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Risk factors for violent behaviour before and after the onset of schizophrenia spectrum disorder: A naturalistic case-control study in the Netherlands

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ABSTRACT

Background: Risk factors for violent behaviour may differ depending on whether this begins before (VBO) or after (VAO) the onset of schizophrenia spectrum disorder. However, previous studies have been limited by selective samples of forensic patients and crude outcome measures.
Methods: The sample consisted of 1013 patients with schizophrenia spectrum disorders recruited from various treatment settings across the Netherlands. Putative risk factors and outcomes were measured with standardised instruments. We used logistic regression models to compare patients with VBO ($n = 48$), patients with VAO ($n = 130$) and nonviolent (NV) patients ($n = 708$) on each risk factor, adjusting for sex and age.
Results: Patients with VBO more often lived in a socially disorganised neighbourhood than NV patients (adjusted odds ratio [aOR] 3.3, 95 % confidence interval [CI] 1.3–8.0) and patients with VAO (aOR 3.3, 95 % CI 1.1–9.6). Clinical risk factors were more prevalent in patients with VAO than in NV patients, with substance misuse (aOR 1.5, 95 % CI 1.0–2.3), impairments in executive functions (aOR 1.6, 95 % CI 1.0–2.4), poor impulse control (aOR 2.4, 9 % CI 1.5–3.6), delusions (aOR 1.5, 95 % CI 1.1–2.3) and lack of illness insight (aOR 1.5, 95 % CI 1.0–2.2) reaching statistical significance. Patients with VBO were also more likely to have poor impulse control than NV patients (aOR 2.6, 95 % CI 1.3–5.1).
Conclusion: Strategies to predict and prevent violence in schizophrenia spectrum disorders should distinguish between VBO and VAO.

1. Introduction

Individuals with schizophrenia spectrum disorders are at increased risk of violent behaviour compared with the general population (Fazel et al., 2009; Large and Nielssen, 2011). In a meta-analysis, the odds of violence in cases were about five times higher than in unaffected controls (Fazel et al., 2009). Estimates of the population attributable fraction are as high as 10 % (Fazel et al., 2018). Among the strongest risk factors for violence in schizophrenia spectrum disorders are parental deviance, childhood maltreatment, substance misuse, poor impulse control, positive symptoms and lack of illness insight (Witt et al., 2013). With regard to positive symptoms, the most consistent associations with violent behaviour have been reported for delusions (Coid et al., 2013; Ullrich et al., 2014) and hallucinations (Haddock et al., 2013; Swanson et al., 2006). Neighbourhood disorganisation (Markowitz, 2011) and cognitive impairment (Reinharth et al., 2014) may be important risk factors as well, although these have received little attention. Apart from positive symptoms (as pathognomonic of schizophrenia spectrum disorders) and lack of illness insight, all of the above are also risk factors for violence in the general population (Farrington et al., 2017).

Risk factors may differ depending on whether violent behaviour develops before (VBO) or after (VAO) the onset of schizophrenia spectrum disorder. In clinical practice, it is usually assumed that VBO is similar in aetiology as violence in the general population and that VAO is mainly illness related (Kooyman et al., 2012). If true, not distinguishing between VBO and VAO could lead to false negative findings

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in research on risk factors, inaccuracies in risk assessment and ineffective prevention strategies. However, the evidence regarding differential risk factors for VBO and VAO is scarce and inconclusive. In a register-based study of all schizophrenia patients born in Denmark between 1963 and 1989 ($N = 4179$), substance misuse at initial treatment contact almost quadrupled (hazard ratio 3.7, 95 % confidence interval [CI] 2.5–5.4) the likelihood of subsequently being convicted of a violent crime for the first time (Munkner et al., 2005). Other studies have used the broader outcome of antisocial behaviour. These studies have consistently reported higher rates of substance misuse in patients with conduct disorder in their youth than in those without (Mathieu and Côté, 2009; Moran and Hodgins, 2004; Sánchez-SanSegundo et al., 2014; Swanson et al., 2008), and in patients who committed any crime before becoming ill than in those who only did so afterwards (Jones et al., 2010; Kooyman et al., 2012; Laajasalo and Häkkänen, 2005; Simpson et al., 2015; Tengström et al., 2001; van Dongen et al., 2014). Studies of parental deviance (Jones et al., 2010; Laajasalo and Häkkänen, 2005; Sánchez-SanSegundo et al., 2014), childhood maltreatment (Mathieu and Côté, 2009; Sánchez-SanSegundo et al., 2014; van Dongen et al., 2015) and positive symptoms (Laajasalo and Häkkänen, 2005; Munkner et al., 2009; van Dongen et al., 2014) have produced conflicting results. Moreover, studies have been limited by selective samples of forensic patients, crude definitions of illness onset (e.g., age, first psychiatric admission), small numbers of selected risk factors and omission of nonantisocial controls. To our knowledge, there have been no studies of neighbourhood disorganisation and only one of cognitive impairment (see immediately below).

To address the limitations of previous studies, we have investigated a wide range of putative risk factors for VBO and VAO in a large sample of general psychiatric patients with schizophrenia spectrum disorders in the Netherlands. We included a control group of nonviolent (NV) patients and defined illness onset as a patient's first psychotic episode. Using the same sample, we have previously shown that cognitive impairment increases the risk of VAO compared with no violence (Lamsma et al., 2020). However, we did not conduct analyses for VBO and therefore included cognitive impairment as a risk factor in the present study.

2. Methods

2.1. Study setting and participants

We used data (release 5.0) that were collected for a larger research project, called Genetic Risk and Outcome of Psychosis (GROUP). The GROUP project was conducted by the psychiatry departments of four university hospitals and affiliated mental healthcare centres ($k = 36$) in the Netherlands. These institutions are located in representative geographical areas of the country and offer treatment in a variety of settings (e.g., psychiatric hospitals, outpatient clinics, residential care facilities) to about 75 % of the population. Throughout 2004, consecutive patients were invited to participate if they met the following criteria: (i) age between 16 and 50; (ii) good command of the Dutch language; and (iii) Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision (DSM-IV-TR) (American Psychiatric Association, 2000) diagnosis of schizophrenia or other non-affective psychotic disorder. The patients' parents were asked to provide informant history. In total, 1013 patients and 907 of their parents enrolled. Assessments took place at the university hospitals, with follow-up waves at three and six years after baseline. The protocol of the GROUP project was approved centrally by the ethics committee of one of the university hospitals (University Medical Centre Utrecht) and all participants gave written informed consent before their first assessment.

2.2. Variables of interest

Table S1 gives an overview of the instruments that were used to measure the risk factors and outcomes selected for the present study, including in which participant group (patients or their parents) and at which wave they were administered. To maximise statistical power and minimise bias due to loss to follow-up, we used data from the earliest wave at which an instrument was administered. The psychometric properties of the instruments have been described elsewhere (Korver et al., 2012).

2.2.1. Environmental risk factors

2.2.1.1. Parental aggression. The Comprehensive Assessment of Symptoms and History (Andreasen et al., 1992) was used to determine whether one or both of the patient's parents had ever been aggressive. It defines aggression as the expression of anger that is grossly inappropriate or disproportionate to the situation at hand, ranging in seriousness from verbal threats to homicide.

2.2.1.2. Parental substance misuse. Lifetime histories of substance misuse in parents were established with the Substance Abuse Module of the Composite International Diagnostic Interview (World Health Organization, 1990). We defined alcohol misuse as a regular intake of >50 units per week for men and >35 units per week for women (National Institute for Health and Clinical Excellence, 2010). For other substances, misuse referred to a DSM-IV-TR diagnosis of abuse or dependence.

2.2.1.3. Childhood maltreatment. The Childhood Trauma Questionnaire-Short Form (Bernstein et al., 2003) was used to assess childhood experiences of maltreatment in patients. There are subscales for five forms of maltreatment: emotional, physical and sexual abuse, and emotional and physical neglect. Each subscale consists of five items, rated on a 5-point scale. Anchors are 'never true' (1) and 'very often true' (5).

2.2.1.4. Neighbourhood disorganisation. Social disorganisation in the patient's current neighbourhood was measured with the Social Environment Assessment Tool (Kirkbride, 2016). It covers four aspects of social disorganisation: frequency and impact of crime, informal social control and social cohesion. Response options vary between 1 (e.g., 'almost never', 'very unlikely') and 5 (e.g., 'almost always', 'very likely').

2.2.2. Clinical risk factors

2.2.2.1. Comorbid substance misuse. Lifetime substance misuse in patients was defined and measured in the same way as in parents.

2.2.2.2. Impairments in executive functions and theory of mind. We chose neuropsychological tests whose targeted cognitive functions (between parentheses) are hypothetically related to violent behaviour: Continuous Performance Test-HQ (CPT-HQ) (Nuechterlein and Dawson, 1984) (inhibition); Response Shifting Task (RST) (Bilder et al., 1992) (cognitive flexibility); Block Design subtest of the Wechsler Adult Intelligence Scale, third edition (Wechsler, 1997) (reasoning and problem solving); Mazes Test of the Neuropsychological Assessment Battery (Stern and White, 2003) (planning); Degraded Facial Affect Recognition Task (van't Wout et al., 2004) (facial affect recognition); and Hinting Task (Corcoran et al., 1995) (understanding indirect speech). The tests are described in the supplement (Table S2).

We separated cognitive functions into executive functions (i.e.,

inhibition, cognitive flexibility, reasoning and problem solving, and planning) and theory of mind (i.e., facial affect recognition and understanding indirect speech), as these domains may be differently related to violence (Meijers et al., 2017; Winter et al., 2017). Executive functions are defined as mental operations needed to direct behaviour towards the realisation of goals (Diamond, 2013) and theory of mind as the ability to infer mental states (e.g., motivations, emotions) in oneself and others (Schaafsma et al., 2015).

2.2.2.3. Impulsivity, positive symptoms, and lack of illness insight. The Positive and Negative Syndrome Scale (Kay et al., 1987) was used to measure impulsivity (item G14), delusions, hallucinations (item P3) and illness insight (item G12) in patients over the previous week. For delusions, we summed the scores on items P1 ('delusions'), P5 ('grandiosity') and P6 ('suspiciousness'). Items are scored from 1 ('no impairment') to 7 ('severe impairment').

2.2.3. Outcomes

Violent behaviour was ascertained with the Life Chart Schedule (LCS) (Susser et al., 2000). Designed to trace the long-term development of symptoms, social functioning and health care consumption in patients with schizophrenia spectrum disorders, the LCS contains the following question regarding violence: 'Has the patient ever physically attacked or abused another person?' Answers were coded as 'no', 'before the first psychotic episode' or 'only after the first psychotic episode'. These answers were used to create groups of NV patients, patients with VBO and patients with VAO, respectively. The LCS was filled out based on review of medical records and patient interviews.

2.3. Statistical analysis

We dichotomised risk factors on ordinal and continuous scales. This enabled us to calculate clinically more meaningful statistics (i.e., proportions and odds ratios with confidence intervals) and assess the relative importance of risk factors. Cut-off scores were chosen on substantive grounds (Table S3). To improve their validity, we required that models had at least five observations per cell in the two-by-two table of the risk factor and outcome (Kraska-Miller, 2014). Since one of the cell counts was lower for parental aggression, we combined it with parental substance misuse into a single variable ('parental deviance'). Higher scores reflected better performance on all neuropsychological tests, apart from certain subscales of the CPT-HQ (i.e., number of commission errors) and RST (i.e., accuracy cost and reaction time cost). For that reason, these subscales were reverse scored for the current analyses. We created composite scores for the CPT-HQ and RST by first transforming the raw scores on the subscales to *z*-scores and then averaging the *z*-scores over the subscales (Harrison et al., 2016). The same approach was used to create composite scores for executive functions and theory of mind.

We used logistic regression models to estimate the effects of each risk factor on VBO and VAO. For theoretical reasons, we included sex and age as potential confounders (Lamsma and Harte, 2015). The outcomes were compared as follows: NV vs VBO, NV vs VAO and VAO vs VBO. We considered both the clinical and statistical significance of our findings (Funder and Ozer, 2019). Based on previous research (Witt et al., 2013) and Cohen (2013)'s benchmarks, we defined clinical significance as an adjusted odds ratio (aOR) of $\leq$0.7 or $\geq$1.5. This corresponds to a Cohen's *d* of $>|0.2|$ (Lipsey and Wilson, 2001) or a 'more than trivial' effect (Cohen, 2013). The level of statistical significance for each comparison was set at 5 %.

Missing data were handled with multiple imputation by chained equations (Azur et al., 2011). The imputation model consisted of all variables used in the analysis models (i.e., potential confounders, risk factors and outcomes). We pooled estimates over 50 imputed datasets using Rubin's Rules (Rubin, 1987). As recommended, we imputed outcomes as well as risk factors (Sterne et al., 2009). Proportions of missing data in most risk factors and the outcomes were modest (<15 %) (van Buuren, 2018). Where risk factors had large proportions of missing data (>30 %), this was because they were only measured in parents (i.e., parental deviance) or at follow-up waves (i.e., childhood maltreatment and neighbourhood disorganisation) (Table S4). Missingness in most variables correlated significantly ($p < .05$) with values on at least one other variable (Table S5). To test the robustness of the imputation procedure, we also conducted complete-case analyses.

All analyses were carried out in SPSS v25.

Table 1
Sample characteristics.

Characteristic	NV (n = 708)	VBO (*n* = 48)	VAO (*n* = 130)
Demographic characteristics			
Male sex	543 (77)	34 (71)	108 (83)
Age	28 (7)	26 (6)	26 (6)
White ethnicity	559 (80)	38 (79)	96 (75)
Completed secondary school	620 (88)	40 (83)	102 (78)
Clinical characteristics			
DSM-IV-TR diagnosis			
Schizophrenia	479 (68)	38 (79)	95 (73)
Schizoaffective disorder	90 (13)	1 (2)	16 (12)
Psychotic disorder NOS	57 (8)	6 (13)	11 (8)
Other	82 (12)	3 (6)	8 (6)
Age of illness onset	23 (7)	22 (6)	22 (5)
Psychiatric readmission	247 (40)	22 (49)	70 (57)
Violent behaviour			
Number of incidents		3 (3)	2 (2)
Injured victim		12 (27)	42 (33)

Data are n (%) or M (SD). NV, no violence; VBO, violence before illness onset; VAO, violence after illness onset only; DSM-IV-TR, Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision; NOS, not otherwise specified.

3. Results

3.1. Descriptive characteristics

Table 1 shows the patients' (N = 886) demographic and clinical characteristics. Patients were mostly male (n = 685, 77 %), white (n = 693, 78 %) and diagnosed with schizophrenia (n = 612, 69 %). Their mean age was 27 (SD = 7) years. Violent behaviour was recorded in 178 (20 %) patients. Of these, 48 (27 %) patients had been violent before their first psychotic episode and 130 (73 %) only thereafter. On average, patients with VBO (M = 26, SD = 6) and patients with VAO (M = 26, SD = 6) were younger than NV patients (M = 28, SD = 7). The rate of repeat admissions to a psychiatric hospital was highest in patients with VAO (n = 70, 57 %).

3.2. Risk factors for VBO and VAO

3.2.1. Environmental risk factors

Patients with VBO more often lived in a socially disorganised neighbourhood than NV patients (aOR 3.3, 95 % CI 1.3–8.0) and patients with VAO (aOR 3.3, 95 % CI 1.1–9.6) (Table 2). They were also less likely to have experienced childhood maltreatment than NV patients (aOR 0.5, 95 % CI 0.3–1.2) and patients with VAO (aOR 0.4, 95 % CI 0.2–1.0). There were no appreciable differences between any of the groups with regard to parental deviance.

3.2.2. Clinical risk factors

Poor impulse control was more common in patients with VBO (aOR 2.6, 95 % CI 1.3–5.1) and patients with VAO (aOR 2.4, 95 % CI 1.5–3.6) than in NV patients. The same was true for comorbid substance misuse, cognitive impairments and lack of illness insight. However, only their effects on VAO (compared with NV) were clinically and statistically significant (comorbid substance misuse: aOR 1.5, 95 % CI 1.0–2.3; impairments in executive functions: aOR 1.6, 95 % CI 1.0–2.4; lack of

Table 2
Risk factors for violent behaviour before and after the onset of schizophrenia spectrum disorder.

Risk factor	n (%)			aOR (95 % CI)[a]		
	NV (n = 708)	VBO (n = 48)	VAO (n = 130)	NV vs VBO	NV vs VAO	VAO vs VBO
Environmental risk factors						
Parental deviance	69 (18)	6 (21)	15 (20)	1.2 (0.5–3.0)	1.0 (0.5–1.9)	1.3 (0.4–3.9)
Childhood maltreatment	214 (43)	9 (30)	42 (47)	0.5 (0.3–1.2)	1.2 (0.8–1.9)	0.4 (0.2–1.0)
Neighbourhood disorganisation	138 (43)	15 (71)	23 (43)	3.3 (1.3–8.0)	1.0 (0.6–1.8)	3.3 (1.1–9.6)
Clinical risk factors						
Comorbid substance misuse	330 (49)	25 (56)	76 (62)	1.4 (0.7–2.6)	1.5 (1.0–2.3)	0.8 (0.4–1.7)
Cognitive impairment						
Executive functions	251 (45)	15 (47)	58 (54)	1.3 (0.6–2.5)	1.6 (1.0–2.4)	0.8 (0.4–1.7)
Theory of mind	234 (39)	16 (41)	53 (47)	1.2 (0.6–2.4)	1.4 (0.9–2.1)	0.9 (0.4–1.8)
Poor impulse control	109 (16)	15 (33)	39 (31)	2.6 (1.3–5.1)	2.4 (1.5–3.6)	1.1 (0.5–2.4)
Positive symptoms						
Delusions	323 (47)	16 (36)	75 (59)	0.6 (0.3–1.2)	1.5 (1.1–2.3)	0.4 (0.2–0.9)
Hallucinations	282 (41)	15 (33)	63 (49)	0.7 (0.4–1.3)	1.3 (0.9–2.0)	0.5 (0.3–1.1)
Lack of illness insight	323 (47)	22 (50)	74 (58)	1.2 (0.7–2.2)	1.5 (1.0–2.2)	0.8 (0.4–1.7)

aOR, adjusted odds ratio; CI, confidence interval; NV, no violence; VBO, violence before illness onset; VAO, violence after illness onset only.
[a] Based on multiple imputation ($N = 1013$, $m = 50$), and adjusted for sex and age.

illness insight: aOR 1.5, 95 % CI 1.0–2.2). Patients with VAO more frequently presented with delusions than NV patients (aOR 1.5, 95 % CI 1.1–2.3) and patients with VBO (aOR 2.3, 95 % CI 1.1–4.8), while patients with VBO did less so than NV patients (aOR 0.6, 95 % CI 0.3–1.2). Similar, but nonsignificant, effects were observed for hallucinations.

3.3. Sensitivity analyses

Similar results were obtained with complete-case analyses (Table S6).

4. Discussion

4.1. Main findings

In a sample of 1013 general psychiatric patients with schizophrenia spectrum disorders in the Netherlands, we have investigated whether risk factors for violent behaviour differ depending on whether this begins before (VBO) or after (VAO) illness onset. There were five main findings:

(i) VAO explains most of the excess risk of violence in schizophrenia spectrum disorders

The rate of violent behaviour in patients was 20 % ($n = 178$), which is in line with previous studies (Fazel et al., 2009; Fazel et al., 2014). The rates of VBO and VAO were 5 % ($n = 48$) and 15 % ($n = 130$), respectively. This finding suggests that VAO accounts for most of the excess risk of violence in schizophrenia spectrum disorders. It also suggests that – as is often assumed in clinical practice – VBO is similar in aetiology as violence in the general population and VAO illness related. The rate of VBO was comparable to that of violence in the general population (Falk et al., 2014), while first-episode psychosis typically occurs at an age (around 25 years [Solmi et al., 2022]) when it is uncommon for violence to begin in the general population (Loeber and Pardini, 2008). Our other findings (in particular findings ii and iii) are consistent with this interpretation.

(ii) Neighbourhood disorganisation is a risk factor for VBO

Patients with VBO were over three times more likely to live in a socially disorganised neighbourhood than NV patients (aOR 3.3, 95 % CI 1.3–8.0) and patients with VAO (aOR 3.3, 95 % CI 1.1–9.6). Neighbourhood disorganisation may reflect economic disadvantage and adverse early-life experiences, both of which are risk factors for violent behaviour (Farrington et al., 2017). However, low educational attainment – a proxy for economic disadvantage (Lindberg et al., 2022) – and adverse early-life experiences – in the form of parental deviance and childhood maltreatment – were not more common in patients with VBO than in NV patients or patients with VAO. These findings suggest that VBO may stem in part from a lack of informal social control or social cohesion (the two elements of social disorganisation) in the patient's neighbourhood. When these elements are lacking, violence may occur because residents are less able or willing to enforce order (Kubrin and Mioduszewski, 2019). Socially disorganised neighbourhoods are also characterised by social norms that approve of violence. Such norms may be internalised or relied upon in conflict situations (Kurtenbach and Rauf, 2019).

(iii) VAO is partly illness related

All clinical risk factors were more prevalent in patients with VAO than in NV patients. Besides impulsivity (discussed below), the effects of comorbid substance misuse (aOR 1.5, 95 % CI 1.0–2.3), impairments in executive functions (aOR 1.6, 95 % CI 1.0–2.4), delusions (aOR 1.5, 95 % CI 1.1–2.3) and lack of illness insight (aOR 1.5, 95 % CI 1.0–2.2)

reached our thresholds for clinical (aOR ≥1.5) and statistical ($p < .05$) significance. Although their individual effects were relatively small, these risk factors may have additive or larger interactive effects when they co-occur (Lamsma and Harte, 2015). Environmental risk factors had no appreciable effect on VAO. Taken together, these findings suggest that VAO is at least partly illness related. Substances may induce or exacerbate positive symptoms (Ham et al., 2017) or reduce the therapeutic effects of antipsychotics (Lindsey et al., 2012). In addition, patients who misuse substances are less likely to seek and adhere to treatment than those who do not (Winklbaur et al., 2006). Impaired executive functioning may lead to violence through an inability to override prepotent responses, adapt to challenging circumstances or learn from the consequences of one's actions (Wood and Worthington, 2017). It also associated with substance misuse (Thoma and Daum, 2013) and treatment nonadherence (Haddad et al., 2014). Lack of illness insight increases the likelihood that someone will act on delusions or hallucinations (Bjørkly, 2006) and avoid treatment (Higashi et al., 2013). Delusions may motivate violent behaviour, especially when they are accompanied by anger (Ullrich et al., 2014). Delusions were the only clinical risk factor for which there was a significant difference between patients with VBO and patients with VAO, with its rate being higher in the latter (aOR 2.3, 95 % CI 1.1–4.8). This suggests that delusions may mediate the associations between other clinical risk factors and VAO.

(iv) Poor impulse control is a risk factor for both VBO and VAO

We found that patients with VBO (aOR 2.6, 95 % CI 1.3–5.1) and patients with VAO (aOR 2.4, 9 % CI 1.5–3.6) were more than twice as likely to have poor impulse control than NV patients. Impulsivity may be a personality trait but is also a clinical feature of schizophrenia spectrum disorders (Ouzir, 2013). Furthermore, it may present before the onset of schizophrenia spectrum disorder. This is supported by two lines of evidence. First, conduct disorder (Hodgins, 2008) and attention deficit hyperactivity disorder (Dalsgaard et al., 2014) – two mental disorders characterised by impulsivity – are precursors of schizophrenia spectrum disorders. Second, brain abnormalities observed in individuals with schizophrenia spectrum disorders, such as low-grade inflammation, hypofunction of *N*-methyl-D-aspartate receptors and disruption of frontostriatal circuits, precede first-episode psychosis by many years (Kahn and Sommer, 2015) and have been linked to impulsive behaviour in the general population (Fineberg et al., 2014; Gassen et al., 2019; Pattij and Vanderschuren, 2008). Impulsivity lowers the threshold for violence through a decreased sensitivity to or concern for its possible consequences, or lack of forethought (Moeller et al., 2001).

(v) Childhood maltreatment and positive symptoms are least common in patients with VBO

An unexpected finding was that childhood maltreatment and positive symptoms (i.e., delusions and hallucinations) were least common in patients with VBO. Childhood maltreatment contributes to the development of positive symptoms (Popovic et al., 2019), which could explain the higher rates of these risk factors in NV patients and patients with VAO. It is also possible that patients with VBO have a different symptom profile. These are preliminary hypotheses, however, and need to be tested in future research.

4.2. Strengths and limitations

This study has several strengths. First, patients were recruited from representative geographical areas of the Netherlands and various treatment settings, which increased the generalisability of the results. Second, the use of multiple data sources increased the sensitivity of the outcome measure. Third, we included the most robust risk factors for violence in schizophrenia spectrum disorders and compared their rates between not only patients with VBO and patients with VAO but also NV patients. Finally, we used multiple imputation to handle missing data, which retains sample size and reduces nonresponse bias (van Ginkel et al., 2020).

However, there are a number of limitations. First, the case-control design precludes causal inference. In addition, time lag and treatment with antipsychotics may have attenuated associations for impulsivity, delusions and hallucinations (Samara et al., 2016; Van Schalkwyk et al., 2018). Second, we only controlled for two potential confounders (i.e., sex and age). Others were unavailable or else excluded because they could lie on the causal pathway to violence (e.g., low educational attainment, comorbid substance misuse) (Cole and Hernán, 2002). Third, the absolute frequencies of parental deviance and childhood maltreatment among patients with VBO were low ($n = 6$ and $n = 9$, respectively, before imputation). The estimated effects of these risk factors on VBO should therefore be treated with caution. Fourth, first-episode psychosis is in most cases preceded by a prodromal stage, which may last from a few days to several years (Addington and Lewis, 2011). It is possible that prodromal symptoms, in particular irritability and attenuated positive symptoms, are conducive to violent behaviour and thus inflated the rate of VBO. However, such symptoms are mild (subclinical by definition) and appear towards the end of the prodrome (Larson et al., 2010). Furthermore, the prodrome typically consists of negative and nonspecific symptoms, such as flat affect, anxiety and social withdrawal (Larson et al., 2010), which are not thought to be related to violent behaviour (Witt et al., 2013). Finally, it was not recorded at what age patients were first violent or whether patients with VBO were also violent after illness onset. It has been suggested that VBO begins in childhood and continues into adulthood, whereas VAO is transient (Hodgins and Klein, 2017). Contrary to this, however, we found no difference in the number of violent incidents between patients with VBO and patients with VAO.

4.3. Implications and recommendations

A clinical implication of our findings is that a distinction should be made between VBO and VAO in the prediction and management of violent behaviour in schizophrenia spectrum disorders. Specifically, our findings indicate that (i) neighbourhood disorganisation should be a primary target for VBO, (ii) comorbid substance misuse, impairments in executive functions, delusions and lack of illness insight primary targets for VAO, and (iii) poor impulse control a primary target for VBO and VAO. It is also important to determine whether this improves the performance of structured tools for violence risk assessment. Such tools do not currently distinguish between VBO and VAO, and rarely do they contain items for neighbourhood disorganisation or cognitive impairment (Singh et al., 2011). To clarify causal mechanisms, we recommend that future studies use longitudinal designs and test for mediators and additional confounders. Finally, there is a need for our study to be replicated with larger samples, across general and forensic psychiatric settings, and in other countries.

CRediT authorship contribution statement

The GROUP investigators coordinated recruitment and data collection; JL and JMH designed the study; JL carried out the analyses and drafted the manuscript; JMH, WC and GROUP investigators critically reviewed and revised the manuscript.

Declaration of competing interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

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