## Original Article

# Socioeconomic Status Impacts the Prognosis of Chronic Rhinosinusitis Treated by Endoscopic Sinus Surgery: An Observational Cohort Study in Northeast China

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**Abstract**

**Objective** To explore the association between socioeconomic status (SES) and postoperative outcomes in patients with chronic sinusitis (CRS) after functional endoscopic sinus surgery (ESS).

**Methods** We conducted an observational cohort study of 1,047 patients with CRS undergoing ESS. Discharged patients were followed up to 72 weeks for all-cause recurrence events. Baseline SES was established based on occupation, education level, and family income of the patients 1 year before the operation. Kaplan–Meier method was used to calculate the recovery rate after ESS, and Cox proportional hazards regression analysis was used to evaluate the relationship between SES and prognosis.

**Results** Patients of middle SES had lower unadjusted all-cause recurrence than those of low or high SES; 24-week overall recovery rate was 90.4% [95 % confidence interval (*CI*): 89.6%–91.2%] in patients of middle SES, 13.5% (95 % *CI*: 12.8%–14.2%) in patients of low SES, and 31.7% (95 % *CI*: 30.7%–32.7%) in patients of high SES (both log-rank $P < 0.001$). After adjustment for covariates, hazard ratios (*HRs*) were 7.69 (95 % *CI*: 6.17–9.71, $P_{trend} < 0.001$) for all-cause recurrence for low SES *versus* middle SES, and 6.19 (95 % *CI*: 4.78–7.93, $P_{trend} < 0.001$) for middle SES *versus* high SES.

**Conclusion** Low SES and high SES were more associated with the worse prognosis of CRS patients after ESS than middle SES.

**Key words:** Chronic rhinosinusitis; Endoscopic sinus surgery; Socioeconomic status

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## INTRODUCTION

Chronic sinusitis (CRS), with or without nasal polyps (CRSwNP/CRSsNP), is a common chronic inflammatory disease of the nasal cavity and paranasal sinus mucosa. CRS symptoms mainly include nasal congestion, runny nose, headache, swelling of the face, and olfactory dysfunction or loss, and the disease duration is at least 12 consecutive weeks[1]. According to some multicenter studies, CRS had a mean prevalence of 10.9% (range of 6.9%–27.1%) in 19 Western centers, from 2011 to 2013[2] and 8.0% (range of 4.8%–9.7%) in seven Chinese centers in 2012[3]. CRS is not a life-threatening disease, but CRS patients often suffer from prolonged and repeated attacks of the disease, which significantly reduces their quality of life[4]. Surgical treatment is usually adopted for CRS in cases where drug treatments are ineffective[5].

Functional endoscopic sinus surgery (ESS) is currently the standard nasal surgery for treatment-resistant CRS[6]. ESS is safe, minimally invasive, and

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can improve the quality of life of patients with severe CRSwNP and CRSsNP; however, some patients (nearly 3/4) have no change in odor perception after operation and about 7%–10% of patients may have deteriorated olfactory function[7-9]. This may be related to the complex pathogenesis of CRS, involving intrinsic (such as infection, allergic inflammation, metabolic diseases, and genetics) and environmental factors (such as air pollution and occupational exposure)[5]. Besides, patients of low socioeconomic status (SES) may have delayed medical diagnosis and limited access to treatment and care[10]; until now only three studies have suggested that low SES may increase symptom severity or reduce the quality of life after ESS[11-13]. However, these studies did not examine the direct or comprehensive effects of socioeconomic factors on prognosis after surgery; moreover, all the data came from high-income countries. As a developing country, China has an imbalanced allocation of medical and health care resources[14]. We aimed to examine the association between SES and prognosis in patients after surgery for CRS, focusing on postoperative inflammatory outcomes and recurrence rates, especially in developing countries or countries with relatively unbalanced health care systems.

## METHODS

### *Study Design and Participants*

This observational cohort study included a total of 1,047 patients with severe CRS who underwent ESS in the Department of Otolaryngology, First Affiliated Hospital of China Medical University (Shenyang, China) in a 33-month period between February 2019 and October 2021. These patients were aged 18–65 years at the time of operation. The demographic and clinical indicators were also collected. Exclusion criteria were: 1) Patients undergoing ESS for other reasons, including odontogenic sinusitis, fungal balls, structural lesions, benign and malignant tumors; 2) Patients with severe heart disease, hypertension, diabetes, chronic obstructive pulmonary disease, or liver and kidney disease. This study was approved by the medical ethics committee of First Affiliated Hospital of China Medical University. Each included subject signed a written informed consent and could withdraw from the study unconditionally.

### *Procedures*

For each CRS patient, baseline demographic and disease characteristics were collected by experienced attending physician through face-to-face questionnaires and from the inpatient medical record system. Clinical information included CRS classification, preoperative biochemical indicators, nasal endoscopy, and sinus computerized tomography (CT) scan. The diagnostic criteria for CRS were based on the CRS Guidelines for Diagnosis and Treatment[15], and patients with unsatisfactory results from drug treatment for 3 months, consecutively, were subjected to surgical treatment. Demographic information was derived from medical records and questionnaires during hospitalization, including SES (occupation, education, and income), living environment (pets and decoration), work stress, and family stress.

The patients came to our hospital for outpatient follow-up 2 and 4 weeks after discharge, and every 4 weeks thereafter. During the follow-up period, we assessed the postoperative sinus recovery through endoscopic views (Supplementary Figure S1, available in www.besjournal.com), Lund-Kennedy endoscopy score, and postoperative status of care, diet, and rest. Where necessary, CT scan of paranasal sinuses was repeated and compared with preoperative results. CRS patients who did not come to our hospital for outpatient follow-up within the prescribed time limit were considered lost to follow-up if they could not be reached after three phone calls. If recurrence was found, we continued to follow up. The longest follow-up was 72 weeks, and patients lost to follow-up were censored as recovery on the date of the last contact. CRS is a chronic disease, and although inflammation may persist endoscopically, patients may have significant improvement in the quality of life. The recurrence of CRS is not fully-defined and is subjective in the clinical setting; hence, we used the aforementioned indicators to comprehensively assess whether there was recurrence or not.

Based on previous factors[13,16], we established a comprehensive scoring system of SES, which comprises the patient's occupation, education, and income 1 year before surgery. Annual household income (unit: RMB) was divided into three grades and scored: low (< 5,000/month, 1 point), middle (5,000–8,000/month, 2 points), and high (8,000–/month, 3 points). Occupation was divided into three grades and scored: manual workers, farmers, unemployed people (low, 1 point), businessmen or employees (middle, 2 points), professionals, managers or government employees (high, 3 points). Similarly, education was divided into

three grades and scored: lower than high school (low, 1 point), high school graduation or equivalent (middle, 2 points), university graduation or above (high, 3 points). Next, we calculated the total SES scores of CRS patients (3–9 points) and divided patients into approximate terciles of SES status distribution: low (≤ 4 points), middle (5–7 points), and high (≥ 8 points).

### *Outcomes*

The follow-up outcome of this study is the all-cause non-recovery (recurrence) rate, that is, the postoperative non-recovery rate of CRS patients influenced by various factors during the follow-up period.

### *Potential Covariates*

Based on the literature[17-20] and clinical experience, we screened for covariates that may affect recovery rates, including patient demographics [sex, body mass index (BMI), and medical insurance] and clinical risk factors [age at operation years, nasal polyposis, smoking, alcohol, dietary patterns, pets, new furniture/redecoration, stressful work-family events, staying up late, fractional exhaled nitric oxide (FeNO), fractional nasal nitric oxide (FnNO), hemoglobin (Hb), and immunoglobulin E (IgE)].

### *Statistical Analysis*

We used the Shapiro–Wilk method to test for normality of all continuous variables, and the results are expressed as the median (Interquartile range, IQR) (25th–75th percentile). The Kruskal-Wallis test was used to compare the differences in continuous variables among the three groups (terciles SES status), and Chi-square test or continuity-corrected Chi-square test was used to determine the differences in categorical variables, which are expressed as frequencies (percentages).

The Kaplan-Meier method was used to calculate the recovery rate after ESS and plot the survival curves. The log-rank test was used to compare the postoperative recovery rates across the three SES groups. Through a multivariate Cox proportional hazards regression model, we adjusted other covariates to analyze the effect of SES status (low, middle, and high) on all-cause recovery, estimated adjusted hazard ratio (*HR*) and its 95 % confidence interval (*CI*), and the interaction between SES and some potential covariates (with or without nasal polyps, medical insurance, and dietary patterns). These covariates, which may affect postoperative recovery, were screened by using univariate Cox regression models and clinical experience. Because of the differences in demographic and clinical information among CRS patients in different SES groups, we first screened out the covariates and incorporated them into the multivariate Cox regression model together with SES to obtain the effect of SES on recovery after adjusting for covariates. When the categorical variable had more than two categories, it was converted into a dummy variable and then included in the model for analysis. Considering the possibility of loss to follow-up due to recovery, we assumed that all of patients lost to follow-up recovered, and we performed a sensitivity analysis to test the robustness of our main analysis. A $P$ value < 0.05 indicated statistical significance. The data were analyzed by using SPSS software for Windows, version 20.0 (IBM SPSS, Inc., Chicago, IL, USA).

### *Sample Size Estimation*

Based on the pilot trial, we assumed a 72-week recovery rate of 40% for patients of low SES in the study, assuming $\alpha = 0.05$ and $\beta = 0.10$. The Kaplan-Meier model analysis showed that 237 CRS patients were in low and middle SES groups, and the recovery rates of the two groups were significantly different. Assuming a 10% loss to follow-up rate, this study required at least 790 CRS patients. Finally, 1,047 CRS patients were included in the survival analysis to meet the sample size requirement.

## RESULTS

### *Participants' Characteristics*

From February 1, 2019 to October 31, 2021, 1,047 ESS-treated CRS patients were enrolled in this study (Table 1, Figure 1). The median age of patients at surgery in this cohort was 36 (IQR 27–46) years. Of the patients, 600 (57.3%) patients were male, 764 (73.0%) patients had CRSwNP, 315 (30.1%) patients belonged to low-income status, and 362 (34.6%) patients were farmers, temporary workers, or unemployed, and 172 (16.4%) patients had no medical insurance and paid at their own expense. Compared with patients in the middle SES group, those in the low or high SES groups were older at the time of surgery ($P < 0.001$) and had higher preoperative FnNO levels ($P = 0.039$). In addition, the proportion of patients with medical insurance in the high SES group was higher than that in the

**Table 1.** Baseline characteristics and clinical features of patients with severe chronic rhinosinusitis (CRS) (*n* = 1,047) by socioeconomic status tertiles

| Characteristics | Total (*n* = 1,047) | Low (*n* = 310) | Middle (*n* = 399) | High (*n* = 338) | *P*-value |
|---|---|---|---|---|---|
| Age at operation years | 34.2 (27.5–46.1) | 36.8 (31.8–50.8) | 30.6 (24.3–48.9) | 36.6 (30.6–44.1) | < 0.001 |
| Sex, *n* (%) | | | | | 0.626 |
| Males | 600 (57.3) | 183 (59.0) | 230 (57.6) | 187 (55.3) | |
| Females | 447 (42.7) | 127 (41.0) | 169 (42.4) | 151 (44.7) | |
| BMI, kg/m$^2$ | 22.6 (20.6–27.2) | 22.8 (20.7–27.3) | 22.5 (20.6–27.6) | 22.0 (20.4–26.7) | 0.594 |
| Education[a], *n* (%) | | | | | |
| < High school | 92 (8.8) | 83 (27.0) | 9 (2.2) | 0 (0.0) | < 0.001 |
| High school | 273 (26.2) | 178 (58.0) | 92 (23.1) | 3 (0.9) | |
| ≥ College | 676 (65.0) | 46 (15.0) | 298 (74.7) | 332 (99.1) | |
| Occupation, *n* (%) | | | | | < 0.001 |
| Low | 362 (34.6) | 169 (54.5) | 187 (46.9) | 6 (1.8) | |
| Medium | 313 (29.9) | 138 (44.5) | 89 (22.3) | 86 (25.4) | |
| High | 372 (35.5) | 3 (1.0) | 123 (30.8) | 246 (72.8) | |
| Household income/month[a], *n* (%) | | | | | < 0.001 |
| < ¥5,000 | 315 (30.2) | 124 (40.0) | 151 (37.8) | 40 (11.9) | |
| ¥5,000–8,000 | 638 (61.1) | 186 (60.0) | 243 (60.9) | 209 (62.4) | |
| > ¥8,000 | 91 (8.7) | 0 (0.0) | 5 (1.3) | 86 (25.7) | |
| Nasal polyposis, *n* (%) | | | | | 0.607 |
| Without | 283 (27.0) | 80 (25.8) | 105 (26.3) | 98 (29.0) | |
| With | 764 (73.0) | 230 (74.2) | 294 (73.7) | 240 (71.0) | |
| Smoking, *n* (%) | | | | | 0.538 |
| No | 683 (65.2) | 203 (65.5) | 267 (66.9) | 213 (63.0) | |
| Yes | 364 (34.8) | 107 (34.5) | 132 (33.1) | 125 (37.0) | |
| Alcohol, *n* (%) | | | | | 0.302 |
| No | 697 (66.6) | 212 (68.4) | 271 (67.9) | 214 (63.3) | |
| Yes | 350 (33.4) | 98 (31.6) | 128 (32.1) | 124 (36.7) | |
| Dietary patterns[a], *n* (%) | | | | | 0.466 |
| Vegetarian-based | 134 (13.3) | 36 (13.2) | 56 (14.0) | 42 (12.4) | |
| Meat-based | 67 (6.6) | 24 (8.8) | 25 (6.3) | 18 (5.3) | |
| Mixed | 809 (80.1) | 213 (78.0) | 318 (79.7) | 278 (82.2) | |
| Furry/feathery Pets, *n* (%) | | | | | 0.356 |
| No | 892 (85.2) | 271 (87.4) | 339 (85.0) | 282 (83.4) | |
| Yes | 155 (14.8) | 39 (12.6) | 60 (15.0) | 56 (16.6) | |
| New furniture/redecoration, *n* (%) | | | | | 0.593 |
| No | 902 (86.2) | 267 (86.1) | 339 (85.0) | 296 (87.6) | |
| Yes | 145 (86.1) | 43 (13.9) | 60 (15.0) | 42 (12.4) | |
| Stressful work or family events during the first 1 year[ab], *n* (%) | | | | | 0.235 |
| No | 711 (68.1) | 207 (66.8) | 284 (71.2) | 220 (65.7) | |
| Yes | 333 (31.9) | 103 (33.2) | 115 (28.8) | 115 (34.3) | |

Continued

| Characteristics | Total (*n* = 1,047) | Low (*n* = 310) | Middle (*n* = 399) | High (*n* = 338) | *P*-value |
|---|---|---|---|---|---|
| Often stay up late, *n* (%) | | | | | 0.296 |
| No | 788 (75.3) | 243 (78.4) | 293 (73.4) | 252 (74.6) | |
| Yes | 259 (24.7) | 67 (21.6) | 106 (26.6) | 86 (25.4) | |
| Before surgery, *n* (%) | | | | | |
| FeNO, ppb | 24.0 (16.0–34.0) | 22.0 (15.0–36.0) | 24.0 (18.0–33.0) | 26.0 (19.0–33.0) | 0.293 |
| FnNO, ppb | 201.0 (151.0–322.0) | 220.0 (168.0–335.0) | 187.0 (145.0–311.0) | 213.0 (169.0–323.0) | 0.039 |
| Hb, g/L | 146.0 (136.0–161.0) | 146.5 (140.0–166.0) | 142.0 (121.0–162.0) | 146.0 (136.0–157.0) | 0.711 |
| IgE, IU/mL | 44.4 (30.8–66.0) | 42.3 (30.3–77.4) | 46.0 (31.1–56.0) | 47.6 (34.9–60.8) | 0.284 |
| Medical insurance, *n* (%) | | | | | < 0.001 |
| No | 172 (16.4) | 83 (26.8) | 86 (21.6) | 3 (0.9) | |
| Yes | 875 (83.6) | 227 (73.2) | 313 (78.4) | 335 (99.1) | |

***Note.*** [a]Total numbers were not equal to 1,047 for these characteristics due to missing data. [b]Among work, separation/divorce, loss of job, serious health problem, or death of a family member or close relative. Values are *n* (%) or median (IQR).

low and middle SES groups ($P < 0.001$).

### *Kaplan-Meier Analysis*

Kaplan-Meier analysis (Figure 2, Supplementary Table S1, available in www.besjournal.com) showed that the recovery rates of 1,047 CRS patients at 12 weeks and 24 weeks after operation were 19.1% (95% *CI*: 18.3%–19.9%) and 44.7% (95% *CI*: 43.7%–45.7%), respectively.

The log-rank tests showed that after follow-up at 24 weeks, the recovery rate (90.4%, 95% *CI*: 89.6%–91.2%) of patients of middle SES was higher than those of patients of low SES (13.5%, 95% *CI*: 12.8%–14.2%) and high SES (31.7%, 95% *CI*: 30.7%–32.7%) (log-rank $P < 0.001$). In addition, multivariate Cox regression model analysis showed that SES had no association with nasal polyps ($P_{interaction} = 0.189$), medical insurance mode ($P_{interaction} = 0.143$), and dietary pattern ($P_{interaction} = 0.438$) (Supplementary Table S2, available in www.besjournal.com).

Based on the literature, we selected variables (surgical age, BMI, nasal polyps, smoking, dietary pattern, stress events, FeNO, FnNO, Hb, and medical insurance mode) that might affect prognosis and

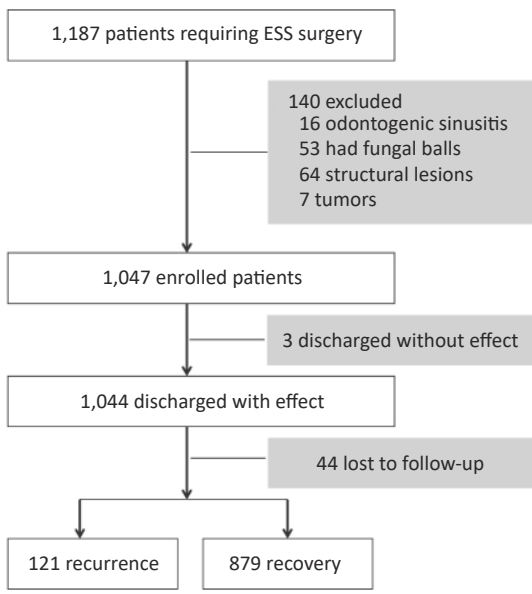


**Figure 1.** Study flowchart. ESS, endoscopic sinus surgery.

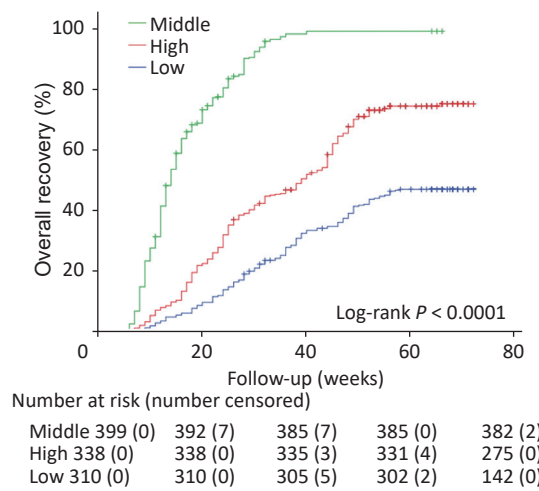


**Figure 2.** Kaplan-Meier survival plot of overall survival by socioeconomic status.

carried out univariate Cox regression model analysis, followed by multivariate Cox regression model analysis to determine their association with SES. Next, we obtained the influence of SES after adjusting the covariates for recovery rate (Figure 3, Table 2).

SES was an independent predictor of postoperative all-cause non-recovery in CRS patients after adjusting for other covariates. During the whole follow-up period of 72 weeks, the risk of non-recovery of patients of low and high SES was significantly higher than that of patients of middle SES.

Patients of low SES had the highest risk of non-recovery, with an *HR* of 7.69 (95% *CI*: 6.17–9.71, $P_{trend}$ < 0.001), followed by patients of high SES, with *HR* of 6.19 (95 % *CI*: 4.78–7.93, $P_{trend}$ < 0.001) (Figure 3, Table 2).

### *Sensitivity Analysis*

In sensitivity analysis, we assumed that all the 44 patients lost to follow-up had reached the end point of recovery. Therefore, we performed univariate and multivariate Cox regression analyses, which yielded similar outcomes: *HRs* for recurrence were 8.77 (95% *CI*: 7.09–10.87) for the low SES group and 7.19 (95% *CI*: 5.95–8.70) for the high SES group, compared with the middle SES group ($P_{trend}$ < 0.001) (Supplementary Table S3, available in www.besjournal.com).

## DISCUSSION

This study demonstrated that CRS patients of low and high SES had a greater risk of postoperative all-cause non-recovery (recurrence) after ESS surgery than patients of middle SES. This trend persisted after adjustment for demographic and clinical characteristics. The risk of non-recovery in CRS patients of low SES was nearly eight folds higher than that of patients of middle SES, and the most significant feature was that the risk of non-recovery in patients of high SES was six folds higher than that of patients of middle SES, which contradicted the previous reports of better clinical prognosis in patients of high SES after surgery[11,13,16]. This possibly reflects the challenges associated with SES.

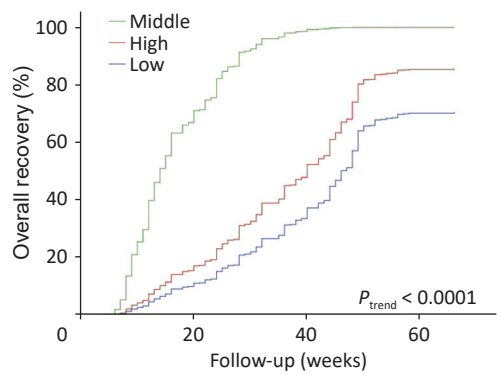


**Figure 3.** Adjusted survival curves for all-cause recurrence by socioeconomic status. Models were adjusted for age at operation, sex, BMI, nasal polyposis, smoking, dietary patterns, stressful family events during the year that precede the operation, FeNO, FnNO, Hb, and medical insurance. FeNO, fractional exhaled nitric oxide; FnNO, fractional nasal nitric oxide; and Hb, hemoglobin.

There is currently no standard method for measuring SES, as previous studies were mainly based on census area/community-based SES measurement. The premise of this method is that the national socio-economic data is promptly completed and updated[11-13,16], which makes it unsuitable for SES assessment in China primarily because such data are not available[14]. Moreover, the CRS patients enrolled in this study come from different regions of Northeast China, which introduces great regional and cultural differences. In addition, we included monthly family income as part of the SES measurement indices because the hospital treated CRS patients from all over Northeast China. However, the economic development in these different regions is extremely unbalanced, and even in the same occupation, the income gap is large.

Among CRS patients of low SES, 27% had no medical insurance, and among those of high SES, only 0.9% had no medical insurance. The patients of low SES had relatively low access to medical resources, including routine physical examination[21-24]. In addition, the cost of ESS operation is about ¥20,000 and medical insurance can reimburse ¥10,000, leaving ¥10,000, which most patients can afford. However, considering the backward economy in Liaoning, it is still a big burden for most patients of low SES[22], and therefore, these patients delay their operation. From this trend, it is expected that patients of high SES would pay more attention to their own health because they have physical examination at least once a year (unit welfare) and do not have to worry about the operation cost[22]. However, our data showed that patients of high SES also delayed their operation, which was similar to the trend observed with low SES patients. This suggests that people of high SES faced greater mental pressure from responsibility than those of middle SES in the current Chinese society. Our study also found that patients of high

**Table 2.** Univariable and multivariable Cox regression model of factors associated with all-cause recurrence

| Characteristics | All-cause non-recovery | | | |
|---|---|---|---|---|
| | Crude *HR* (95% *CI*) | *P*-value | Adjusted *HR*[*] (95% *CI*) | *P*-value |
| Socioeconomic status | | | | |
| Low | 10.42 (8.55–12.66) | < 0.001 | 7.69 (6.17–9.71) | < 0.001 |
| High | 6.54 (5.49–7.81) | < 0.001 | 6.19 (4.78–7.93) | < 0.001 |
| Middle | 1 | (ref) | 1 | (ref) |
| Age at operation, years | 1.01 (1.00–1.02) | 0.013 | 1.01 (0.99–1.02) | 0.128 |
| Sex | | | | |
| Males | 0.86 (0.72–1.01) | 0.27 | 0.93 (0.79–1.08) | 0.313 |
| Females | 1 | (ref) | 1 | (ref) |
| BMI, kg/m$^2$ | 1.02 (1.00–1.03) | 0.19 | NA | |
| Nasal polyposis | | | | |
| Without | 0.75 (0.65–0.87) | < 0.001 | 0.83 (0.69–1.00) | 0.039 |
| With | 1 | (ref) | 1 | (ref) |
| Smoking | | | NA | |
| No | 0.87 (0.76–0.99) | 0.039 | | |
| Yes | 1 | (ref) | | |
| Alcohol | | | NA | |
| No | 1.03 (0.89–1.19) | 0.648 | | |
| Yes | 1 | (ref) | | |
| Dietary patterns[*] | | | | |
| Vegetarian-based | 2.11 (1.69–2.64) | < 0.001 | 1.45 (0.87–2.42) | 0.149 |
| Meat-based | 1.66 (1.23–2.22) | 0.001 | 0.88 (0.50–1.52) | 0.631 |
| Mixed | 1 | (ref) | 1 | (ref) |
| Furry/feathery Pets | | | NA | |
| No | 0.94 (0.78–1.13) | 0.511 | | |
| Yes | 1 | (ref) | | |
| New furniture/redecoration | | | NA | |
| No | 0.89 (0.73–1.08) | 0.231 | | |
| Yes | 1 | (ref) | | |
| Stressful work or family events during the first 1 year | | | | |
| No | 0.80 (0.66–0.99) | 0.032 | 1.02 (0.80–1.30) | 0.871 |
| Yes | 1 | (ref) | 1 | (ref) |
| Often stay up late | | | | |
| No | 1.00 (0.85–1.17) | 0.989 | NA | |
| Yes | 1 | (ref) | | |
| Before surgery | | | | |
| FeNO, ppb | 1.00 (1.00–1.01) | < 0.001 | 1.00 (0.98–1.02) | 0.954 |
| FnNO, ppb | 0.99 (0.99–1.00) | 0.001 | 0.99 (0.99–1.01) | 0.196 |
| Hb, g/L | 1.00 (1.00–1.01) | 0.025 | 0.99 (0.98–1.01) | 0.122 |
| IgE, IU/mL | 1.00 (0.99–1.01) | 0.538 | 1.00 (1.00–1.01) | 0.032 |
| Medical insurance | | | | |
| No | 1.26 (1.19–1.33) | < 0.001 | 1.23 (1.07–1.42) | 0.003 |
| Yes | 1 | (ref) | 1 | (ref) |

***Note.*** CRS, chronic sinusitis; FeNO, fractional exhaled nitric oxide; FnNO, fractional nasal nitric oxide; HR, hazard ratio; NA, not applicable. [*]Adjusted for age at operation, sex, BMI, nasal polyposis, smoking, dietary patterns, stressful work or family events during the first 1 year, FeNO, FnNO, Hb, and medical insurance.

SES had the highest proportion of major stressful events at work or family, as well as increased smoking and drinking, during a period of 1 year before surgery, which explains the mental stress associated with this group[23,25]. Although the difference was not statistically significant from that observed with low and middle SES, patients of high SES experienced the highest mental stress in contemporary China. Chronic psychological stress may be one of the factors that increase CRS severity and lead to uncontrolled disease in CRS patients[26]. FnNO is used as a noninvasive long-term biomarker to monitor sinus disease severity and to determine the prognosis of CRS patients[27]. This also corresponded to the slower postoperative recovery observed in CRS patients of low and high SES.

This study had several limitations. First, all the CRS patients in this cohort were from a single center and the results might not reflect the situation of other nasal endoscopy centers in China. However, single-center surgeons with similar surgical expertise and standardized medical practices do not need to readjust for variables. Second, we did not analyze the impact of each indicator of SES on all-cause non-recovery. Because a single index can only reflect one dimension of SES, and even if it is analyzed one by one, it will only reflect the impact of different dimensions on prognosis. The SES indicators are more comprehensive, scientific, and more suitable for China's national conditions. Third, our data came from Liaoning Province in Northeast China, which is an economically backward area (population: 8.32 million, area: 12,948 $km^2$). SES in Liaoning is lower than the national average as a whole, and hence, it cannot represent the impact of SES status in other parts of China on CRS after ESS operation. Fourth, this study did not show the interactions between SES, pollutant exposure, and CRS prognosis. However, it has been previously reported that lower SES predicted higher exposure to air pollution and disease severity in patients with CRS[12]. Fifth, European Position Paper on Rhinosinusitis and Nasal Polyps 2020 criteria does not include the traditional classification methods for CRSwNP/CRSsNP, but it classifies CRS into primary and secondary, local and diffuse, as well as eosinophilic and non-eosinophilic CRS. Based on the difference in surgical effect and recurrence rate, CRSwNP can be simply divided into eosinophilic or non-eosinophilic CRSwNP. Eosinophilic CRSwNP easily recurs and is not easily treated[28]; however, our study did not classify CRS into eosinophilic and non-eosinophilic CRS.

In conclusion, CRS patients of low and high SES had greater risk of postoperative recurrence rate than those of middle SES, even after adjusting for nasal polyps, dietary patterns, stressful events, medical insurance methods, and demographic and clinical characteristics in a multivariate Cox proportional risk regression model. SES represents the socioeconomic status of patients and is generally considered a difficult factor to change. Our results showed two-handed intervention policies for CRS patients of different SES status. On the one hand, we urge the government to introduce policies that can reduce the burden of medical expenses on patients and provide more high-quality health care services. On the other hand, the attention of the society should be called to the long-term mental stress experienced by CRS patients of high SES. These strategies may improve the surgical prognosis of CRS patients.

## AUTHORS' CONTRIBUTIONS

HAO Shuai wrote the main manuscript text. ZHANG Xue Yan and GAO Jiao collected the data. HAO Shuai analyzed the data. WANG Yan and YAN Ai Hui prepared clinical tests. All authors have read and agreed to the published version of the manuscript.

## INSTITUTIONAL REVIEW BOARD STATEMENT

The study was conducted in accordance with the Declaration of Helsinki and approved by medical ethics committee of First Affiliated Hospital of China Medical University. (Approval number: SCXK_LN CMU 2019-1302).

## INFORMED CONSENT STATEMENT

Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

## DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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