Association between stock market volatility and severe mental disorders: a multi-city time-series study

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ABSTRACT

Background: Stock market volatility was commonly considered as a psychological stressor. However, the association between stock market volatility and severe mental disorders (SMD) has not been investigated.
Methods: Daily numbers of SMD hospital admissions and Shanghai Stock Exchange Composite (SSEC) Index in 7 cities in southwestern China from 2020 to 2023 were collected. A two-stage time-series analysis was conducted to reveal the association between stock volatility and the risk of hospital admission for SMD. Stratified analyses were performed by age, gender, and ICD-10 codes to explore potential high-risk groups.
Results: The association between the SSEC percentage change, SSEC closing price and SMD hospital admissions both exhibit a U-shaped curve. A 1 % decrease in SSEC is associated with a 7.2 % (95 %CI: 4.1 %–10.4 %) increase in the SMD admission, while a 1 % increase in SSEC is associated with a 2.6 % (95 %CI: 0.1 %–5.2 %) increase in the SMD admissions. With 3400 points as the dividing point, every 10-point increase in SSEC closing price is associated with a 9 % (95 %CI: 3.6 %–14.7 %) increase in the SMD hospital admissions, while each 10-point decrease is associated with a 4.4 % (95 %CI: 0.6 %–8.3 %) increase in the SMD hospital admissions. Furthermore, these associations tended to be stronger in the female and non-schizophrenia patients.
Conclusion: These associations indicate that both rise and fall in stock prices increase the risk of SMD. This finding suggests that it is an effective way to take the stock speculation behavior into consideration when managing and treating the SMD patients.

1. Introduction

Severe mental disorders (SMD) are now increasingly recognized as a major global public health concern due to their prominent role as leading causes of disability and premature mortality (Collaborators, 2022). Individuals with SMD, such as schizophrenia, bipolar disorder, and major depressive disorder, have a significantly higher risk of mortality due to cardiovascular and respiratory diseases, resulting in a lifespan 10 to 20 years shorter than the general population (Liu et al., 2017). Considering the substantial contribution of SMD to the global disease burden, there is an urgent need to develop intervention measures that effectively promote mental health by targeting identified risk factors associated with SMD.

Convincing evidence indicates that social determinants across

various levels, including individual, familial, and broader social environment, contribute to adverse mental health outcomes (Kirkbride et al., 2024). Socioeconomic status is considered as a key component of these social determinants, and a lower socioeconomic status may adversely affect individual's mental health through multiple pathways (Ankur Singh et al., 2019; Esch et al., 2014; Papadopoulos & Sosso, 2023; Utzet et al., 2020). Numerous studies have consistently identified the association between SMD and socioeconomic status indicators, such as education, occupation, and living standards (Chang et al., 2017; Dalgard et al., 2007; Reiss, 2013). In addition to these extensively studied socioeconomic indicators, economic events like job loss and economic contraction may also increase the risk of SMD due to their adverse effect on mental health (Gili et al., 2013; Kim et al., 2022; Mandal et al., 2011).

Stock market volatility, as a common economic event in daily life, can lead to catastrophic financial losses for investors and their families within a short period, consequently imposing immense stress to their physical and mental health. Previous studies on the adverse health effects of stock market volatility have primarily focused on cardiovascular diseases (Li et al., 2023; Ma et al., 2011; Zhu et al., 2023). Limited studies have explored the association between stock market volatility and specific mental disorders, such as panic disorders and affective disorders, or google search terms related to mental disorders (Engelberg & Parsons, 2016; Lin et al., 2015; Qin et al., 2019; Senarathne & Perera, 2021). Despite representing a significant psychosocial stressor, there has been a lack of research analyzing the association between stock market volatility and SMD until now. Given the exacerbation of global mental health issues and financial market volatility during the COVID-19 pandemic, it's crucial to investigate the impact of stock market volatility on SMD and provide evidence-based support for mental health intervention strategies.

As the world's second largest economy, by the end of 2023, the number of existing investors in China's stock market has exceeded 221.4 million, accounting for 15.70 % of the country's total population. However, there is tremendous uncertainty in China's stock market, with large risks and information opacity that increase the investment vulnerability of small and medium investors. The volatility and market changes of the stock market are more likely to aggravate the psychological pressure and spiritual burden of small and medium investors. Meanwhile, the rapid development of society has increased the burden on patients with SMD in China, resulting in a number over 6.4 million SMD patients in 2020 (Tang et al., 2024). The above situation provides an objective basis for ecological research on stock market volatility and the risk of disease occurrence and hospitalization in China. Therefore, our study aims to fill this gap by conducting a two-stage time-series analysis in Southwest China to reveal the association between stock market volatility and the risk of hospital admission for SMD.
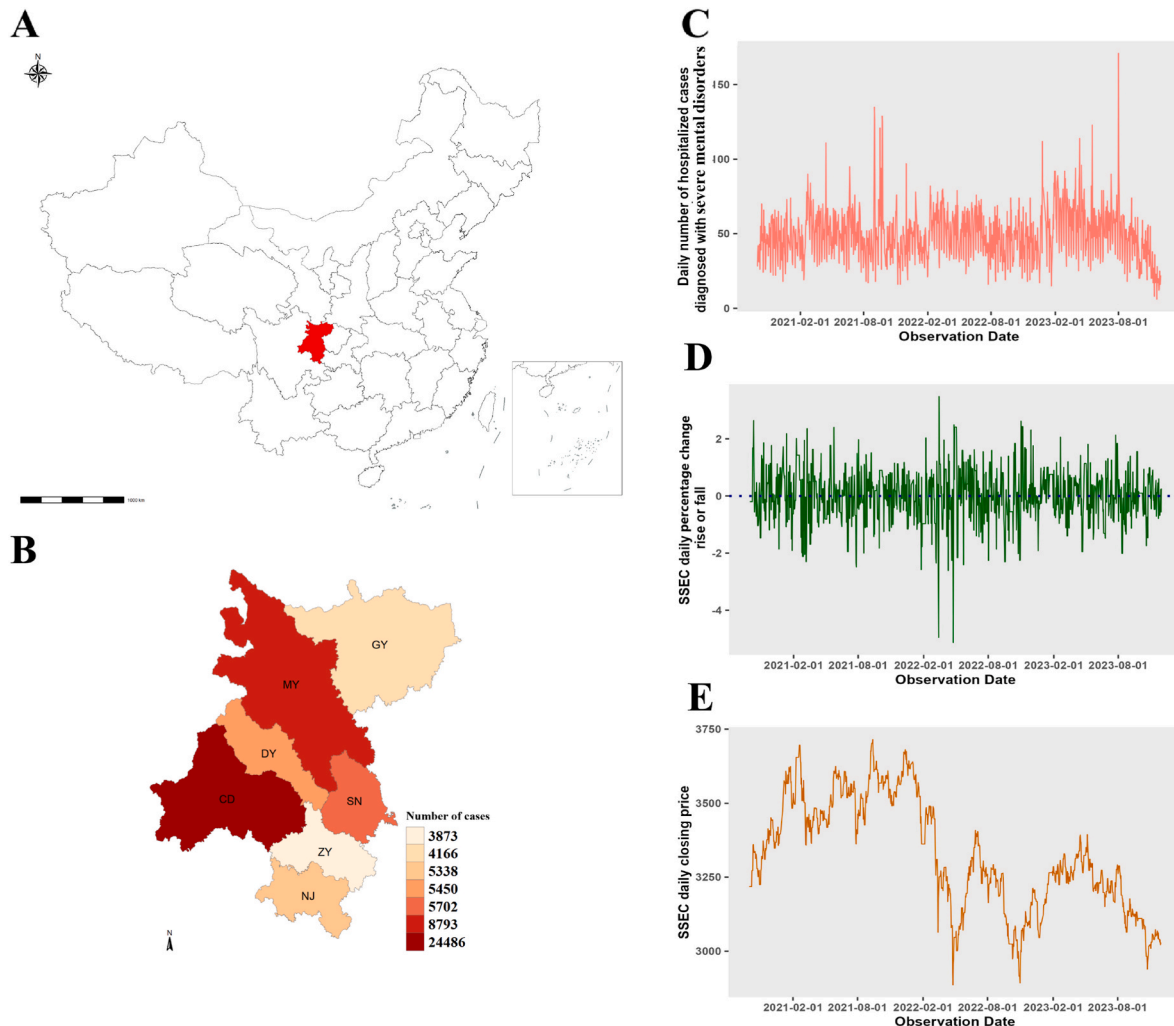

Fig. 1. Description of this study (A: location of seven cities in Southwest China, B: number of admissions in seven cities, C: time series of SMD hospital admissions, D: time series of SSEC percentage change, E: time series of SSEC closing price).

2. Materials and methods

2.1. Data source

Seven cities located in southwestern China with a combined population of 40 million (2022) were included in this study, including the megacity Chengdu, the economic hub of western China (Fig. 1A and B). Since September 2019, the National Center for Mental Health has implemented mandatory reporting of SMD hospitalizations, which ensures the representativeness of the data. To avoid underreporting of cases caused by COVID-19 outbreaks, city-specific daily numbers of SMD hospital admissions between September 2020 and November 2023 were obtained from Sichuan Provincial Center for Mental Health. The individuals diagnosed with SMD include the following six mental disorders: schizophrenia, schizoaffective disorder, delusional disorder, bipolar disorder, mental disorders caused by epilepsy, and intellectual disabilities, the classification was based on the International Classification of Diseases10th revision (ICD-10). The Serious Mental Illness Management System in China provides community-based care for individuals with SMD.

Daily opening and closing prices of the Shanghai Stock Exchange Composite (SSEC) Index during the study period were collected. On the weekend when the market was closed, the closing price on Friday was used as a substitute. Two indices were calculated as follows to reflect the stock market:

SSEC percentage change (%)
$$= \frac{\text{Closing price of today} - \text{Opening value of today}}{\text{Opening value of today}}$$

$$\text{SSEC closing price} = \frac{\sum_{i=1}^{7}(closing\ price_{t-i})}{7}$$

The SSEC percentage change reflects the daily stock returns (%), i.e., the volatility of the stock on that day, while the SSEC closing price reflects the stock price over a period by calculating the average closing price across seven consecutive days, i.e., the performance of the stock market over the past week.

2.2. Statistical analysis

The associations between the SSEC percentage change, SSEC closing price, and SMD hospital admissions were estimated using a widely utilized two-stage approach in multicity time-series studies. In the first stage, a generalized additive model was employed to model the nonlinear associations between the two stock indices and SMD hospital admissions in each city as follows:

$$Y_t \sim Quasi - Poisson(\mu_t)$$

$$\log(\mu_t) = \alpha + bs(X_t, df, L) + dow + holiday + ns(calendar\ time, df)$$

A Quasi-Poisson distribution was employed to address the potential overdispersion of SMD admissions. Where μ_t represents the expected number of SMD admissions on calendar day t; X_t denotes the SSEC percentage change or SSEC closing price on day t. The exposure-response association between stock market volatility and SMD admissions was characterized by a B-splines with 3 degrees of freedom (df = 3), which is widely used in epidemiological studies to characterize nonlinear associations (Gasparrini et al., 2015; Li et al., 2023; Liu et al., 2019). A lag of 1 day was considered for the SSEC percentage change to account for the lag effect. The lag day was selected by minimizing the generalized cross-validation scores (GCVs), as shown in supplementary materials (Fig. S1) (Liu et al., 2019; Wang et al., 2023, 2024). Additionally, we also controlled the effects from the day of week and holiday. The long-term trend was adjusted for using a natural cubic spline with 11 df per calendar year, which was selected by minimizing the Bayesian

Information Criterion (Fig. S2). Two additional analyses were conducted to evaluate the impact of COVID-19 on the association between stock market volatility and SMD hospital admissions: 1) incorporating the dummy variable, representing the periods before and after the lifting of the COVID-19 lockdown, into the model to further control for the confounding effects of the pandemic; 2) adding an interaction term between the dummy variable and the B-splines basis function with respect to stock market volatility into the model to examine the differences in the stock-SMD association before and after the lockdown was lifted.

The city-specific exposure-response associations from the first stage were then pooled in a multivariate meta model to estimate the overall associations between SSEC percentage change, SSEC closing price, and SMD admissions (Sera et al., 2019). Stratified analyses were conducted by age, gender, ICD-10 codes. Additionally, segmented linear regression was used to provide an intuitively linear depiction of the association between SSEC percentage change, SSEC closing price, and SMD admissions. All analyses were performed using R version 4.0.3.

3. Results

A total of 57,808 SMD hospital admissions were derived from the Sichuan Provincial Center for Mental Health between September 2020 and November 2023, with Chengdu city reporting the highest number at 24,486 admissions (Fig. 1B). Table 1 displays the description of daily SMD admissions, SSEC percentage change, and SSEC closing price during the study period. The distribution of SMD admissions is comparable between genders, and the count of SMD admissions in individuals aged under 60 is significantly higher than those aged over 60. Additionally, the majority of SMD admissions belong to the ICD-F20 subgroup (schizophrenia). Fig. 1C–E illustrate the time series data for SMD hospital admissions, SSEC percentage change, and SSEC closing price, respectively. The number of daily SMD hospital admissions during the study period ranged mostly between 30 and 60, with the highest count of admissions being 160 on August 1, 2023 (Fig. 1C). The daily SSEC percentage change primarily ranged between −2 % and 2 %, experiencing its largest fluctuation on May 1, 2022 when it reached −5 % (Fig. 1D). The SSEC closing price showed an upward trend from September 2020 to February 2022, followed by a decline thereafter.

Fig. 2 illustrates the exposure-response association between SSEC percentage change and the 1-day-later SMD hospital admission, as well the association between SSEC closing price and SMD. The findings revealed a statistically significant non-linear association ($P < 0.05$) between the percentage change in SSEC and the closing price of SSEC with the SMD hospitalization rate, and both exhibit a U-shaped curve. The stock-SMD associations from the models incorporating the lockdown-related dummy variable were displayed in Fig. S3. Theses non-linear curves were similar with those in main analyses. The interaction terms in both the SSEC change-percent and SSEC closing price models are not statistically significant ($p > 0.05$), suggesting that the observed associations presented no significant difference between before and after the lifting of the COVID-19 lockdown (Table S1).

Fig. 3 shows the forest graph of segmented linear regression, and the turning point of the U-shaped curve was selected as the breakpoint. The lowest value for the association between SSEC percentage change and SMD hospital admission occurs at around 0 % of SSEC change percentage. The decrease percentage of SSEC showed a substantially stronger association with the risk of SMD admission than the increase percentage of SSEC (Fig. 2A). On average, as showed by the segmented regression (Fig. 3A and B), a 1 % decrease in SSEC is associated with a 7.2 % (95 % CI: 4.1 %–10.4 %) increase in the SMD admission, while a 1 % increase in SSEC is associated with a 2.6 % (95 %CI: 0.1 %–5.2 %) increase in the SMD admission. For the association between SSEC closing price and SMD hospital admission, the lowest value occurs at around 3400 points and the increase of SSEC closing price showed a substantially stronger association than the decrease of SSEC (Fig. 2B). On average, when the SSEC closing price is more than 3400 points, a 10-point increase is

Table 1

Descriptions of daily SMD admissions, SSEC percentage change, and SSEC closing price.

| Variables	Total	2020	2021	2022	2023
Admissions					
Full data	48.838 ± 17.406	44.326 ± 13.173	49.244 ± 17.390	47.822 ± 14.791	50.708 ± 20.537
Male	24.802 ± 9.840	22.483 ± 7.384	24.678 ± 9.991	24.569 ± 8.887	25.810 ± 11.067
Female	24.036 ± 9.262	21.843 ± 7.348	24.567 ± 9.197	23.253 ± 7.967	24.898 ± 10.839
Age under 60	39.642 ± 14.115	35.090 ± 10.802	39.842 ± 13.938	38.711 ± 11.804	41.654 ± 16.815
Age over 60	9.196 ± 4.586	9.236 ± 3.983	9.403 ± 4.907	9.111 ± 4.167	9.054 ± 4.815
ICD-F20	34.680 ± 13.137	32.213 ± 10.042	35.567 ± 13.466	33.822 ± 11.251	35.310 ± 15.164
None ICD-F20	14.158 ± 5.712	12.112 ± 4.461	13.678 ± 5.383	14.000 ± 5.258	15.398 ± 6.537
SSEC percentage change	0.003 ± 0.930	0.041 ± 0.849	0.021 ± 0.882	−0.026 ± 1.119	0.006 ± 0.766
SSEC closing price	3325.454 ± 187.630	3336.623 ± 66.610	3540.104 ± 75.151	3225.581 ± 158.764	3198.002 ± 96.540

Mean ± Standard Deviation.
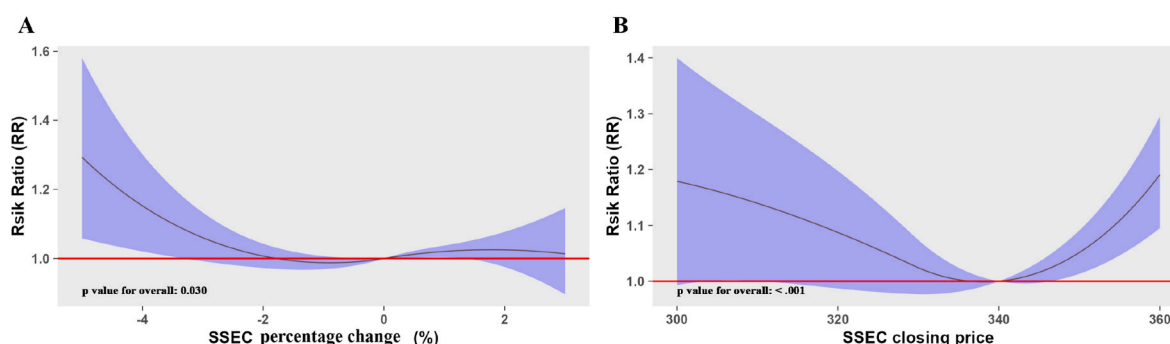
Fig. 2. Exposure-response associations of SMD admission with SSEC percentage change (A), and SSEC closing price (B).
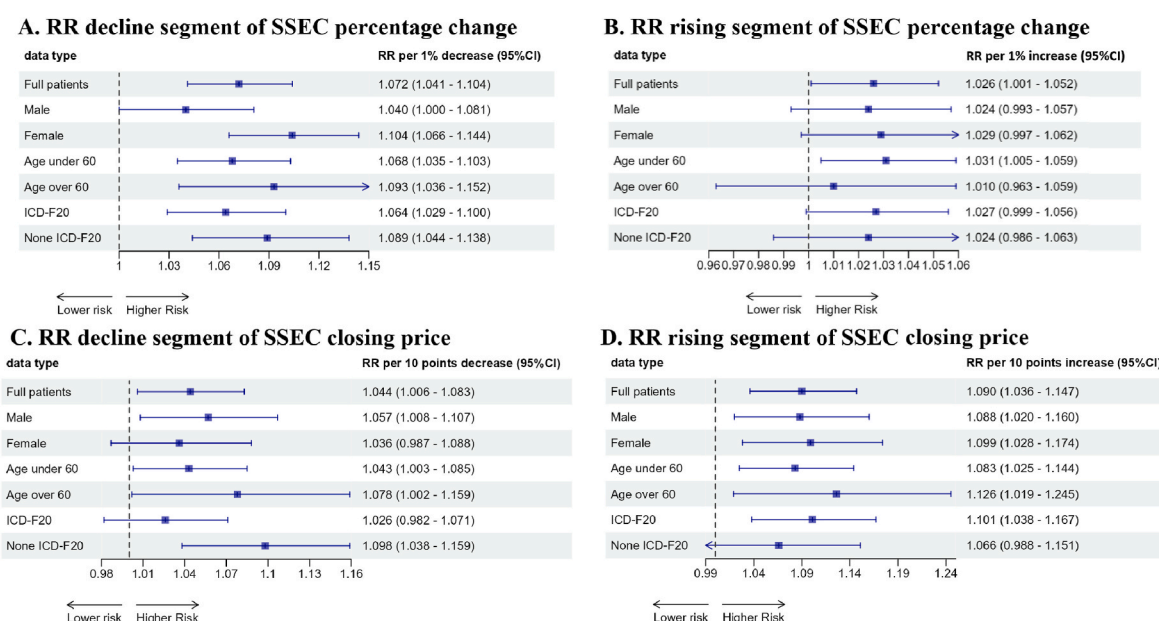

Fig. 3. Forest graph of segmented regression (A: RR decline segment of SSEC percentage change, B: RR rising segment of SSEC percentage change, C: RR decline segment of SSEC closing price, D: RR rising segment of SSEC closing price).

associated with a 9 % (95 %CI: 3.6 %–14.7 %) increase in the SMD hospital admission; when the SSEC closing price is lower than 3400 points, a 10-point decrease is associated with a 4.4 % (95 %CI: 0.6 %–8.3 %) increase in the SMD hospital admission (Fig. 3C–D).

In stratified analyses, the exposure-response associations of SSEC percentage change and SSEC closing price with SMD in all subgroups consistently demonstrate a U-shaped curve (Figs. 4–5), aligning with the overall associations (Fig. 2). Seen in Fig. 3A, when the SSEC declines, all

the subgroups except for the male show significant associations. The increased risk of SMD admission in females (10.4 %, 95 %CI: 6.6 %–14.4 %) per 1 % decrease in SSEC was substantially higher compared to males (4 %, 95 %CI: 0 %–8.7 %), although this difference was not statistically significant. As shown in Fig. 3B, when the SSEC increased, the subgroup aged under 60 exhibited a significant association while the other subgroups did not. The wide 95 % confidence intervals suggest that no significant subgroup-between difference was observed in the
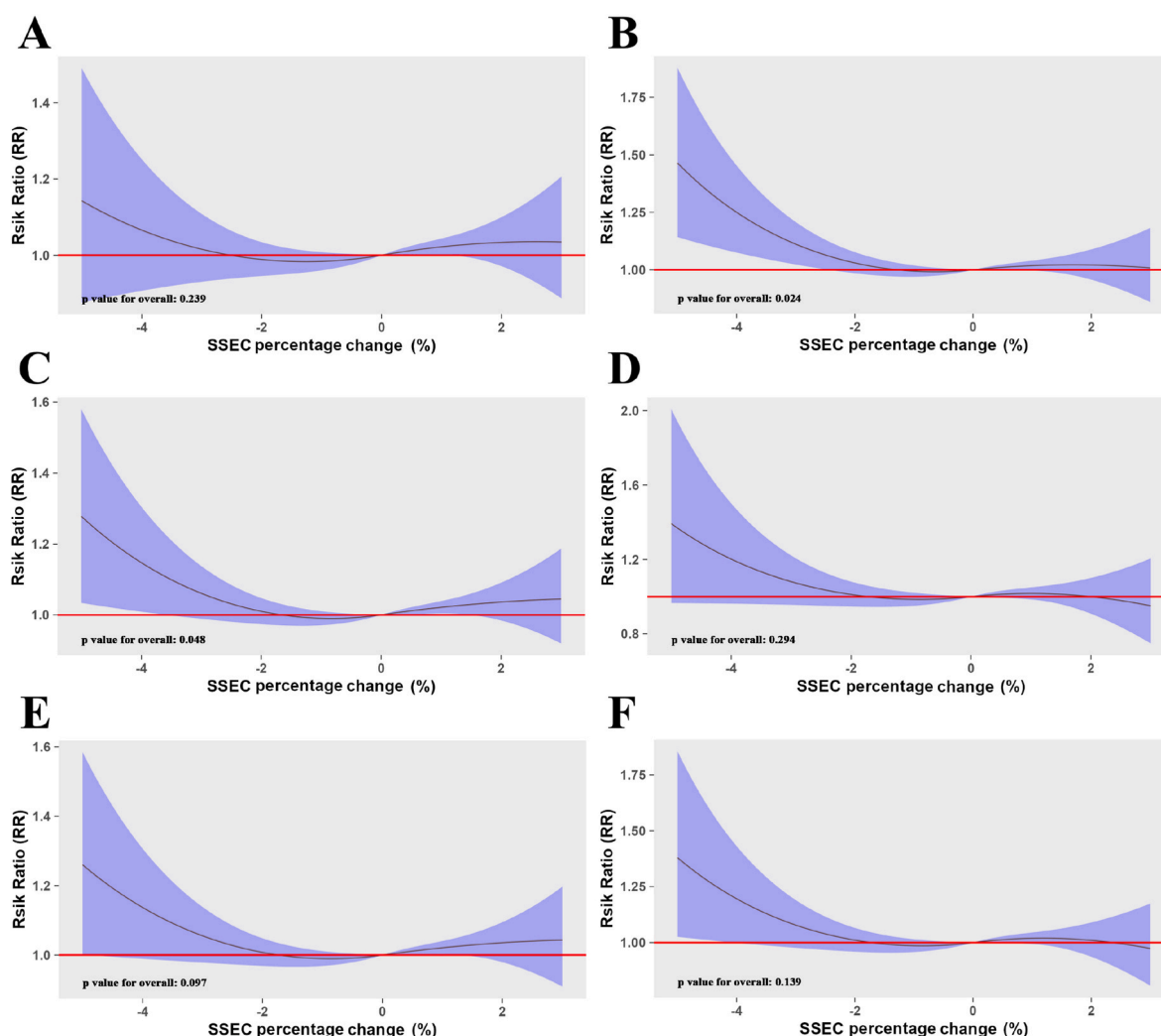
Fig. 4. Exposure-response associations of SMD admission with SSEC percentage change stratified by gender (male: A; female: B), age (under 60 years: C; over 60 years: D), and ICD-10 codes (ICD-10 belongs to F20: E; ICD-10 not belongs to F20: F).

associations between increased SSEC and the SMD hospital admission. When the SSEC closing price is lower than 3400 points, although the number of patients diagnosed with non-schizophrenia is substantially smaller than that of schizophrenia, the declined SSEC closing price exhibited significant association in the non-schizophrenia subgroup and not in the schizophrenia subgroup. When the SSEC closing price is more than 3400 points, all the subgroup exhibited significant and comparable association between the increased closing price and SMD hospital admission, except that the non-schizophrenia exhibited no significant association due to its insufficient sample size.

4. Discussion

This study utilized a two-stage time-series analysis across 7 cities in Southwest China to explore the association between stock market volatility and hospital admissions for SMD. Our findings indicated that the SSEC percentage change on previous day and average SSEC closing prices over the past week were associated with risk of SMD admissions. Additionally, these associations tended to be stronger in the female and non-schizophrenia-related SMD.

Two previous studies investigating the relationship between stock market volatility and mental health outcomes showed that daily stock declines are associated with increased mental disorders hospital admissions such as affective disorders, anxiety, and panic disorder on the same day or the following day (Engelberg & Parsons, 2016; Lin et al.,

2015). However, our results revealed a non-linear relationship between two stock market volatility indicators and SMD, suggesting that both stock price increases and decreases may lead to adverse mental health outcome. It is noteworthy that we found a significantly higher increase in the risk of SMD admissions associated with daily stock declines compared to stock increases. This may imply that the emotional and psychological impact of stock declines on individuals with SMD is more intense than that of stock increase. The findings align with research inferring the causality between income and mental health, which provides compelling evidence that loss of income has a greater impact on mental health than increase in income improve mental health (Thomson et al., 2022). Conversely, we also observed that the risk of SMD increased to a greater extent when the SSEC closing price was higher over a period compared to when it was lower. This could be due to investors paying more attention to the stock market when closing prices are higher, simultaneously fearing a decline while hoping for further increases. Research suggests that investor anxiety significantly increases during bull markets, when stock prices are high (Qin et al., 2019). Moreover, our segmented regression estimations on daily stock declines were much greater than those in the previous study from Taiwan (7.2 % vs 0.36 %), which based on date from 1998 to 2009 (Lin et al., 2015). These disparities may be attributed to different market engagement and cultural responses to market loss. With the rapid economic growth in mainland China over the past two decades, an increasing number of individual investors have entered the stock market (Fig. S4). These
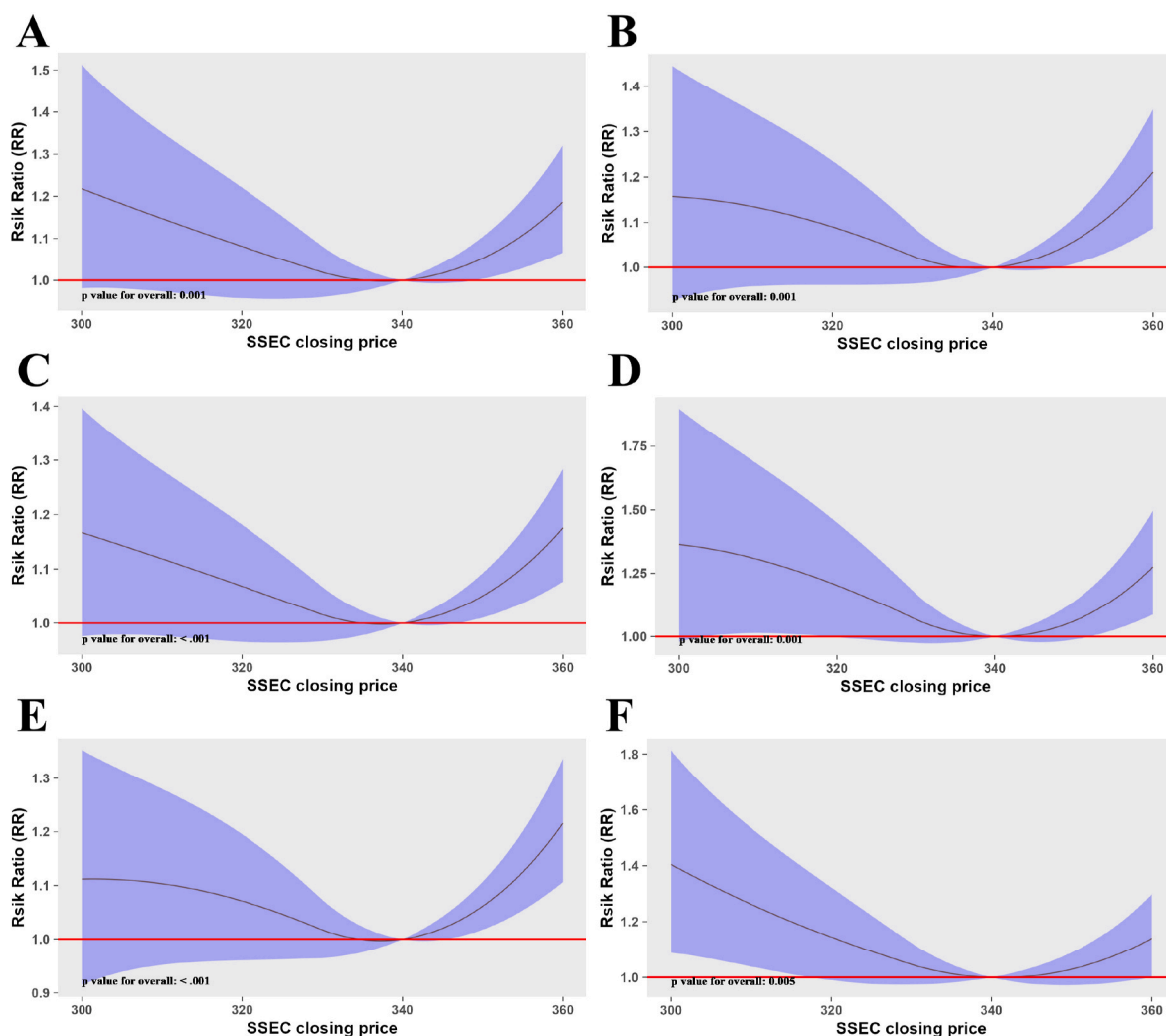
Fig. 5. Exposure-response associations of SMD admission with SSEC closing price stratified by gender (male: A; female: B), age (under 60 years: C; over 60 years: D), and ICD-10 codes (ICD-10 belongs to F20: E; ICD-10 not belongs to F20: F).

newly entered and less skilled individual investors often expect to achieve substantial financial returns through irrational investment behaviors, they are also more susceptible to the impacts of market volatility (Chen & Wu, 2022).

Stratified analysis indicates that the association between stock market volatility and SMD tended to be stronger in the Female and non-schizophrenia-related SMD, highlighting the need for targeted interventions for these priority demographics. Furthermore, considering evidence that cardiovascular diseases, a primary cause of SMD-related mortality, are also affected by stock market volatility, urgent interventions are needed to mitigate the adverse health effect associated with stock market volatility (Chen et al., 2012; Yap et al., 2016; Zhang et al., 2013). Firstly, doctors could advise SMD patients or their families during outpatient visits to avoid engaging in stock trading. Secondly, governments could raise awareness about the potential adverse effects of stock trading on mental health through home visits, informational brochures, educational lecture, and community outreach, which have been widely used in communities and around psychiatric hospitals in Sichuan Province (Fig. S5). Finally, medical institutions could monitor stock market fluctuations as a predictor for short-term SMD hospital admissions, aiding in the planning of bed availability, healthcare personnel, and other resources.

Although the specific mechanism of the stock market volatility affecting SMD remains unclear, it is reasonable to speculate that psychological stress plays a crucial role in this association. Due to its direct impact on investors' wealth and its indirect effects on non-investors' financial well-being through events like economic recessions, stock market volatility emerges as a significant psychological stressor. The adverse effects of psychological stress induced by changes in wealth on mental health, such as increased risks of depression and anxiety, have been extensively documented (Guan et al., 2022; McLaughlin et al., 2012; Pool et al., 2017; Ridley et al., 2020). However, exploring the causal mechanisms underlying the association between stock market volatility and SMD is beyond the scope of this study, and further study is still needed.

Several notable strengths are evident in our study. Firstly, to the best of our knowledge, it is the first research endeavor exploring the association between stock market volatility and SMD. Secondly, by utilizing the full-coverage surveillance SMD data obtained from the severe mental illness management system, the results obtained in this study are more representative than those of studies that rely solely on data from several local hospitals (Gebeyehu & Mulatie, 2021; Peters et al., 2022). Thirdly, we investigated the associations between stock market volatility and SMD admission, as well as among multiple subgroups, facilitating further tailored interventions for the more vulnerable target populations. Fourth, unlike most studies focusing on analyzing the association between daily stock market volatility and mental health, this study is the first to explore the impact of stock market performance over a period on mental health. Nevertheless, several limitations of this study should be acknowledged. First, the absence of investment data from

SMD patients participating in the stock market may have resulted in underestimated exposure-response associations, as individuals not involved in stock market investments would be less affected by its volatility. Second, this study was conducted in Southwest China, so the caution should be exercised when extrapolating these findings to other regions with varying levels of economic development and disease burdens associated with SMD. Third, overly wide confidence intervals were observed in subgroup analysis, which may suggest insufficient sample size or variability within some subgroups such as non-schizophrenia SMD. Further studies with larger sample size or based on individual data were needed to verify this potential variability within subgroups. Fourth, this study is an ecological analysis, any further inference should be made with caution. Future studies based on individual-level data could further validate the causal relationship between stock market volatility and SMD by, for example, 1) comparing that whether the association in investors were larger than in non-investors, 2) furtherly controlling for factors such as education, income, and occupation to assess that the association still hold, 3) comparing the association differences across income and education.

5. Conclusion

Our study analyzed the association between stock price and SMD from two perspectives: daily volatility and performance over a period. The U-shaped exposure-response associations indicate that both increases and decreases in stock prices increase the risk of hospitalization for SMD. Furthermore, stronger associations were observed among females and non-schizophrenia patients. These findings suggest that stock market volatility may be a risk factor for SMD. Interventions such as providing psychological counseling and ensuring adequate medical preparedness need to be implemented during periods of wild fluctuations in stock prices, particularly for female and non-schizophrenia patients.

5.1. Ethics approval and consent to participate

Not applicable.

CRediT authorship contribution statement

Jiangli Hu: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Yantao Yin:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Ruiqing Guo:** Writing – review & editing. **Yunqiong Wang:** Writing – review & editing, Writing – original draft, Conceptualization. **Shuming Ji:** Writing – review & editing, Conceptualization. **Jinyu Wang:** Writing – review & editing, Methodology. **Benying Feng:** Methodology, Formal analysis. **Jian Qian:** Formal analysis. **Bo Zhou:** Funding acquisition. **Hui Li:** Supervision, Resources, Project administration, Data curation, Conceptualization. **Fang Liao:** Supervision, Resources, Project administration, Data curation, Conceptualization.

Consent for publication

The authors declare that they all agree to publish this paper.

Availability of data and materials

Not applicable.

Ethical statement

Our study was constructed at the population level. Since all of the patients' records were anonymized and no individual information can be identified, ethical approval was not required.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2025.101807.

Data availability

The authors do not have permission to share data.

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