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# Does college education reduce the risk of schizophrenia? Evidence from a college enrollment expansion policy in China



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#### ABSTRACT

*Background:* Schizophrenia occurs worldwide, and the health, and economic burden is substantial. As one of the common proxies of socioeconomic status (SES), education was reported to be associated with the risk of developing schizophrenia. However, there is no causal evidence about the relationship. This paper explores the health benefits of college education for schizophrenia.

*Method*: Based on exogenous variation in college enrollment across regions and cohorts induced by college enrollment expansion policy, we use instrument variable (IV) estimate strategy to estimate impacts of college education on the risk of schizophrenia with the data from Second National Sample Survey on Disability.

*Results:* We find that college education reduces the risk of developing schizophrenia by 4.2 percentage points. Some further analyses suggest the causal protective effect is only found among men, rural, and low-income individuals.

*Conclusions*: These findings provide new evidence for the causal relationship between college education and schizophrenia, and add to the literature on the health benefits of education.

# 1. Introduction

Schizophrenia is a common psychiatric disorder that occurs across the globe, and the risk of morbidity associated with it across time, geography, and gender was generally regarded as 1 % for life (Owen et al., 2016). Globally, over 21 million people are affected by schizophrenia (Charlson et al., 2018; Hakulinen et al., 2019), which results in a reduced life expectancy of 10 to 20 years (Laursen et al., 2014). Schizophrenia presents a considerable burden not only to patients, but also to families, other caregivers, and the broader society (Chong et al., 2016; Cloutier et al., 2016; Evensen et al., 2016).

Education has been identified as a potential risk factor for schizophrenia (Kohn, 1968), although no causal evidence is available. An important proxy of socioeconomic status (SES), education has been demonstrated to be linked with the risk of schizophrenia (Bohrenwend, 1990; Castle et al., 1993; Luo et al., 2020a; Luo et al., 2020b). Moreover, an inverted U-shaped relationship between the two has been identified in certain specific environments (Luo et al., 2020a). However, due to confounding, pleiotropy, or reverse causation, observational epidemiology does not distinguish causality from association (Owen et al., 2016).

In the field of sociology and economics, the education-health nexus is among the most widely known and well documented topics (Xue et al., 2021). Specifically, the most prominent strand of the economic literature explores the effect of policy that increased school years on different measures of health and health-related behavior (Janke et al., 2020). However, the majority of previous studies have focused on changes in compulsory schooling laws at the primary or secondary levels (Buckles et al., 2016). There is a limited external validity to higher education (Cutler and Lleras-Muney, 2008b; Cutler and Lleras-Muney, 2008a;

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Cutler and Lleras-Muney, 2010). Galama et al. (Galama et al., 2018) provide a review, which points out the nature of the quasi-experimental variation in education is critical, particularly the level of education at which the variation occurs.

In a limited number of studies, quasi-experimental methods have been used to determine the causal effects of college education on health, including longevity gains (Hong et al., 2020) and mortality (Buckles et al., 2016; Gonzalez et al., 2022). Most of studies focused on the impact of education on physical health. Mental health is typically neglected in this context, likely due to the difficulty of measuring it (Dahmann and Schnitzlein, 2019). Despite limited research exploring this relationship, there is no causal evidence for schizophrenia, primarily due to constraints in data sources and deficiencies in identification strategies (McFarland and Wagner, 2015).

There two main contributions made in this paper that shed light on the relationship between college education and health. First, our study fills a significant important gap in previous research on the effects of higher education on health, in particular mental health. Our study is the first to establish a causal link between college education and schizophrenia risk, to the best of our knowledge. Although previous research has explored outcomes related to physical health and health behavior (Fu et al., 2022). Second, our representative dataset contains a large number of observations, which significantly improves the power of statistical tests. In addition, the large sample size allows for a range of heterogeneity analyses.

It is worth mentioning that, we have confirmed the association between education and schizophrenia in our previous study (Luo et al., 2020b). In order to answer whether the relationship is causal, here, we exploit exogenous variation of college enrollment among cohorts and regions induced by college enrollment expansion policy in China. Furthermore, we identify causality based on instrument variable (IV) estimates between college education and schizophrenia.

# 2. Methods

#### 2.1. Data sources

We use data from Second National Sample Survey on Disability, employing a multistage, stratified, random-clustered probability sampling strategy. It constructs a nationally representative sample in China with the survey conducted in 2006. This survey covered all provincial administrative areas in mainland China. In total, 734 counties (districts), 2980 towns (streets) and 5964 communities (villages) from 31 provinces, autonomous regions, and municipalities across China was selected. The household interviews were conducted face to face with all members of each household (Li et al., 2015). Finally, a total of 2,526,145 individuals from 771,797 households were collected for the survey. Mental disability prevalence is about 0.6 %, with schizophrenia comprising the largest proportion (48.2 %) (Zheng et al., 2011). Details on this survey have been previously published (Zheng et al., 2011).

We restrict the sample to individuals who are with schizophrenia after the age of 18, to exclude those who had a mental disorder as a child or adolescent that prevented them from attending college. In China, the typical age of college enrollment is 18 years old. Consequently, if individuals develop schizophrenia before the age of 18, it can affect their probability of entering college. Despite the fact that the typical age of onset for schizophrenia is in late adolescence or early twenties (Gogtay et al., 2011), we exclude individuals who developed schizophrenia before the age of 18.

#### 2.1.1. Schizophrenia assessment

The outcome variable was schizophrenia, which was defined as a binary measure. The first step of schizophrenia assessment was to identify individuals who were psychiatrically disabled (Liu et al., 2013). Experienced psychiatrists then used the ICD-10 to diagnose schizophrenia among the psychiatrically disabled individuals (WHO, 1992).

The ICD-10 diagnostic criteria had been used to diagnose schizophrenia among Chinese individuals and showed satisfactory validity (St. Clair et al., 2006).

### 2.1.2. College education

The key explanatory variable in this study is college education. To measure the impact of college education, we divided educational attainment of individuals into two levels, which takes a value of 1 if the respondent' level of education is college and above, and 0 otherwise.

## 2.1.3. Control variables

The analysis includes several control variables that may have a bearing on the relationship between education and schizophrenia. In Table 1, we list the other control variables. We control for respondents' gender, hukou (urban versus rural), ethnicity (han and minority), and financial status (income).

# 2.2. Statistical methods

A natural model to estimate the relationship between college education and the risk of schizophrenia would be as follows:

$$D_{i,b,p} = \beta_0 + \beta College_i + \delta X_{i,b,j} + \delta_b + \theta_p + \theta_p \times \delta_b + \varepsilon_{i,b,p}$$
(1)

where  $D_{i,b,p}$  is a dummy indicating whether individual *i* suffers from schizophrenia. *College*<sub>i</sub> is a dummy equal to 1 for individuals with any college degree or above. $X_{i,b,j}$  is a vector of controls that potentially vary across individuals.  $\delta_b$  and  $\theta_p$  indicate birth year and province fixed effects to control for all time-invariant differences between cohorts and changes over time that affect all individuals similarly.

| Table | 1 |
|-------|---|
|       | - |

Descriptive statistics.

|                  | Total (N = 680,267) | Sample with<br>college degree (N<br>= 70,529) | Sample without<br>college degree (N =<br>609,738) |
|------------------|---------------------|---|---|
| Age (mean, SD)   | 30.71(5.15)         | 29.5(5.15)                                    | 30.9(5.13)  |
| Mala             | 227 104             | 2E 00E(E1 04)                                 | 201 100(40 28)                                    |
| wate             | (40 EE)             | 33,993(31.04)                                 | 301,109(49.30)                                    |
| Fomalo           | (49.33)             | 24 524(49.06)                                 | 208 620(50 62)                                    |
| remaie           | (E0 4E)             | 34,334(40.90)                                 | 300,029(30.02)                                    |
| Hukou            | (30.43)             |   |   |
| Urban            | 196 894             | 66 008(93 77)                                 | 130 886(21 48)                                    |
| Orban            | (28.96)             | 00,000(55.77)                                 | 130,000(21.40)                                    |
| Rural            | 482 908             | 4382(6.23)                                    | 478 526(78 52)                                    |
| Rurai            | (71.04)             | 4302(0.23)                                    | 470,520(70.52)                                    |
| Ethnicity        | (/1.04)             |   |   |
| Han              | 595 779             | 64 485(91 43)                                 | 531 294(87 13)                                    |
| min              | (87 58)             | 01,100(91.10)                                 | 001,25 ((07.10)                                   |
| Minority         | 84 488              | 6044(8.57)                                    | 78 444(12 87)                                     |
| minority         | (12.42)             | 0011(0107)                                    | / 0, 11 (12:0/ )                                  |
| Education        | (12112)             |   |   |
| No schooling     | 32,443              |   |   |
|                  | (4.77)              |   |   |
| Primary school   | 163.865             |   |   |
| J                | (24.09)             |   |   |
| Junior high      | 313,739             |   |   |
| 0                | (46.12)             |   |   |
| Senior high      | 99,691              |   |   |
| -                | (14.65)             |   |   |
| College and      | 70,529              |   |   |
| above            | (10.37)             |   |   |
| Financial status |                     |   |   |
| Low-income       | 233,244             | 2165(3.07)                                    | 231,079(37.90)                                    |
| group            | (34.29)             |   |   |
| Middle-income    | 203,848             | 6971(9.88)                                    | 196,877(32.29)                                    |
| group            | (29.97)             |   |   |
| High-income      | 243,175             | 61,393(87.05)                                 | 181,782(29.81)                                    |
| group            | (35.75)             |   |   |
| Schizophrenia    | 2478(0.36)          | 61(0.09)                                      | 2417(0.40)  |
| cases            |                     |   |   |

As control, we include a region by cohort fixed effect, denoted by  $\theta_p \times \delta_b$ , which accounts for geographical differences in schizophrenia risk and allows such differences to change over time. It also includes common shocks in health and allows their effect to vary across regions as well. The parameter of interest is  $\beta$ , which captures the average difference in schizophrenia risk for people with and without a college degree.

The model in Eq. (1) poses two problems. First, we must overcome the reverse causality problem. As a result of schizophrenia, these individuals have serious problems with their intelligence and brain development, which can greatly affect their educational attainment, especially higher education. Secondly, even if we could, we cannot interpret the OLS estimate of  $\beta$  as the causal effect due to concerns about omitted variable bias (OVB) (Card, 1999). In our context, OVB may result from unobservable differences in individual preferences, parental input, and genetics that impacts both the decision to enroll in college as well as their health (Card, 1999).

In part, our sample construction process contributed to eliminating the reverse causality problem. In order to further eliminate estimation bias, we used an IV approach as our identification strategy. The IV strategy – based on a supply-side view – allows us to eliminate the potential bias.

The period from 1995 to 1998 saw a modest growth in college admissions, averaging 4.7 % annually. To increase the employment rates, the Ministry of Education (MOE) implemented a nationwide college enrollment expansion policy in 1999 (Fig. 1), and since then, there has been a rapid increase in the number of students attending colleges. From 1998 to 1999, college admissions in China sharply rose by 43 %, and the average growth rate was 27 % between 1999 and 2005 (Fig. 1 (Panel A)). We are provided with an opportunity to construct a reasonable and valid instrument variable as a result of the exogenous variation across provinces and cohorts.

Following Li et al. (Li et al., 2017), we constructed an IV for an individual's college education:

$$Potential \ Expansion_{ps} = Total \ Expansion_{s}^{*} Enrollment \ Share_{p,1998}$$
(2)

where *Total Expansion*<sub>s</sub> represents the difference between actual national enrollment and its pre-1999 linear trend in *year*<sub>s</sub>, and *Enrollment Share*<sub>p,1998</sub> represents the share of per *Province*<sub>p</sub> national

enrollment in 1998.

In order to construct our IV, we proceed as follows. Firstly, we estimate a model with respect to time (year) via the number of students enrolled in college each year from 1981 to 2017. Using this model, we then predicted the number of new college students enrolled in every year from 1999 to 2006. And we calculate *Total Expansion*<sub>s</sub>, which is the difference between the actual number and predicted values (Fig. 1 (Panel B)). Finally, we construct our IV. The data used in the calculation are from the Chinese Education Examination Yearbook.

As opposed to actual college enrollment expansion, *Potential Expansion*<sub>ps</sub> is only dependent on a province's latent enrollment capacity. In this case, each province expands its college enrollment in proportion to its predetermined level.

Using actual college enrollment expansion directly as IV may suffer from the issue of anticipated effects (such as economic development), which will affect population health. The exclusion restriction of IV strategy will not be satisfied in such a case.

The regression equation is

$$College_{i} = \gamma_{0} + \gamma Potential \ Expansion_{ps} + \alpha X_{i,b,p} + \delta_{b} + \theta_{p} + \theta_{p} \times \delta_{b} + \epsilon_{i,b,p}$$
(3)

$$D_{i,b,p} = \beta_0 + \widetilde{\beta} \widehat{\text{College}}_i + \delta X_{i,b,j} + \delta_b + \theta_p + \theta_p \times \delta_b + \varepsilon_{i,b,p}$$
(4)

where  $\gamma$  is the first-stage estimate and  $\tilde{\beta}$  is the IV estimate of the causal effect of college enrollment on the risk of schizophrenia. Notably, it is be interpreted as a local average treatment effect (LATE) (Imbens and Angrist, 1994; Oreopoulos, 2006). It represents the average causal effect of college entry for the set of compliers whose enrollment in college was positively influenced by the expansion policy. Subscript *s* represents the year in which the respondent actually or potentially. We use the potential year for taking the college entrance examination (birth year +18) to measure potentially taking the college entrance examination.

Our IV strategy requires the exclusion restriction to be satisfied. We consider this assumption plausible insofar as the expansion policy directly affect individual college enrollment, and our IV is derived from potential enrollment expansion.

A wide range of gender and SES differences exist widely in terms of



Source : China Education Statistical Yearbooks

Fig. 1. College expansion policy.

clinical presentation, psychosocial functioning and course of illness in schizophrenia patients (Castillejos et al., 2018; Ran et al., 2015; Usall et al., 2003; Willhite et al., 2008). To shed light on potential heterogeneous effects of college education, grouping by gender, income, and place of residence, we conduct the same analysis process by.

# 3. Results

# 3.1. Descriptive analysis

Table 1 presents the socio-demographic characteristics of the participants. A total of 680,267 individuals were included in this study, of whom 343,163(50.45 %) were women and 337,104 (49.55 %) were men. The percentage of people with schizophrenia among those with less than college education is 0.4 %, much higher than among those with college and above (0.09 %).

#### 3.2. Impact on risk of schizophrenia

Table 2 shows the IV estimates of the effect of college education. We report at the bottom the *Cragg-Donald Wald F* statistic, which exceeds the rule of thumb value of 10 and indicates a very strong first stage relationship. The IV estimates showed a significant, negative effect of college education on the risk of schizophrenia, which indicates that college enrollment reduces the risk of suffering from schizophrenia by 4.2 percentage points (pp).

#### 3.3. Heterogeneous analysis

In Table 3, we present results for the effect of college education on risk of schizophrenia based on two sub-samples, male and female. In the case of men, the estimates in columns 1 and 2 point to reductions in the probability of suffering from schizophrenia of -6.7 pp. For the female sample, although college education also reduced the risk of schizophrenia, this was not statistically significant.

China is a typically dualistic social system of urban and rural. Next, we constructed IV estimates grouped by Hukou. The estimation results are reported in Table 4. The coefficient in column 2 indicates that rural

### Table 2

# The effects of college on schizophrenia

|                           | College         | Schizophrenia   |
|---------------------------|-----------------|-----------------|
| College expansion         | 0.003           |                 |
|                           | [0.002,0.003]   |                 |
|                           | (P < 0.001)     |                 |
| College                   |                 | -0.042          |
| 0                         |                 | [-0.071,-0.013] |
|                           |                 | (0.004)         |
| Controls                  |                 |                 |
| Sex (Ref: Female)         |                 |                 |
| Male                      | 0.007           | 0.001           |
|                           | [0.006,0.008]   | [0.000,0.001]   |
|                           | (P < 0.001)     | (P < 0.001)     |
| Hukou (Ref: Rural)        |                 |                 |
| Urban                     | 0.239           | 0.010           |
|                           | [0.237,0.240]   | [0.004,0.017]   |
|                           | (P < 0.001)     | (0.003)         |
| Ethnicity (Ref: Minority) |                 |                 |
| Han                       | -0.015          | -0.000          |
|                           | [-0.017,-0.013] | [-0.001, 0.000] |
|                           | (P < 0.001)     | (0.630)         |
| Income                    | 0.016           | 0.000           |
|                           | [0.016,0.017]   | [-0.000,0.001]  |
|                           | (P < 0.001)     | (0.064)         |
| Province                  | Yes             | Yes             |
| Birth Year                | Yes             | Yes             |
| Province* Birth Year      | Yes             | Yes             |
| CD Wald F                 | 224.706         |                 |

95 % confidence intervals in brackets; p-values in parentheses.

cohorts who have attended college experiences a 9.1 pp. decrease in the rick of schizophrenia. However, the risk of schizophrenia in urban cohorts is not reduced by college attainment.

Next, to shed light on potential heterogeneous effects by income level, we investigated whether the causal relationship is significantly different between different income level individuals, which were shown in Table 5. We found that the effect was only present in individuals with lower levels of income.

# 4. Discussion

Our findings provide novel evidence on the impact of education on health. To the best of our knowledge, this is the first study to investigate the causal relationship between college education and schizophrenia risk using a nationally representative sample. In general, we found that college attainment reduced the risk of schizophrenia by 4.2 percentage points (pp). Our analysis of the heterogeneous effects indicates there are socioeconomic and gender-specific effects. In particular, college education was found to protect against schizophrenia only in males, rural residents, and low-income groups.

#### 4.1. Effect of college education on risk of schizophrenia

We demonstrate the protective causal effect of college education on schizophrenia. Prior studies have demonstrated that higher education was associated with greater awareness of the disease (Buckley et al., 2007), better cognitive-functional performance and fewer clinical problems among schizophrenia patients (Cámara et al., 2021). In this study, we provide novel and potentially robust evidence that college education reduces the risk of developing schizophrenia. In causal terms, the following can be explained: high education levels are indicative of improved cognitive reserve, fewer chronic stressors, and a healthier lifestyle (Halpern-Manners et al., 2016), which leads to a strengthened neural network as well as further compensatory mechanisms that can protect against the development of schizophrenia (Cadar et al., 2018). Furthermore, college education has been proven to affect economic resources and social support, which are crucial resources when dealing with psychological challenges (Jalovaara, 2003). In order to mitigate the prevalence and burden of schizophrenia, the college education stage serves as a pivotal period for intervention and detection. Firstly, strengthening interdisciplinary collaboration is imperative, involving the efforts between the educational sector and public health authorities. This entails augmenting mental health support services within university campuses. In addition, in formulating healthcare guidelines related to schizophrenia, it is imperative to consider college education a key social determinant.

# 4.2. Sex-specific effects

Among the most commonly reported aspects of schizophrenia is the existence of gender differences (Abel et al., 2010; Goldstein et al., 2002; Leung and Chue, 2000; White, 1955). Furthermore, whether and how women and men with schizophrenia differ from each other is one of the most interesting and clinically relevant topics in related research (Abel et al., 2010). In the present study, we found that college education reduced the incidence of schizophrenia in men, meaning that the male group benefited more significantly from college education. This could reflect a differential impact of higher education on transformation of health knowledge and even neurodevelopment, whereby men with college degree have a more efficient use of health and economics resources. Previous studies indicate that women have a better course of illness than men (Abel et al., 2010), and women with schizophrenia may have better psychosocial functioning or be more skilled and less disabled than men (Ganev, 2000; Leung and Chue, 2000; Mueser et al., 1990). Therefore, our results may reflect that college education helps to narrow schizophrenia-specific gender differences. However, gender-specific

#### Table 3

The Effects of College on Schizophrenia (Stratified by Gender).

|                           | Male            |                 | Female          |                 |
|---------------------------|-----------------|-----------------|-----------------|-----------------|
|                           | First-stage     | Second-stage    | First-stage     | Second-stage    |
|                           | College         | Schizophrenia   | College         | Schizophrenia   |
| College expansion         | 0.003           |                 | 0.003           |                 |
|                           | [0.002,0.003]   |                 | [0.003,0.004]   |                 |
|                           | (P < 0.001)     |                 | (P < 0.001)     |                 |
| College                   |                 | -0.067          |                 | -0.022          |
|                           |                 | [-0.113,-0.020] |                 | [-0.058, 0.014] |
|                           |                 | (0.005)         |                 | (0.232)         |
| Controls                  |                 |                 |                 |                 |
| Hukou (Ref: Rural)        |                 |                 |                 |                 |
| Urban                     | 0.250           | 0.017           | 0.228           | 0.005           |
|                           | [0.248,0.252]   | [0.006,0.029]   | [0.225,0.230]   | [-0.003, 0.013] |
|                           | (P < 0.001)     | (0.004)         | (P < 0.001)     | (0.230)         |
| Ethnicity (Ref: Minority) |                 |                 |                 |                 |
| Han                       | -0.017          | -0.001          | -0.013          | 0.000           |
|                           | [-0.020,-0.014] | [-0.002,0.000]  | [-0.015,-0.010] | [-0.000,0.001]  |
|                           | (P < 0.001)     | (0.173)         | (P < 0.001)     | (0.477)         |
| Income                    | 0.016           | 0.001           | 0.017           | 0.000           |
|                           | [0.016,0.016]   | [0.000,0.002]   | [0.016,0.017]   | [-0.000, 0.001] |
|                           | (P < 0.001)     | (0.033)         | (P < 0.001)     | (0.674)         |
| Province                  | Yes             | Yes             | Yes             | Yes             |
| Birth Year                | Yes             | Yes             | Yes             | Yes             |
| Province* Birth Year      | Yes             | Yes             | Yes             | Yes             |
| CD Wald F                 | 90.055          |                 | 132.766         |                 |

95 % confidence intervals in brackets; p-values in parentheses.

#### Table 4

The effects of college on schizophrenia (stratified by Hukou).

|                           | Rural                    |                 | Urban           |                 |
|---------------------------|--------------------------|-----------------|-----------------|-----------------|
|                           | First-stage Second-stage |                 | First-stage     | Second-stage    |
|                           | College                  | Schizophrenia   | College         | Schizophrenia   |
| College expansion         | 0.001                    |                 | 0.008           |                 |
|                           | [0.001,0.001]            |                 | [0.007,0.010]   |                 |
|                           | (P < 0.001)              |                 | (P < 0.001)     |                 |
| College                   |                          | -0.091          |                 | -0.016          |
|                           |                          | [-0.175,-0.007] |                 | [-0.032, 0.000] |
|                           |                          | (0.035)         |                 | (0.050)         |
| Controls                  |                          |                 |                 |                 |
| Sex (Ref: Female)         |                          |                 |                 |                 |
| Male                      | 0.003                    | 0.000           | 0.019           | 0.001           |
|                           | [0.002,0.004]            | [0.000,0.001]   | [0.015,0.022]   | [0.000,0.001]   |
|                           | (P < 0.001)              | (0.033)         | (P < 0.001)     | (0.001)         |
| Ethnicity (Ref: Minority) |                          |                 |                 |                 |
| Han                       | -0.000                   | 0.000           | -0.038          | 0.000           |
|                           | [-0.001,0.001]           | [-0.000,0.001]  | [-0.045,-0.030] | [-0.001, 0.001] |
|                           | (0.640)                  | (0.085)         | (P < 0.001)     | (0.974)         |
| Income                    | 0.003                    | -0.000          | 0.022           | 0.000           |
|                           | [0.003,0.004]            | [-0.000,0.000]  | [0.022,0.022]   | [-0.000, 0.001] |
|                           | (P < 0.001)              | (0.489)         | (P < 0.001)     | (0.338)         |
| Province                  | Yes                      | Yes             | Yes             | Yes             |
| Birth Year                | Yes                      | Yes             | Yes             | Yes             |
| Province* birth year      | Yes                      | Yes             | Yes             | Yes             |
| CD Wald F                 | 194.229                  |                 | 190.234         |                 |

95 % confidence intervals in brackets; p-values in parentheses.

effects in disease severity, and treatment outcomes of schizophrenia need to be investigated with prospective methods such as cohort studies and randomized controlled trials. We leave this analysis to future research.

# 4.3. SES-specific effects

A college education reduces inequalities in schizophrenia onset due to equality of SES. Our study demonstrated that college education not only significantly reduced the overall incidence of schizophrenia but also reduced health inequalities across urban-rural areas and income. Growing up in cities has been associated with a higher risk of developing schizophrenia according to epidemiological studies (Castillejos et al., 2018; Vassos et al., 2016). In China, schizophrenia was more prevalent in urban areas (Chan et al., 2015; Phillips et al., 2004). In comparison with rural residents, urban residents are more likely to experience a variety of factors for schizophrenia such as urban social stress, noise (Costa e Silva and Steffen, 2019; Lederbogen et al., 2013), toxic exposure, housing quality and fear of crime (Wu et al., 2022). In contrast to our previous findings based on three metropolises (Luo et al., 2020a), we fail to find causal evidence for urban individuals. We cannot further compare the results with the findings in this study, due to differences in research question and sample. In term of our results, potential explanation may be: although the prevalence is lower in rural areas, the

#### Table 5

The effects of college on schizophrenia (stratified by income).

|  | Low-Income                            |  | Middle-Income                         |  | High-Income                              |   |
|--|---------------------------------------|--|---------------------------------------|--|--|---|
|  | First-stage                           | Second-stage                             | First-stage                           | Second-stage                             | First-stage                              | Second-stage                                |
|  | College                               | Schizophrenia                            | College                               | Schizophrenia                            | College                                  | Schizophrenia                               |
| College expansion                              | 0.002<br>[0.002,0.003]<br>(P < 0.001) |  | 0.004<br>[0.004,0.005]<br>(P < 0.001) |  | 0.003<br>[0.002,0.003]<br>(P < 0.001)    |   |
| College  |                                       | -0.103<br>[ $-0.189,-0.018$ ]<br>(0.018) |                                       | -0.010<br>[-0.039,0.019]<br>(0.503)      |  | -0.031<br>[-0.065,0.004]<br>(0.079)         |
| <b>Controls</b><br>Sex (Ref: Female)           |                                       |  |                                       |  |  |   |
| Male   | 0.002<br>[0.001,0.003]<br>(P < 0.001) | 0.001<br>[0.000,0.001]<br>(0.020)        | 0.008<br>[0.006,0.009]<br>(P < 0.001) | 0.000<br>[-0.000,0.001]<br>(0.510)       | 0.013<br>[0.010,0.016]<br>(P < 0.001)    | 0.001<br>[0.000,0.001]<br>(0.034)           |
| Hukou (Ref: Rural)                             | <b>(</b>                              |  |                                       |  |  | (   |
| Urban  | 0.067<br>[0.065,0.068]<br>(P < 0.001) | 0.009<br>[0.003,0.015]<br>(0.003)        | 0.122<br>[0.120,0.124]<br>(P < 0.001) | 0.003<br>[-0.001,0.007]<br>(0.094)       | 0.355<br>[0.352,0.358]<br>(P < 0.001)    | 0.011<br>[-0.001,0.023]<br>(0.068)          |
| Ethnicity (Ref: Minority)                      |                                       | (,                                       |                                       |  |  | (,  |
| Han  | -0.001<br>[-0.002,0.000]<br>(0.169)   | 0.001<br>[0.001,0.002]<br>(0.002)        | -0.004<br>[-0.007,-0.001]<br>(0.005)  | 0.001<br>[-0.000,0.001]<br>(0.146)       | -0.038<br>[-0.045,-0.032]<br>(P < 0.001) | -0.001<br>[ $-0.002,0.001$ ]<br>( $0.211$ ) |
| Income   | 0.002<br>[0.001,0.003]<br>(P < 0.001) | -0.005<br>[-0.006,-0.004]<br>(P < 0.001) | 0.013<br>[0.012,0.014]<br>(P < 0.001) | -0.001<br>[-0.002,-0.001]<br>(P < 0.001) | 0.014<br>[0.014,0.014]<br>(P < 0.001)    | 0.000<br>[-0.000,0.001]<br>(0.145)          |
| Province<br>Birth Year<br>Province* Birth Year | Yes<br>Yes<br>Yes                     | Yes<br>Yes<br>Yes                        | Yes<br>Yes<br>Yes                     | Yes<br>Yes<br>Yes                        | Yes<br>Yes<br>Yes                        | Yes<br>Yes<br>Yes                           |
| CD Wald F                                      | 315.262                               |  | 339.354                               |  | 34.066                                   |   |

95 % confidence intervals in brackets; p-values in parentheses.

benefits of college education are more pronounced for rural individuals because the risk factors for schizophrenia are relatively less severe in rural areas. However, the benefits of college education for urban individuals, who are surrounded by numerous and serious risk factors, are marginal.

It has been consistently demonstrated that living in a lower socioeconomic environment increases the risk of developing schizophrenia (Dean and Murray, 2005; El-Missiry et al., 2009; O'Donoghue et al., 2016). As a result of our study, college education reduced the risk of schizophrenia in low-income groups, reflecting the fact that college education can reduce income-related health inequalities. Overall, to some extent, our results confirms that education can alleviate socioeconomic-related health inequity.

There are several limitations of this study. First, the treatment effect we identify is the effect of college education on individuals who decide to obtain additional higher education as a result of the expansion policy. There may be a difference in the effects of going to college for other reasons as well. Secondly, we cannot entirely eliminate the endogeneity bias caused by reverse causation. Despite efforts in sample construction and the identification strategies to mitigate this issue, the nature of selfreported data and the non-randomized assignment in college education, present challenges associated with reverse causation in our research. Thirdly, data limitations prevent us from further exploring the mechanisms and the severity of schizophrenia. The individuals with schizophrenia in our dataset represent relatively severe cases, as they had experienced psychiatric symptoms for a minimum of one year. Consequently, individuals with milder severity, were excluded from this study. Fourth, we failed to examine the effects of educational quality and specialization heterogeneity. Due to the fact that quantity and quality in education may face tradeoffs, the investigation of quality or specialties in education may reveal a different picture (Xue et al., 2021).

Numerous research studies have demonstrated that education can have benefits that go beyond its potential impact on the labor market. This study sheds new light on the causal protective effect of college education on schizophrenia. We believe that our findings, given the representative sample, contribute to addressing one possible source of inefficiency in the investment of human capital, especially mental health. Additionally, our findings are applicable to other developing countries with similar social environments.

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# CRediT authorship contribution statement

Yanshang Wang: Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. Ruoxi Ding: Writing – review & editing. Yanan Luo: Investigation, Methodology. Ping He: Conceptualization, Funding acquisition, Writing – review & editing. Xiaoying Zheng: Conceptualization, Writing – review & editing.

# 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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