%	18.8%	< 0.0001
Socioeconomic status				
Neighborhood deprivation [SDI (SD)]	0.47, -0.09 (2.0)	1.20, 0.54 (2.3)	1.42, 0.75 (2.4)	< 0.0001
Income [mean (SD)]	0.30, 0.03 (1.3)	-0.10, -0.18 (0.8)	-0.24, -0.24 (0.6)	< 0.0001
Social welfare [n (%)]	11.6%	34.1%	57.7%	< 0.0001
Modus operandi				
With firearm [n (%)]	1120 (78%)	2721 (74%)	2144 (77%)	NS
Without firearm [n (%)]	325 (22%)	978 (26%)	653 (23%)	NS
Parents (n = 14,195)				
Convicted for the studied crimes [%]	2.3%	3.0%	2.5%	0.0510
Psychiatric disorder [%]	19.9%	29.0%	38.7%	< 0.0001
White collar crime [%]	12.1%	21.8%	26.6%	< 0.0001
Property crime [%]	20.5%	34.3%	38.3%	< 0.0001
Violent crime [%]	13.7%	26.4%	28.4%	< 0.0001
Drug abuse [%]	6.0%	13.7%	16.1%	< 0.0001
Alcohol abuse [%]	15.2%	26.6%	37.9%	< 0.0001
Resilience (n = 5916) [mean (SD)]	-0.09, -0.04 (1.0)	-0.65, -0.66 (1.0)	-1.12, -1.26 (1.0)	< 0.0001
IQ (n = 6774) [mean (SD)]	-0.25, -0.25 (1.0)	-0.70, -0.74 (0.9)	-0.92, -1.05 (0.8)	< 0.0001
School achievement (n = 7808) [mean (SD)]	-0.58, -0.45 (1.1)	-1.25, -1.12 (1.1)	-1.46, -1.40 (1.0)	< 0.0001

Table 6
Results from a multivariate logistic regression.

	Class 1 = 0 Class 2 = 1	Class 1 = 0 Class 3 = 1	Class 2 = 0 Class 3 = 1
Demographics			
Year of birth	0.99 (0.98; 1.00)	0.98 (0.96; 0.99)	0.98 (0.97; 0.99)
Men vs female	1.72 (1.51; 1.97)	3.34 (2.74; 4.07)	2.40 (2.02; 2.85)
Low education	2.05 (1.86; 1.97)	2.97 (2.63; 3.35)	1.56 (1.41; 1.72)
Age at first registration	1.01 (1.00; 1.02)	1.05 (1.03; 1.06)	1.05 (1.03; 1.06)
Country of birth			
Swedish born with Swedish born parents	Reference	Reference	Reference
Swedish born with one parent born in Sweden	1.40 (1.20; 1.63)	1.43 (1.18; 1.74)	1.15 (0.98; 1.33)
Swedish born with no parent born in Sweden	1.37 (1.18; 1.59)	1.43 (1.17; 1.74)	1.02 (0.88; 1.19)
Born outside Sweden	1.18 (1.04; 1.35)	1.04 (0.88; 1.24)	1.00 (0.87; 1.14)
Parents variables			
Convicted for the studied crimes	0.69 (0.51; 0.94)	0.55 (0.36; 0.83)	0.80 (0.59; 1.09)
Psychiatric disorder	1.10 (0.98; 1.23)	1.12 (0.97; 1.30)	1.13 (1.01; 1.26)
White collar crime	1.19 (1.04; 1.37)	1.28 (1.07; 1.52)	1.20 (1.05; 1.36)
Property crime	1.28 (1.14; 1.44)	1.54 (1.32; 1.79)	1.16 (1.03; 1.31)
Violent crime	1.43 (1.25; 1.64)	1.39 (1.17; 1.65)	1.05 (0.92; 1.19)
Drug abuse	1.33 (1.10; 1.59)	1.29 (1.04; 1.61)	1.03 (0.89; 1.20)
Alcohol abuse	1.51 (1.33; 1.72)	2.30 (1.96; 2.71)	1.44 (1.27; 1.63)
Neighborhood deprivation	1.07 (1.04; 1.09)	1.09 (1.06; 1.12)	1.03 (1.00; 1.05)
Income	0.77 (0.72; 0.82)	0.49 (0.44; 0.54)	0.67 (0.62; 0.73)
Social welfare	2.63 (2.34; 2.96)	7.17 (6.29; 8.17)	2.73 (2.47; 3.01)

Table 7
Tetrachoric correlations among all full siblings in the Swedish population born 1940–2000.

	Class 1	Class 2	Class 3
	Conviction class	Mixed class A	Mixed class B
Class 1: Conviction class	0.25 (0.01)	0.27 (0.01)	0.19 (0.02)
Class 2: Mixed class A		0.42 (0.01)	0.35 (0.01)
Class 3: Mixed class B			0.38 (0.01)

validators, to compare classes as well as comparing full siblings.

A clear majority of the included offenders were male (85.5%) which is in accordance with previous studies. One of the most robust facts with regard to violent crimes is that males are overrepresented in the statistics (Howitt, 2009; Liem et al., 2013; Zahn & Sagi, 1987).

In contrast to international studies, however, the individuals in our study were older with a mean age of 39. Serious violent crimes, including homicide +, are usually the young man's crime (Howitt, 2009). Previous studies have shown that most offenders committing such serious crimes are under the age of 30 (Gottlieb et al., 1990; Gruenewald & Pridemore, 2009; O'Brien, Stockard, & Isaacson, 1999;

Salfati & Canter, 1999). Studies on Swedish violent offenders though have shown similar results as ours (Khoshnood & Väfors Fritz, 2017; Liem et al., 2013; Lindqvist, 1986).

Although previous studies have suggested that immigrants are overrepresented in the crime statistics (BRÅ, 2015; Hällsten, Szulkin, & Sarnecki, 2013; Skardhamar, Aaltonen, & Lehti, 2014), the focus of those studies have been crime in general. Our study, as far as we are aware of, is the first to study this variable with respect to homicide+. Even though the majority of the individuals in our study were Swedish-born with Swedish-born parents, immigrants in the first and second generation constituted almost half of the included individuals. Comparing the proportions based on population size, immigrants seem to be over-represented in the homicide+ statistics and future studies could examine which factors that may lie behind these findings in order to prevent processes leading to deadly violence.

Our findings that the majority of individuals belongs to a low socioeconomic class and that a substantial part of the individuals had alcohol and/or drug abuse are in line with previous studies showing that a high level of education (Gottfredson, Wilson, & Skroban-Najaka, 2006) and employment (Bijleveld & Smit, 2006; Tita & Griffiths, 2005) may be protective while substance abuse (Chaiken & Chaiken, 1990) may be detrimental for criminal offences.

Most studies also show that a previous history of crime is both a risk factor for recidivism and committing other types of crimes (Cornell, 1990; Gottlieb et al., 1990; Pridemore, 2006). In regard to homicide+, previous violent crimes have been shown to increase the risk for committing further more violent crimes (Langevin & Handy, 1987), why it is not surprising that close to half of the of the included individuals in our study had been convicted for violent crimes previously. This proportion is higher than previous studies from Sweden showing that between 33% and 43% of convicted homicide and attempted homicide offenders have no previous convictions or previous violent crime convictions (Belfrage & Rying, 2004; Khoshnood & Väfors Fritz, 2017; Lindqvist, 1986). One reason for this discrepancy may be that we also included offenders suspected for homicide+ in addition to those convicted. Another reason may be that we have a larger sample and focus on all homicide typologies, in comparison with other studies which, for example, only focuses on intimate partner homicide.

4.1. Latent class analysis

We identified three latent classes: the conviction class, mixed class A and mixed class B. In the next step we aimed to determine whether these classes were 'valid' by examining how much they differed on variables potentially important for homicide and that were external to the LCA. The results suggest that the three latent classes are meaningful and relatively distinct.

One of the most important finding of the LCA was the substantial differences between the conviction class and the two mixed classes, which represents a novel contribution.

The validation of our latent classes in full-sibling pairs also represents novel findings that could be important in the preventive work. For example, it is noteworthy that the more "severe" classes (i.e., mixed class A and B) also had the highest familial aggregation with a risk for the variable homicide+ in their siblings almost twice that observed in the siblings of the conviction class. Of note is also the evidence for specificity of familial transmission.

Our three identified classes, which are clearly distinguishable, are similar to the findings by Vaughn et al. (2009). The authors studied 160 multiple homicide offenders and found three latent classes that resembled ours. The resemblances of our results to the ones by Vaughn et al., is interesting because they focused solely on multiple homicide offenders. According to the Federal Bureau of Investigation (Morton & Hiltz, 2008), a serial killer is defined as an individual killing two or more victims in separate events. Based on this, at least some of the individuals included in the study by Vaughn et al. (2009) may in fact

also be serial killers. As the etiology and motives of serial offenders like serial killers differ from a murderer that is not a serial killer (Forsyth, 2015; Haggerty, 2009; Holmes et al., 1988; Holmes & Holmes, 2008), it is highly interesting that our three classes are similar. The two most important questions that arise by this similarity are then why there is a class constituting of highly violent offenders with minimal previous criminality and how the resemblance between our results and the results by Vaughn et al. (2009) can be further clarified.

It is possible that several factors can explain the existence of a low offender class; first, in the current study, we have also included individuals convicted for preparation as well as conspiracy to commit homicide. This may to some degree explain why some individuals in our study are so called low offenders. These "low" offenders may not be very prone to violence and therefore do not commit violent crimes to a high degree. Second, homicide typologies like crime of passion and intimate partner homicide are usually, at least in a Swedish context, committed by individuals who have lower rates of both total convictions as well as violent crime convictions, in relation to other homicide typologies (Caman, Howner, et al., 2017; Caman, Kristiansson, et al., 2017), and are also better educated (Khoshnood & Väfors Fritz, 2017). The individuals in the conviction class may perhaps be those that have been convicted for homicide+ with respect to crime of passion or intimate partner homicide. Third, it is likely that some of the offenders in this class have committed homicide+ unexpectedly and in the heat of the moment after feeling violated or insulted. Vaughn et al. (2009) discusses this matter stating that the low offender's class "would appear to contain offenders who unexpectedly 'snap' [...]". The authors further argue that these offenders probably have psychiatric disorders. This is a claim which is antagonistic to our findings showing that the rate of psychiatric disorders in the conviction class (low offenders) are four and eight times lower than in the mixed class A and B, respectively, and that only a low proportion of the offenders (5.8%) in the conviction class have a psychiatric disorder. One reason for this discrepancy may be that psychiatric disorders was not a variable studied by Vaughn et al. (2009).

The similarities between our results and the results by Vaughn et al. (2009) illustrates that offenders committing violent crimes like homicide+ can be divided into two profiles; one containing offenders with few previous criminal convictions and one containing more traditional criminals with a heavy criminal record. The second evident finding is that these profiles seems to be the same irrespective of whether the offenders are single murderers, serial killers or multiple homicide offenders.

Although we had no information on whether the individuals included in the present study belonged to a criminal gang and/or took part in organized crime it may be relevant to mention previous literature on the characteristics of such members in criminal gangs. This is because many of their individual characteristics are similar to the variables included in our latent classes as well as the external validators. Furthermore, a life-course perspective on these individuals includes characteristics that often develop already in childhood and youth and then follow the offenders into adulthood (Coid et al., 2013; Glesmann, Krisberg, & Marchionna, 2009; Wood, Kallis, & Coid, 2017).

Our results of the LCA should be interpreted with caution as they need to be replicated in other settings before considered valid. In an attempt to validate our findings, we used several methods such as external validators, tetrachoric correlations and hold-out validation samples but not k-fold cross-validation. Our results should also be interpreted in a context where we included several types of homicide crimes; homicide, attempted homicide, preparation to commit homicide and conspiracy to commit homicide. It is possible that other classes would have been obtained if homicide had been the only crime studied. In our view though, including several types of homicide crimes gives a more comprehensive picture since the intent of the offender in homicide+ is to kill and take the life of another human being. In the interpretation of our results, it is also important to keep in mind that

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