Influencing Factors of Multiple Adverse Outcomes Among Schizophrenia Patients Using Count Regression Models: A Cross-Sectional Study

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Abstract

Background: Schizophrenia patients have increased risks of several adverse outcomes, including violent crime, aggressiveness and suicide. However, studies of different adverse outcomes in the same population are rare and the influencing factors for these outcomes need clarification by appropriate models. This study aimed to identify influencing factors of these adverse outcomes by examining and comparing different count regression models.

Methods: This study included schizophrenia patients who had at least once follow-up record in the Guangdong Mental Health Center Network Medical System during 2020. Three types of adverse outcomes including a) aggressiveness with police dispatch or violence crime, b) aggressiveness without police dispatch, and c) self-harm or suicide attempts. First, we investigated the incidence of these adverse outcomes in each type. Second, the Poisson, negative binomial (NB), zero-inflated Poisson (ZIP), and zero-inflated negative binomial (ZINB) regression models were fitted and compared for their intensity. Finally, We analysed associations between these adverse outcomes intensity and sociodemographic, clinical factors with the best model.

Results: A total of 130474 schizophrenia patients were selected. Each type of adverse outcomes was reported by less than 1% of schizophrenia patients in 2020. NB regression model is the best model for fitting the number of aggressiveness without police dispatch because of the best goodness of fit and relatively simple interpretation, whereas ZINB models for the other two outcomes. Age, sex, and history of adverse outcomes were influencing factors shared across these adverse outcomes. Higher educational level, employment were protective factors shared between aggressiveness with police dispatch or violent crime, and aggressiveness without police dispatch. Aggressiveness without police dispatch, and self-harm or suicide attempts shared older onset age (≥ 18 years) as a risk factor. Family history of mental disease was a risk factor of self-harm or suicide attempts individually.

Conclusions: NB and ZINB models were selected for fitting the number of adverse outcomes in our studies. Influencing factors for adverse outcomes intensity included both those shared across different types and those individual to specific types. Therefore, combined and customized tools in risk assessment and intervention for different types of these outcomes might be necessary.

Background

Schizophrenia is a severe mental disorder characterized by delusions, hallucinations, impaired motivation, reduction in spontaneous speech, and social withdrawal[1]. According to the Global Burden of Disease Study 2019, the worldwide prevalence of schizophrenia was 0.32% and China has the higher prevalence, which reached 0.4%[2]. In addition, schizophrenia was associated with a weighted average of 14.5 years of potential life lost[3]. Schizophrenia patients are at an increased risk of many adverse outcomes, such as aggression, crime, suicide attempt, and suicide. The odds ratio of violent crime, suicide, and premature mortality for patients with schizophrenia and related disorders was over 7.5 compared with the general population[4]. The prevalence of aggression in schizophrenia patients was above 30%[5, 6], the frequency of experiencing physical violence in their primary caregivers was 75.8%[7], and the lifetime risk of suicide attempt was 40-50%[8, 9]. Therefore, these adverse outcomes represent a public health concern and pose a challenge to both clinical treatment and patient's health. On the other hand, these adverse events are considered to be preventable by controlling related factors, and it is necessary to develop effective assessment methods.

Many studies investigated the influencing factors for these adverse outcomes among schizophrenia patients. Being male and early in age were the common risk factors[10–12]. Other socio-demographic characteristics were risk factors of violence, including unemployment, lower levels of education, single status, and lower income[10, 13, 14]. Some studies also suggested that these adverse outcomes were associated with a history of these outcomes, a history of drug use, and a family history of psychiatric illness [12–14]. Other clinical factors including hospitalizations, lower satisfaction, or treatment adherence had been suggested in some studies[11, 13, 15]. However, the previous researches investigated these outcomes separately. Few studies focused on the individual and shared influencing factors for different types of adverse events in the same population. Such influencing factor information contributes to the prevention and treatment of schizophrenia and helps to risk assessment.

In addition, patients can take these events several times during the specified period, which means these outcomes should be considered to be count data. However, most studies treated these outcomes as dichotomous data. For instance, they used the Modified Overt Aggression Scale (MOAS) to assess the aggressive and violent behaviors occurring in the week and used the MOAS score as a dichotomous variable. Some studies suggested that severer psychiatric symptoms were associated with higher aggressive levels [16, 17]. Treating the variable as a dichotomous variable may result in loss of information. Few studies can be found investigating the association of the intensity of these events in patients with schizophrenia, and treating the number of these events as a count data and investigating its influencing factors is necessary.

The Poisson regression model is commonly used to model count data, but its assumption of equal mean and variance is not reasonable in some cases. For overdispersed count data (greater variance compared with mean), the negative binomial regression is more appropriate[18, 19]. However, the above models cannot handle count data with excess zeros. The zero-inflated regression models considered the data as a mixture of a “zero” subset and another “non-zero” subset following specific distribution to address excess zeros[20, 21]. There are few studies to investigate and compare the performance of different count models in terms of modeling adverse events in schizophrenia patients. In this study, we aimed to identify influencing factors that lead to different types of adverse outcomes, whether they are shared or individual related to these outcomes, by examining and comparing different count regression models.

Methods

Study participants

The study participants were selected from the Guangdong Mental Health Center Network Medical System (GDMHS), a disease registration report system of community mental health service. GDMHS was covered over 99% of schizophrenia patients in the province. There were over 348000 patients registered in GDMHS during the periods from 2010 to 2019 in Guangdong, one of the biggest provinces in China[22]. Patient profile, clinical characteristics, and treatment information were recorded and maintained into GDMHS. Psychiatrist doctors and chief physicians were responsible for the data validation. To ensure data reliability, the Guangdong Health Commission conducted verification on the dataset annually by sampling surveys. The present study included schizophrenia patients with International Classification of Diseases, Tenth Revision code F20* in GDMHS. Other inclusion criteria were as follows: (1) the age of onset between 6-65 years of age; (2) having at least once follow-up during the period from January 1, 2020, to December 31, 2020; (3) no missing or implausible data.

Measures

We classified adverse outcomes for three types according to different characteristics of behaviors, victim objects, interventions as well as services. The first type is aggressiveness with police dispatch and violent crime, which is aggression or violence against others and leads to police dispatch or violate the law. Public safety was responsible for the identified work of violent crime and aggressiveness. The second type is aggressiveness without police dispatch, which is aggression or violence against others but does not lead to police dispatch. The third type is self-harm and suicide attempts. Aggressiveness without police dispatch, self-harm, and suicide attempts were reported by patients or their caregivers and assessed by community public health service workers. The total number of these events in each type during the period of 2020 was considered as the dependence variables.

Independence variables included gender, age, register type, education level, employment status, marital status, residential type, economic status, other medical history, family history of mental disease, duration of illness, psychosis treatment status, duration of untreated psychosis, onset age, history of adverse outcomes. Independence variables were collected at baseline. All the categorical variables were entered into the models as dummy.

Analysis methods

First, we described the adverse outcome and independent variables. Then, we used the Poisson regression, negative binomial (NB) regression, zero-inflated Poisson (ZIP) regression, and zero-inflated negative binomial (ZINB) regression to fit the data without covariates in each type of adverse outcomes. The Likelihood Ratio test was used to identify overdispersion. The Vuong test was used for the non-nested model to see whether there were excess zeros. In addition, the fitting goodness of regressions was evaluated by the difference between predicted and observed probabilities, log-likelihood, and Akaike information criterion (AIC). Then, we selected the best fit model for multivariate regression of adverse outcomes in each type. We used backward stepwise selection as the variable selection method in our study. The logit part of ZIP and ZING regression included intercept and the non-zero part included the same covariates of the Poisson and NB regression. Statistical significance was defined as $p \leq 0.05$. All analyses were conducted using R, version 4.0.

Results

As shown in Table 1, there were 130474 schizophrenia patients in this study, and each type of adverse outcomes was reported by less than 1% of schizophrenia patients in 2020. The majority of them have reported no adverse events in 2020, with about 99.8% of them reported no aggressiveness with police dispatch or violent crime, 99.3% reported no aggressiveness without police dispatch, and 99.9% reported no self-harm or suicide attempts.

Table1

Numbers and proportions of each count in different types of adverse outcomes

Number of adverse outcomes	Aggressiveness with police dispatch or violent crime	Aggressiveness without police dispatch	Self-harm or suicide attempts
0	130219 (99.805)	129502 (99.255)	130400 (99.943)
1	179 (0.137)	640 (0.491)	63 (0.048)
2	35 (0.027)	154 (0.118)	6 (0.005)
3	13 (0.010)	58 (0.044)	2 (0.002)
4	5 (0.004)	28 (0.021)	2 (0.002)
≥5	23 (0.018)	92 (0.071)	1 (0.001)
total	130474(100)	130474(100)	130474(100)
Data are n (%).			

Table 2 shows the distribution of independent variables. The mean age in schizophrenia patients was 47.6 ± 13.9 years with ranging from 9.25 years to 99.8 years. Compared with total patients, those who had adverse events had lower mean age, and self-harm or suicide attempts cases had the lowest mean age (35.9 ± 13.4). Among schizophrenia patients, 54.0% were males and males had more proportion in three types of adverse events cases, with 68.6%, 69.0%, and 56.8% respectively. Most of the patients (87.7%) were register. Among these patients, 85.5% had education levels of junior high school education or below. About 43.7% of the patients were unemployed. Aggressiveness with police dispatch or violent crime cases had a lower proportion of unemployment (40.4%), while aggressiveness without police dispatch cases and self-harm or suicide attempts cases had a higher proportion, with 47.0% and 60.8% respectively. Among schizophrenia patients, 51.3% of them were married, 64.3% of them lived in rural areas, and 41.3% of them were living in poverty (their income was below the local poverty level). Compared with total patients, there is a higher proportion of living in a rural area in aggressiveness with police dispatch or violent crime cases, and aggressiveness without police dispatch cases, with 74.5% and 66.4% respectively. Aggressiveness with police dispatch or violent crime cases had a lower proportion of living with poverty (29.0%) compared with total patients. A small proportion of patients (3.0%) had a medical history, and 6.4% of them had a family history of mental disease. Aggressiveness with police dispatch or violent crime cases had the lowest proportion of other medical history (0.4%), and self-harm or suicide attempts cases had the highest proportion of family history of mental disease (17.6%). The majority of patients (82.9%) had their age at onset of schizophrenia at ≥ 18 years, but the cases of three outcomes had less proportion, with 79.6%, 80.3%, and 74.3% respectively. The mean duration of untreated psychosis was 4.17 ± 7.78 years (range 0-73 years), the mean duration of illness was 19.2 ± 11.1 years (range 0.2-89.3 years). All types of adverse events cases had a shorter duration of illness as well as the duration of untreated psychosis. Most of the patients (99.7%) were received treatment and 86.1% of them had adverse outcomes history. However, all types of adverse outcomes cases had less proportion of, with 65.1%, 62.8%, and 60.8% respectively.

Table 2

Descriptive statistics for the characteristics of schizophrenia patients and adverse outcomes cases

Variable	Total Patients (<i>n</i> =130474)	Aggressiveness with police dispatch or violent crime cases (<i>n</i> =255)	Aggressiveness without police dispatch cases (<i>n</i> =972)	Self-harm or Suicide attempts cases (<i>n</i> =74)
Age(years)	47.6±13.9	42.0±12.5	42.9±12.9	35.9±13.4
Duration of untreated psychosis (years)	4.17±7.78	2.84±5.05	3.29±6.34	2.54±5.32
Duration of illness (years)	19.2±11.1	15.7±9.46	17.0±10.1	13.6±9.75
Gender				
Male	70441 (54.0)	175 (68.6)	671 (69.0)	42 (56.8)
Female	60033 (46.0)	80 (31.4)	301 (31.0)	32 (43.2)
Register type				
Register	114390 (87.7)	228 (89.4)	857 (88.2)	58 (78.4)
Non-register	16084 (12.3)	27 (10.6)	115 (11.8)	16 (21.6)
Educational level				
No education	19933 (15.3)	35 (13.7)	92 (9.5)	6 (8.1)
Primary education	47181 (36.2)	89 (34.9)	290 (29.8)	19 (25.7)
Junior high school education	44329 (34.0)	93 (36.5)	408 (42.0)	31 (41.9)
High school education	11180 (8.6)	26 (10.2)	102 (10.5)	8 (10.8)
Higher education	7851 (6.0)	12 (4.7)	80 (8.2)	10 (13.5)
Employment status				
unemployment	57007 (43.7)	103 (40.4)	457 (47.0)	45 (60.8)
Employment	73467 (56.3)	152 (59.6)	515 (53.0)	29 (39.2)
Marital status				

Variable	Total Patients (<i>n</i>=130474)	Aggressiveness with police dispatch or violent crime cases (<i>n</i>=255)	Aggressiveness without police dispatch cases (<i>n</i>=972)	Self-harm or Suicide attempts cases (<i>n</i>=74)
Single	53400 (40.9)	136 (53.3)	522 (53.7)	47 (63.5)
Married	66990 (51.3)	93 (36.5)	364 (37.4)	23 (31.1)
Widowed	3786 (2.9)	2 (0.8)	21 (2.2)	1 (1.4)
Divorced	6298 (4.8)	24 (9.4)	65 (6.7)	3 (4.1)

Table 2 (Continued.)

Variable	Total Patients (<i>n</i>=130474)	Aggressiveness with police dispatch or violent crime cases (<i>n</i>=255)	Aggressiveness without police dispatch cases (<i>n</i>=972)	Self-harm or Suicide attempts cases (<i>n</i>=74)
Residential type				
Urban	46555 (35.7)	65 (25.5)	327 (33.6)	28 (37.8)
Rural	83919 (64.3)	190 (74.5)	645 (66.4)	46 (62.2)
Economic status				
Non-poverty	76546 (58.7)	181 (71.0)	549 (56.5)	35 (47.3)
Poverty	53928 (41.3)	74 (29.0)	423 (43.5)	39 (52.7)
Medical history				
Yes	3925 (3.0)	1 (0.4)	37(3.8)	2 (2.7)
No	126549 (97.0)	254 (99.6)	935 (96.2)	72 (97.3)
Family history of mental disease				
Yes	8533 (6.6)	20 (7.8)	94 (9.7)	13 (17.6)
No	120697 (93.4)	235 (92.2)	878 (90.3)	61 (82.4)
Onset age(years)				
<18 years	22364 (17.1)	52 (20.4)	191 (19.7)	19 (25.7)
≥18 years	108110 (82.9)	203 (79.6)	781 (80.3)	55 (74.3)
Psychosis treatment				
Yes	130030 (99.7)	255 (100)	968 (99.6)	74 (100)
No	444 (0.3)	0 (0)	4 (0.4)	0 (0)
Adverse outcomes history				
Yes	112329 (86.1)	166 (65.1)	610 (62.8)	45 (60.8)
No	18145 (13.9)	89 (34.9)	362 (37.2)	29 (39.2)
Data are mean±SD for continuous variables, n(%) for categorical variables.				

Figure 1 shows the difference between the predicted and observed probabilities at each count for each intercept-only model fitted to the number of each type of outcomes. It was clear that the Poisson model was a poor fit for three outcomes. The Poisson model underestimated the probabilities of zeros and overestimated the probabilities of ones. The ZIP model gave a better prediction of counts than the Poisson model, but the ZIP model predicted less ones and more bigger counts excepting fitting the number of self-harm or suicide attempts. The NB and ZINB model produced better fit compared to the ZIP model fitted to the number of aggressiveness without police dispatch. The NB model overestimated the probabilities of zeros and underestimated the probabilities of ones in fitting the number of aggressiveness with police dispatch or violent crime as well as in fitting the number of self-harm or suicide attempts, while the ZINB gave the best fit. Table 3 displayed that the number of events was overdispersed since the significant likelihood ratio test ($p \leq 0.001$). The Vuong test indicated that the ZIP was favored over the PI ($p \leq 0.001$) excepting fitting the number of self-harm or suicide attempts. It also indicated that the ZINB was favored over the NB ($p \leq 0.05$) excepting fitting the number of aggressiveness without police dispatch. In addition, the value of Log-likelihood and AIC showed the same results. Taking the fitness and interpretation into account, the ZINB was the best choice in modeling aggressiveness with police dispatch or violent crime intensity, and self-harm or suicide attempts intensity, while the NB was the final model for fitting the number of aggressiveness without police dispatch.

Table 3

The results of goodness-of-fit statistics and tests for four intercept-only models.

Models	Log likelihood	AIC	The likelihood ratio test (p-Value) ^a	The Vuong test (p-Value) ^b
Aggressiveness with police dispatch or violent crime				
Poisson	-4827.2	9656.4	4893.7(<0.001)	-4.2(<0.001)
NB	-2380.3	4764.7	—	-4.1(<0.001)
ZIP	-2870.0	5744.1	1121.8(<0.001)	—
ZINB	-2309.1	4624.3	—	—
Aggressiveness without police dispatch				
Poisson	-18726.1	37454.2	22152.0(<0.001)	-8.6(<0.001)
NB	-7650.2	15304.4	—	-0.002 (=0.499)
ZIP	-10786.3	21576.6	6272.2(<0.001)	—
ZINB	-7650.2	15306.4	—	—
Self-harm or suicide attempts				
Poisson	-990.9	1983.7	513.4(<0.001)	-1.6(=0.054)
NB	-734.2	1472.4	—	-1.7(=0.046)
ZIP	-762.7	1529.3	92.8(<0.001)	—
ZINB	-716.3	1438.6	—	—
NB, negative binomial; ZIP, zero-inflated Poisson; ZINB, zero-inflated negative binomial. a, the likelihood ratio test for overdispersion (Poisson vs. NB and ZIP vs. ZINB) b, the Vuong test for excess zeros (Poisson vs. ZIP and NB vs. ZINB)				

The results of multivariate count regression models are shown in Table 4. Gender, age, and adverse outcomes history were associated with all types of adverse outcomes. The number of aggressiveness with police dispatch or violent crime and the number of aggressiveness without police dispatch by female patients was lower than that of males patients, with incidence rate ratios (IRR) equaled 0.52 (95% CI: 0.33,0.82; p=0.005) and 0.45 (95% CI: 0.35,0.58; p=0.001) respectively. On the other hand, female was a risk factor for self-harm or suicide attempts (IRR=2.20; 95% CI: 1.14,4.25; p = 0.019). Older patients and those having adverse outcomes history patients showed less risk in three adverse outcomes. Patients who had higher educational level exhibited a lower likelihood of aggressiveness with police dispatch or violent crime. Having higher education (IRR=0.48; 95% CI: 0.27, 0.89; p=0.010) also decreased the number of aggressiveness without police dispatch compared to those who had no education. There was an association between unemployment and an increased number of

aggressiveness with police dispatch or violent crime, and that of aggressiveness without police dispatch. Living in rural (IRR=0.44; 95% CI: 0.33, 0.57; $p=0.001$) and poverty (IRR=0.28; 95% CI: 0.17, 0.49; $p=0.001$) was associated with reduced risk of aggressiveness without police dispatch, and aggressiveness with police dispatch or violent crime respectively. Having medical history was associated with higher number of aggressiveness without police dispatch (IRR= 2.62; 95% CI: 1.39,5.42; $p=0.002$), but with lower number of aggressiveness with police dispatch or violent crime (IRR= 0.28; 95% CI: 0.17,0.47; $p=0.001$). Longer duration of illness (IRR= 1.02; 95% CI: 1.01,1.04; $p=0.002$) and adult-onset schizophrenia (onset $\geq$ age 18) (IRR= 1.78; 95% CI: 1.20,2.64; $p=0.001$) significantly increased number of aggressiveness without police dispatch. Adult-onset schizophrenia (IRR= 2.82; 95% CI: 1.24,6.42; $p=0.002$) and having family history of mental disease (IRR= 6.55; 95% CI: 2.78,15.43; $p=0.001$) were risk factor for self-harm or suicide attempts.

Table 4

Multivariate count regression models for the number of adverse outcomes among schizophrenia patients

	Aggressiveness with police dispatch or violent crime		Aggressiveness without police dispatch		Self-harm or suicide attempts	
	IRR(95%CI)	p-Value	IRR(95%CI)	p-Value	IRR(95%CI)	p-Value
Gender						
Male	Reference		Reference		Reference	
Female	0.52(0.33,0.82)	0.005	0.45(0.35,0.58)	<0.001	2.20(1.14,4.25)	0.019
Age (years)	0.98(0.95,1.00)	0.029	0.96(0.95,0.98)	<0.001	0.92(0.89,0.95)	<0.001
Register type						
Register			Reference		(D)	
Non-register			0.74(0.51,1.08)	0.081		
Educational level						
No education	Reference		Reference		(D)	
Primary education	0.55(0.28,1.07)	0.080	0.95(0.65,1.37)	0.760		
Junior high school education	0.30(0.14,0.61)	0.001	0.75(0.50,1.12)	0.111		
High school education	0.22(0.08,0.62)	0.005	1.06(0.63,1.79)	0.826		
Higher education	0.07(0.02,0.25)	<0.001	0.48(0.27,0.89)	0.010		
Employment status						
Unemployment	Reference		Reference		(D)	
Employment	0.42(0.26,0.67)	<0.001	0.70(0.54,0.92)	0.002		
Marital status						
Single	(D)		(D)		Reference	
Married					0.48(0.22,1.02)	0.055
Widowed					0.35(0.03,4.69)	0.425
Divorced					0.53(0.14,2.01)	0.347

Table 4
(Continued.)

	Aggressiveness with police dispatch or violent crime		Aggressiveness without police dispatch		Self-harm or suicide attempts	
	IRR(95%CI)	p-Value	IRR(95%CI)	p-Value	IRR(95%CI)	p-Value
Residential type						
Urban	(D)		Reference		(D)	
Rural			0.44(0.33,0.57)	<0.001		
Economic status						
Non-poverty	Reference		(D)		(D)	
Poverty	0.28(0.17,0.47)	<0.001				
Medical history						
No	Ref		Reference		(D)	
Yes	0.09(0.01,0.62)	0.014	2.62(1.39,5.42)	0.002		
Family history of mental disease						
No	(D)		(D)		Reference	
Yes					6.55(2.78,15.43)	<0.001
Duration of illness(years)	0.99(0.97,1.01)	0.369	1.02(1.01,1.04)	0.002	(D)	
Onset age						
<18 years	(D)		Reference		Reference	
≥18 years			1.78(1.20,2.64)	0.001	2.82(1.24,6.42)	0.013
Adverse outcomes history						
No	Reference		Reference		Reference	

Zero-inflated Negative Binominal regression was used to model the number of aggressiveness with police dispatch or violent crime, and to the number of self-harm and suicide attempts, count model regression results were displayed;

Negative Binominal regression was used to model the number of aggressiveness without police dispatch;

(D), Excluding from model

	Aggressiveness with police dispatch or violent crime		Aggressiveness without police dispatch		Self-harm or suicide attempts	
	IRR(95%CI)	p-Value	IRR(95%CI)	p-Value	IRR(95%CI)	p-Value
Yes	0.13(0.07,0.24)	<0.001	0.14(0.10,0.19)	<0.001	0.12(0.06,0.25)	<0.001
Zero-inflated Negative Binominal regression was used to model the number of aggressiveness with police dispatch or violent crime, and to the number of self-harm and suicide attempts, count model regression results were displayed;						
Negative Binominal regression was used to model the number of aggressiveness without police dispatch;						
(D), Excluding from model						

Discussion

Although there are many studies explored count models in epidemiology and public health area, it is the first study to utilize count regression models to fit the intensity of the adverse outcomes in schizophrenia patients [23–26]. Moreover, it is crucially important to select the best-fitted model for the data since there is no model fitted well for all data. Here, we used four count regression models to investigate influencing factors associated with the number of adverse outcomes in schizophrenia patients and to compare the goodness-of-fit. In our study, over 99% of schizophrenia patients have reported no adverse outcomes in 2020. Traditional Poisson regression had the worst fit to this study data for all types of outcomes because of the overdispersion and excess zeros. To solve the zero-inflated phenomenon, the ZIP model was used and provided a considerable improvement over Poisson regression. To deal with the overdispersion problem, the NB model was used and fitted the data better than the Poisson model, but cannot solve the zero-inflated phenomenon. The ZINB model can account for both overdispersion and the excess zeroes but provided a similar fit compared to the NB model because of no zero-inflated phenomenon with the NB model in fitting aggressiveness without police dispatch intensity. Therefore, the NB model was selected to be the simplest and first choice to fit the number of aggressiveness without police dispatch, and the ZINB model was preferred for the other two events intensity.

Investigation of influencing factors for adverse outcomes is of benefit to intervention and prevention of schizophrenia. In our study, a wide range of sociodemographic and clinical factors were assessed.

Our finding indicated that younger age increased the risk of all outcomes, including aggressiveness with police dispatch or violent crime, aggressiveness without police dispatch, and self-harm or suicide attempts. These results are consistent with the results of other studies that have explored risk factors with binominal response[10, 11, 27, 28]. Males increased the number of adverse events that violence against others and consistent findings were found in other studies[29]. However, the association between gender and self-harm or suicide attempts was mixed and inconclusive in previous studies[30–32], we found that males decreased the intensity of self-harm or suicide attempts.

In addition, our findings revealed that having adverse outcomes history significantly decreases the likelihood of all three outcomes. It is contrary to the finding of previous studies[14, 30, 33, 34]. It is worth noting that the

schizophrenia patients in our study were participants in basic public health services in China. They receive regular follow-up and intervention by community doctors. Patients who had adverse outcomes history had higher risk assessments and received more frequent follow-up[22]. In addition, their psychiatrists may adjust drug doses or modify treatment regimens according to their condition. Therefore, having adverse outcomes history may decrease the number of adverse events because of the above intervention. It needs further researches to explore the relationship between such intervention and adverse outcomes intensity.

On the other hand, results from our study showed that many risk factors were not shared across the different types of adverse outcomes. It suggests that it is distinct for mechanism between violence and self-harm or suicide attempts, and customized tools in risk assessment and intervention for specific events are necessary. For example, educational level, employment status, and medical history were related to violence against others but not self-harm and suicide attempts. Our findings were in concordance with the results of previous studies that unemployment status and low educational level were risk factors for violence [16, 35, 36]. The previous studies indicated that having medical history increases the risk of violence. However, our study found an inverse relationship with a medical history and aggressiveness with police dispatch or violent crime. The possible reasons may be similar to the association between adverse outcomes history and violence. Having medical history may increase the risk of adverse effects [37–39]. Once patients having an adverse effect, he or she may be assessed to be unstable patient and received more intensive follow-up and symptomatic treatment. Those interventions may contribute to decreasing the violence intensity.

Having a family history of mental disease increased the risk of self-harm or suicide attempts but did not affect violence. The previous research also found that family history of mental disease was the risk factor of self-harm or suicide attempts[12, 40–42], but it was rarely found in terms of violence[43]. This finding support that self-harm or suicide attempts are affected by genetic factors[44, 45]. Although previous studies found that earlier age of illness onset was a risk factor of violence and suicide, we founded that adult-onset schizophrenia increases the risk of aggressiveness without police dispatch and the risk of self-harm or suicide attempts. This is in line with results from some previous studies and suggests that adult-onset patients are more unbearable with the disease and have more passive aggressive personality disorder traits compared with early-onset patients [30, 46, 47]. Further studies are warranted to evaluate this relationship between these events intensity and age of illness onset.

In our study, patients who had a longer duration of illness were more likely to aggressiveness without police dispatch, but not to aggressiveness with police dispatch or violent crime, and to self-harm or suicide attempts. However, schizophrenia patients with a history of severe violence or with suicide attempts had a longer duration of illness in other studies[31, 32, 48]. It is possible that with a longer duration of illness, caregivers, as well as community doctors, gained a greater awareness of severer outcomes, such as and suicide attempts and severer violence. Further studies are needed to clarify the relationship between the duration of illness and different types of adverse outcomes.

In addition, the residential type was another individual influencing factor of aggressiveness without police dispatch, and living in rural was a protective factor. A possible explanation is that rural schizophrenia patients are much willing to receive basic public health services and have better access to primary medical institutions in China, which may contribute to achieving effective control and decreasing the risk of violence[49, 50]. The different treatment of schizophrenia between urban and rural areas may be another possible explanation. A

previous study in China found that rural patients were more likely to receive anticholinergics compared to urban patients [51]. Similarly, poverty was an individual protective factor for aggressiveness with police dispatch or violent crime. This may be attributed to the higher rate of receiving follow-ups regularly and increasing demand and utilization of health services among poverty patients[49, 52].

In our study, some factors were not significantly associated with the number of adverse outcomes. For instance, psychosis treatment status showed insignificantly associate with the number of these outcomes. It may be too few psychosis untreated patients to have enough power to find the differences. Other factors, such as marital status, register type were not related to the number of adverse outcomes. It may be attributed to the different statistical analysis methods. In the count regression model of our study, the exponentiated regression coefficient of the count model is the ratio of expected counts instead of the odds ratio in the logistic regression model. In other words, the exponentiated coefficient represents the IRR for each unit change in the predictor, while the other predictors in the model are held constant. Another possible reason for the non-significance is the differences in the definition of these adverse outcomes and the research population. Further studies should assess the impact of varying covariates on the intensity of these events among schizophrenia patients.

Several limitations should be noted. First, the inclusion criteria of patients may introduce selection bias, but the demographics distribution of our study sample was similar to that of the schizophrenia patients followed up in 2020. Secondly, the correlation between covariates was not considered in our study, but the correlation cannot have a significant influence on the results of our study. Finally, our results were limited due to the lack of variables that may contribute to adverse outcomes, including antipsychotic drugs, drug adherence, drug abuse, parental abuse, and clinical symptoms.

Conclusions

Count regression model not only assesses the presence or absence of adverse outcomes but also the intensity of it. We compared the fitted performance of the Poisson, NB, ZIP, and ZINB regression models to investigate the potential influencing factors of three types of adverse outcomes in schizophrenia patients and selected the NB and ZINB as the best models. Several shared influencing factors across different adverse outcomes were detected, such as age, gender, and history of adverse events. On the other hand, many factors were not shared across different outcomes, which suggests that risk assessment and intervention might have to be customized for specific outcomes. Moreover, some influencing factors were inconsistent with previous studies because of the different analysis models, study population, and intervention of community public health. Further studies should assess the causal effect of these factors.

Abbreviations

GDMHS: Guangdong Mental Health Center Network Medical System; NB: negative binomial; ZIP: zero-inflated Poisson; ZINB: zero-inflated negative binomial; AIC: Akaike information criterion

Declarations

Ethics approval and consent to participate

Ethics approval was obtained for the study from the research ethics committee of the Guangdong Mental Health Center in China (authorization No.GDMHR2019201H). All participants (or their parent or legal guardian in the case of children under 16, or their legally authorized representative in the case of illiterate participants) signed informed consent after receiving oral and written information about the study. All procedures were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from Guangdong Mental Health Center but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Guangdong Mental Health Center.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

LC conceived and designed the research, performed the analyses and drafted the manuscript. WT designed the research, collected the data and drafted the manuscript. XL, HL, JX, YZ, FJ and YH contributed to visualization and investigation of the manuscript. All authors read and approved the final manuscript.

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Figures

Figure 1

Predicted minus observed probabilities for four intercept-only models. NB, negative binomial; ZIP, zero-inflated Poisson; ZINB, zero-inflated negative binomial