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Prevalence of chronic obstructive pulmonary disease in high-risk populations at low, intermediate, high altitudes: a population based cross-sectional study in Yunnan Province, China

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Abstract

Background Chronic obstructive pulmonary disease (COPD) represents a significant public health challenge. This study aimed to investigate the epidemiological characteristics of COPD across different altitudes and evaluate the potential influence of altitude on its prevalence of high-risk populations.

Methods This cross-sectional study employed a multi-stage randomized cluster sampling method and enrolled 11,095 adult residents aged ≥ 20 years at different elevations in Yunnan Province, China. Screening questionnaires identified high-risk individuals among participants, who then underwent pulmonary function tests. COPD was diagnosed based on post-bronchodilator test results. We utilized multivariate logistic regression models to examine the association between altitudes and COPD prevalence while controlling for demographic variables, lifestyle factors, and disease characteristics.

Results A total of 2,252 (20.3%) were in the high-risk group. The prevalence of COPD in high-risk populations increased with age across low, intermediate, and high altitude areas. COPD patients in high-risk populations at high-altitude areas had a higher prevalence of ethnic minorities and significant biomass fuel exposure. Conversely, the proportion of COPD patients in the severe stages (GOLD III-IV) was notably lower in high-altitude regions. Logistic regression models revealed COPD prevalence in high-risk populations at high altitudes to be significantly lower than at low altitudes, with odds ratios of 0.538(95% *CI*: 0.343–0.844), 0.470(95% *CI*: 0.289–0.766), and 0.518 (95% *CI*: 0.316–0.848) for Models 1, 2, and 3, respectively (all $P < 0.05$).

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Conclusion The prevalence of COPD in high-risk populations is the lowest in the high-altitude regions of Yunnan Province, and high altitude is an independent factor negatively associated with COPD.

Keywords Chronic obstructive pulmonary disease, High altitude, Prevalence, Epidemiological characteristics

Background

Chronic Obstructive Pulmonary Disease (COPD) is a common chronic respiratory disease, posing a significant disease burden. The latest Global Burden of Disease study shows that COPD is the fourth leading cause of age-standardized death worldwide and the sixth leading cause of disability-adjusted life-years globally [1, 2]. Based on large scale epidemiological studies, it is estimated that the global prevalence of COPD is 10.3% [3]. Although the prevalence and mortality of COPD vary in different countries and areas, it cannot be denied that COPD seriously affects public health.

Currently, across the globe, there are an estimated 500.3 million people residing at altitudes of 1,500 m or higher, 81.6 million at 2,500 m or higher, and 14.4 million at elevations exceeding 3,500 m [4]. In order to adapt to the unique natural environment of the plateau area, humans have undergone a series of adaptive changes from physiological states to lifestyles. These changes affect the characteristics of the diseases. A multitude of cross-sectional studies have meticulously documented the prevalence of COPD in a wide array of areas globally, all of which are located at altitudes below the 1,500-meter mark. The prevalence of COPD has been reported to be 8.5% at high altitudes and 9.9% at low altitudes, with altitude inversely correlated with the risk of COPD prevalence [5]. Another review showed an overall prevalence of COPD at high altitudes of 10.0% [6]. However, there is a significant dearth of research on the prevalence of COPD in high-risk populations at high-altitude areas.

Due to various factors such as unclear respiratory symptoms and low education level, people in high-altitude areas face the problem of insufficient diagnosis of COPD and living at high altitude is linked to an increased risk of undiagnosed COPD [5]. COPD in high-altitude areas warrants attention and emphasis, necessitating the conduct of further pertinent research.

To the best of our knowledge, no existing research has yet to focus on the nuances of COPD across the varied altitude areas of Yunnan Province in China. This study is designed to fill that gap by delving into the prevalence characteristics of COPD in these diverse altitude zones. Additionally, it seeks to assess the influence of the varied altitude environments on the prevalence of COPD in high-risk populations and to concurrently examine the demographic traits of COPD sufferers in these areas.

Methods

Study design and participants

In the early stages, the largest-scale survey of COPD was conducted among a representative sample of the general adult population in Yunnan Province, filling several gaps in the knowledge regarding the prevalence of COPD in Yunnan Province. The study design, sampling methodologies, and inclusion and exclusion criteria of participants have been delineated with meticulous detail in previous work [7].

Minimum sample size was calculated using the formula:

$$N = \frac{(Z_{\alpha/2})^2 pq}{\delta^2}$$

where,

N = the minimum sample size.

$Z_{\alpha/2}$ = the standard normal deviate corresponding to a level of significance of 0.05 is 1.96

p = the prevalence rate of hypertension, according to the China Pulmonary Health study, the prevalence of COPD in people over 20 years of age is 8.6% [8].

q = 1-p.

δ = the desired precision: 0.01

Deff = the sampling design efficiency: 2.

Assuming a 80% response rate for the questionnaire, the sample size is calculated using PASS 15.0 software, and the minimum sample size is $N = 7300$. In order to facilitate the implementation and calculation, the sample size of this survey is allocated in each county (district/city) with equal capacity.

Briefly, a representative sample of 11,095 adult residents aged ≥ 20 years from different areas in Yunnan Province was recruited through a meticulously executed multi-stage cluster sampling methodology.

Procedures

COPD-PS questionnaire [9] and COPD-SQ questionnaire [10] were utilized for initial high-risk COPD population screening among all study participants, with high risk defined as a COPD-SQ score ≥ 16 or (and) a COPD-PS score ≥ 5. Next, trained technicians performed pulmonary function tests (PFTs) on high-risk individuals, adhering strictly to guidelines. Post-bronchodilator pulmonary function test was performed for individuals with a pre-bronchodilator $FEV_1/FVC < 0.7$. All high-risk individuals also underwent a detailed questionnaire survey, including basic and sociodemographical information, exposure to risk factors, personal histories and comorbidities. Finally, COPD was definitively diagnosed based on the diagnostic criteria [3].

Measures

The independent variable of this study was altitude. According to the altitude stratification standard [11], Yunnan Province was divided into low (< 1500 m), intermediate (1500–2500 m) and high (> 2500 m) altitude areas in this study. All baseline covariate data were obtained by trained investigators using a standard questionnaire. Age, gender, nationality, educational attainment and marital status were self-reported. The Waist to Hip Ratio (WHR) was calculated by dividing the waist circumference by the hip circumference. Abdominal obesity was identified if the WHR was 0.9 or higher for men, and 0.85 or higher for women [12]. The smoking index was determined by multiplying the number of packs smoked daily by the number of years of smoking. A family history of respiratory disease was ascertained by confirming whether any family member had been diagnosed with conditions such as COPD, chronic bronchitis, or emphysema et al. A history of childhood respiratory disease was established if there was a record of pneumonia, asthma, bronchitis, or any other respiratory illness at least once before the age of 14. Biomass use was defined as the regular use of primarily wood fuels or animal waste for cooking or heating over the past six months or longer. The severity of pulmonary function impairment in COPD patients is divided into four grades according to the ratio of FEV_1 measured value to predicted value, namely GOLD stage I-IV [3]. We refer to GOLD 2024 [3] and Chinese guideline of COPD [13] to determine the type of comorbidities. In this study, participants self-reported their comorbidities by answering yes or no questions, in which having one of the conditions such as hypertension, coronary atherosclerotic heart disease, heart failure, ischemic heart disease, and atrial fibrillation was defined as comorbid cardiovascular disease. Co-respiratory disease is defined as having one of the diseases such as bronchiectasis, bronchial asthma, pulmonary embolism, lung cancer, obstructive sleep apnea, etc. Suffering from one of the metabolic diseases such as diabetes, hyperuricemia, and hyperlipidemia is defined as having endocrine and metabolic diseases. Number of comorbidities is defined as the number of people with the above diseases, classified as "0", "1", "2", and "≥3".

Statistical analysis

Continuous variables that conformed to a normal distribution were represented using the mean and standard deviation (SD), and analysis of variance (ANOVA) was employed to compare differences in measurement indicators between groups. For continuous variables that did not conform to a normal distribution, the median and interquartile range were used for representation, and the Kruskal-Wallis test was utilized for comparing differences in measurement indicators between groups. Categorical variables were described using frequency number (*n*) and percentage (*%*). Differences between groups in three altitude areas were analyzed using chi-square tests or Fisher's exact probability method.

A multivariate logistic regression model was used to estimate the odds ratio (*OR*) and 95% confidence interval (*CI*) to assess the association between altitude and the risk of COPD. Variables with a univariate analysis *p*-value less than 0.10 were considered eligible for inclusion in the multivariate model. Adjustments were made sequentially for demographic factors (gender, age), lifestyle factors (smoking exposure, central obesity, use of biomass fuels), and disease characteristics (history of respiratory diseases in childhood, family history of respiratory diseases, coexisting respiratory system diseases, coexisting cardiovascular diseases, coexisting metabolic diseases, and the number of comorbidities), and the *OR* and 95% *CI* were reported.

All statistical analyses were conducted using SPSS 26.0 software, and R 4.4.0 software (https://www.r-project.org/) was used for visualizing the prevalence rates of different subgroups. All statistical inferences were set to have a two-tailed *p*-value < 0.05.

Results

Analysis of sociodemographic characteristics of population at different altitudes

The study included 11,095 individuals with an average age of 48.41 years ± 15.52 years. Individuals were categorized into low (3,901), intermediate (6,273), and high (921) altitude groups. High-risk individuals accounted for 34.8% in low, 58.3% in intermediate, and 6.9% in high altitudes. Biomass fuel use was highest in high altitudes at 0.1%. Significant differences in gender, age, ethnicity, high-risk status, smoking index, and biomass fuel use were observed across the three altitude groups ($P < 0.05$), as shown in Table 1.

Prevalence of COPD in high-risk populations at different altitudes

In the study, out of 11,095 individuals, 2,252 were high-risk and 612 were diagnosed with COPD: 207 at low altitude, 377 at intermediate altitude, and 28 at high altitude. COPD prevalence among high-risk individuals rose with altitude to a peak at intermediate levels, then declined (26.4% low, 28.7% intermediate, 17.9% high, $P < 0.05$). The prevalence of COPD among high-risk population with different characteristics at different altitudes was analyzed.

Table 1 Social demographic characteristics of population at different altitudes

Proportion of participants	Low altitude counties	Intermediate altitude counties	High altitude counties	χ^2 value	*P* for difference
Gender					
Male	1851(47.4)	1747(43.8)	403(43.8)	13.708	< 0.001
Female	2050(52.6)	3526(56.2)	518(56.2)		
Age group					
< 60	2966(76.0)	4615(73.6)	667(72.4)	21.601	< 0.001
60–69	609(15.6)	1032(16.5)	185(20.1)		
≥ 70	326(8.4)	626(10.0)	69(7.5)		
Nationality					
Han nationality	2055(52.7)	5662(90.3)	122(13.2)	3231.722	0.161
Ethnic minorities	1846(47.3)	611(9.7)	799(86.8)		
Marital status					
Unmarried	695(17.8)	1102(17.6)	134(14.5)	5.798	0.055
Married	3206(82.2)	5171(82.4)	787(85.5)		
High-risk population					
No	3118(79.9)	4960(79.1)	765(83.1)	8.104	0.017
Yes	783(20.1)	1313(20.9)	156(16.9)		
Smoking exposure (pack-years)					
0	2673(68.5)	4318(68.8)	613(66.6)	21.614	0.006
1–14.9	380(9.7)	658(10.5)	93(10.1)		
15–29.9	392(10.0)	579(9.2)	75(8.1)		
≥ 30	17(0.4)	25(0.4)	140(15.2)		
Family history of respiratory system diseases					
No	3563(91.3)	5710(91.0)	849(92.2)	1.428	0.490
Yes	338(8.7)	563(9.0)	72(7.8)		
Biomass use					
No	2669(68.4)	4959(79.1)	183(19.9)	1361.273	< 0.001
Yes	1232(31.6)	1314(20.9)	738(80.1)		

In low, intermediate, and high-altitude areas, COPD prevalence among high-risk males was 32.8%, 34.3%, and 23.3%, respectively, significantly higher than among females (15.8%, 17.8%, 7.5%). COPD prevalence was also higher in high-risk individuals aged ≥ 70 years (39.9%, 34.9%, 25.0%) compared to those < 60 years (16.7%, 23.5%, 10.7%), with statistical significance ($P < 0.05$). Among Han individuals, those < 60 years old, and those with junior high school education or above, COPD prevalence in high-risk populations increased then decreased with altitude ($P < 0.05$), as depicted in Fig. 1.

At intermediate and high altitudes, COPD prevalence with central obesity was significantly higher in high-risk groups (36.4% and 28.6%) than in normal patients (24.7% and 12.6%). In the low altitude area, the prevalence rate of high-risk individuals with a smoking index of 15 ~ 29.9 was the highest (31.6%), while that of high-risk individuals with a smoking index of ≥ 30 was 37.6% in the intermediate altitude area. COPD prevalence was higher in individuals without a family history of respiratory diseases at 28.3% in low altitude and 30.1% in intermediate altitude, compared to 18.7% and 22.8% in those with such a history ($P < 0.05$).

In normal weight individuals, COPD prevalence in high-risk populations decreased with altitude. For those with a smoking index of 1-14.9, no family history of respiratory diseases, and no childhood respiratory illnesses, COPD prevalence in high-risk populations rose then fell with increasing altitude ($P < 0.05$), as illustrated in Fig. 2.

Analysis of population characteristics of COPD patients in high-risk populations at different altitudes

COPD patients in high-risk populations were mostly older males with low education and a smoking index ≥ 30 pack-years, with consistent patterns across altitudes. High altitude areas had the highest proportion of ethnic minorities (92.9%) and biomass fuel users (78.6%) among COPD patients in high-risk populations, showing significant differences. Low altitude areas had the highest central obesity rate (68.5%) and the lowest childhood respiratory disease history (3.9%) among COPD patients in high-risk populations, both statistically significant.

Patients in low and mid-altitude areas were more likely to have advanced COPD (GOLD Stages II and III–IV), while those in high altitude areas were mainly in the early GOLD Stage I, indicating a significant statistical difference. High-altitude COPD patients in high-risk populations also had significantly better post-dilatation lung function measures. Cardiovascular diseases were the most common comorbidities across all altitudes, but respiratory-related comorbidities showed significant differences. These findings are detailed in Table 2.

Multivariate analysis of the prevalence of COPD in high-risk populations at different altitudes

Our study began with a univariate analysis, detailed in Supplementary material. Variables with a p-value < 0.10 were selected for multivariate analysis. Model 1, adjusting for gender and age, found COPD prevalence in high altitude areas was 0.538 times that of low altitude areas (OR = 0.538, 95% CI: 0.343–0.844). Model 2, adding adjustments for lifestyle factors like central obesity, smoking index, and biomass fuel use, revealing that the prevalence of COPD in high-risk populations at high altitude was 0.470 times higher than at low altitude (OR = 0.470, 95% CI: 0.289–0.766). Model 3, further adjusting for disease history, including childhood respiratory diseases, family history, cardiovascular and metabolic comorbidities, and total comorbidities, and the results showed that the prevalence of COPD in high altitude was 0.518 times that of low altitude (OR = 0.518, 95% CI: 0.316–0.848). Full results are in Table 3.

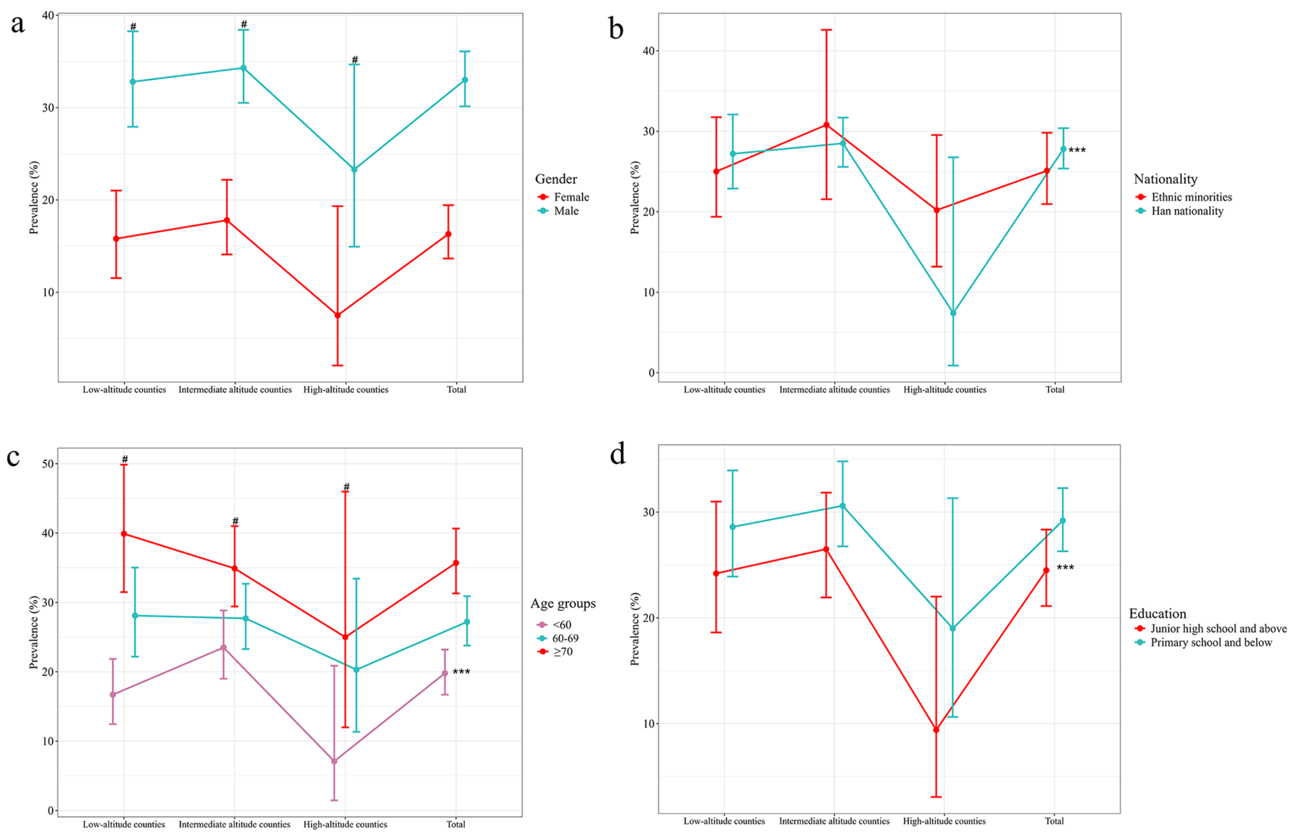

Fig. 1 Prevalence of COPD by different demographic characteristics at different altitudes. (**a**) Stratified by gender. (**b**) Stratified by nationality. (**c**) Stratified by age. (**d**) Stratified by level of education. *** indicated that there was a statistically significant difference in the prevalence of different altitudes in the same population, P<0.05. #indicated that there was a statistically significant differences in the prevalence of different populations in the same altitude, P<0.05.

Discussion

Yunnan Province, situated in southwest China, features a terrain that slopes downward from high northwest to low southeast, with notable altitude differences. Expanding on prior COPD research in the region [7], this study is the first to assess COPD prevalence among high-risk individuals aged ≥ 20 years and to examine patient demographics across varying altitudes in Yunnan.

Most studies utilize population-wide pulmonary function tests to investigate the prevalence of COPD in specific regions, with variations influenced by research methodologies, as well as economic, social, and environmental factors. For example, the China Pulmonary Health study reported a COPD prevalence of 8.6% among individuals aged ≥ 20 years and 13.7% among those aged ≥ 40 years in China [8]. However, the prevalence of COPD varied by geographic region, with the highest prevalence observed in southwest China (20.2%) and the lowest in central China (10.2%) [14]. Furthermore, there are notable variations in the prevalence of COPD across different provinces and cities in China. Among individuals aged 40 and above, the prevalence of COPD was 11.6% in Fujian Province [15], 9.8% in Anhui Province [16], 11.9% in Jiangsu Province [17], 10.6% in Jiangxi Province [18], 17.01% in Kashi, Xinjiang Uygur Autonomous Region [19], and 15.9% in Yinchuan, Ningxia Hui Autonomous Region [20]. Given the uneven economic development across Yunnan Province and the feasibility of screening tools in primary healthcare settings and low-to-middle-income areas [21-23], we employed a combined approach of questionnaire screening and pulmonary function testing. Among the 11,095 individuals aged ≥ 20 years screened, 2,252 (20.30% of total individuals) were identified as high-risk, with 612 (27.18% of high-risk individuals) diagnosed with spirometry-defined COPD. A study from other regions in China, using the COPD-SQ combined with pulmonary function tests, found that 31.59% of high-risk individuals were diagnosed with COPD [24], significantly higher than our findings, likely due to differences in population sampling methods.

The study revealed COPD prevalence rates of 26.4% below 1,500 m, 28.7% between 1,500 and 2,500 m, and 17.9% above 2,500 m. A limited number of previous studies have reported on the prevalence of COPD in different altitude areas. Data from the PREPOCOL-PLATINO-BOLD-EPI-SCAN studies [5] indicated that the

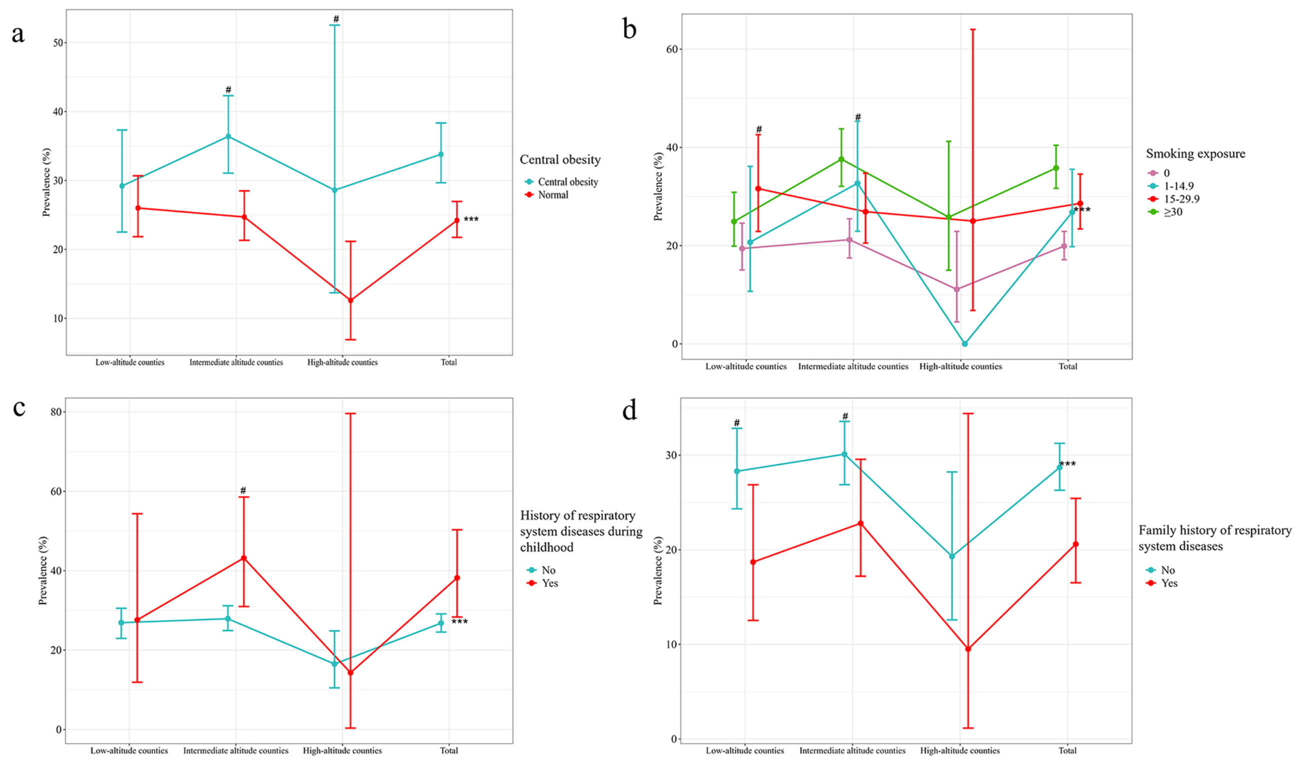

Fig. 2 Prevalence of COPD among Different Behavioral Characteristics and Disease Histories at different altitudes. (**a**) Categorized by Central obesity. (**b**) Classified by Smoking exposure. (**c**) Classified by History of respiratory system diseases during childhood. (**d**) Classified by level of Family history of respiratory system diseases. *** indicated that there was a statistically significant difference in the prevalence of different altitudes in the same population, P<0.05. #indicated that there was a statistically significant differences in the prevalence of different populations in the same altitude, P<0.05.

prevalence in individuals aged ≥ 40 years residing above 1500 m was 8.5%. The PLATINO study [25] reported the prevalence was 7.8% in individuals aged ≥ 40 years in Mexico City (2240 m). In Sichuan's Aba Hongyuan (3500 m), the prevalence was 12.16% in individuals aged ≥ 40 years [26]. In Puno (3825 m), urban and rural populations ≥ 35 years old had prevalences of 6.1% and 9.9%, respectively [27]. Unlike previous studies, this study included individuals aged ≥ 20 years and used a combined questionnaire and pulmonary function test survey method. We also compared low, intermediate, and high altitude areas in Yunnan Province to explore altitude's impact on COPD prevalence.

An intriguing phenomenon observed in this study is the trend of COPD prevalence rates initially increasing and then decreasing with rising altitude. A similar pattern was noted in the PREPOCOL Study [28], which employed a cross-sectional design and random multistage cluster sampling to investigate 5,539 subjects aged 40 and above in five Colombian cities. The study found COPD prevalence rates to be 7.5%, 13.5%, and 8.5% for altitudes below 1500 m, between 1500 and 2500 m, and above 2500 m, respectively. These observations seem to suggest a particular characteristic of areas within the 1500–2500 m range, although the exact reasons remain unclear.

However, at higher altitudes, COPD prevalence shows a continuous decline. A Chinese study involving 4,697 patients aged ≥ 15 years from Xinjiang and Tibet categorized altitude into three bands: 2100–3000 m, 3000–4000 m, and above 4000 m, with prevalence rates of 12.1%, 6.9%, and 5.4%, respectively [29]. This could be linked to pulmonary function adaptations, reduced smoking rates, and lower indoor air pollution at higher altitudes. Due to the limited epidemiological data on high-altitude COPD, further research is needed to understand the relationship between COPD prevalence and altitude and to identify the causes.

The link between high altitude and COPD prevalence is debated. A study, using multifactorial analysis, confirmed high altitude as an independent factor negatively associated with COPD [30], aligning with the PLATINO study's finding of a negative correlation [25]. Another study noted a weak but significant negative correlation [31]. A Chinese research also showed declining COPD prevalence with altitude [29]. High-altitude populations exhibit adaptive lung function changes, such as increased FVC, FEV_1 and tidal volume [32-34], which may contribute to the lower COPD prevalence in these areas.

Table 2 Population characteristics of COPD patients at different altitudes

Factor	Low altitude counties	Intermediate altitude counties	High altitude counties	χ^2/H value	*P* for difference
Gender					
Male	161(77.8)	298(79.0)	24(85.7)	0.943	0.624
Female	46(22.2)	79(21.0)	4(14.3)		
Age group					
< 60	52(25.1)	93(24.7)	3(10.7)	4.228	0.376
60–69	78(37.7)	139(36.9)	15(53.6)		
≥ 70	77(37.2)	145(38.5)	10(35.7)		
Nationality					
Han nationality	140(67.6)	341(90.5)	2(7.1)	132.701	< 0.001
Ethnic minorities	67(32.4)	36(9.5)	26(92.9)		
Marital status					
Unmarried	23(11.1)	57(15.1)	6(21.4)	3.099	0.212
Married	184(88.9)	320(84.9)	22(78.6)		
Education					
Primary school and below	131(67.5)	230(66.5)	15(75.0)	0.643	0.725
Junior high school and above	63(32.5)	116(33.5)	5(25.0)		
Biomass use					
No	126(60.9)	253(67.1)	6(21.4)	23.866	< 0.001
Yes	81(39.1)	124(32.9)	22(78.6)		
Central obesity					
No	64(31.5)	168(47.1)	10(41.7)	12.865	0.002
Yes	139(68.5)	189(52.9)	14(58.3)		
Smoking exposure (pack-years)					
0	68(32.9)	114(30.5)	7(25.0)	9.785	0.134
1 ~ 14.9	12(5.8)	36(9.6)	0(0.0)		
15 ~ 29.9	43(20.8)	59(15.8)	4(14.3)		
≥ 30	84(40.6)	165(44.1)	17(60.7)		
GOLD Stage					
GOLD Stage I	60(29.0)	145(38.5)	20(71.4)	20.388	< 0.001
GOLD Stage II	94(45.4)	151(40.1)	5(17.9)		
GOLD Stage III–IV	53(25.6)	81(21.5)	3(10.7)		
History of respiratory system diseases during childhood					
No	195(96.1)	316(88.5)	23(95.8)	10.025	0.007
Yes	8(3.9)	41(11.5)	1(4.2)		
Family history of respiratory system diseases					
No	178(86.0)	321(85.1)	26(92.9)	1.282	0.527
Yes	29(14.0)	56(14.9)	2(7.1)		
Comorbid cardiovascular disease					
No	148(71.5)	279(74.0)	22(78.6)	0.837	0.658
Yes	59(28.5)	98(26.0)	6(21.4)		
Comorbid respiratory disease					
No	178(86.0)	300(79.6)	26(92.9)	6.011	0.049
Yes	29(14.0)	77(20.4)	2(7.1)		
Comorbid metabolic diseases					
No	181(87.4)	345(91.5)	23(82.1)	4.217	0.121
Yes	26(12.6)	32(8.5)	5(17.9)		
Number of comorbidities					
0	73(35.3)	142(37.7)	12(42.9)	13.336	0.038
1	45(21.7)	71(18.8)	11(39.3)		
2	46(22.2)	66(17.5)	3(10.7)		
≥ 3	43(20.8)	98(26.0)	2(7.1)		

Table 2 (continued)

Factor	Low altitude counties	Intermediate altitude counties	High altitude counties	χ^2/H value	*P* for difference
Post-diastolic FEV_1%pred	66.06(49.71,85.37)	71.80(52.97,90.63)	90.38(71.29,99.56)	14.779	0.001
Post-diastolic FVC%pred	90.28(74.08,107.71)	98.92(80.34,110.97)	90.75(105.20,118.14)	11.756	0.003
Post-diastolic FEV_1/FVC	57.87(49.3,65.34)	59.64(48.19,65.81)	65.44(61.12,68.80)	13.321	0.001
Post-diastolic FVC	2.68(2.17,3.29)	2.96(2.32,3.70)	3.67(2.98,4.05)	23.867	< 0.001
Post-diastolic FEV_1	1.60(1.10, 1.98)	1.68(1.23,2.27)	1.76(2.47,2.72)	25.611	< 0.001

Notes: FEV_1 = Forced Expiratory Volume in one second, FVC = Forced Vital Capacity, FEV_1%pred = FEV_1 Percentage of the actual value to the predicted value, FVC%pred = FVC Percentage of the actual value to the predicted value

Table 3 Multivariate analysis of the prevalence of COPD in high-risk population at different altitudes

	Model 1		Model 2		Model 3	
	OR (95%CI)	***P* for difference**	**OR (95%CI)**	***P* for difference**	**OR (95%CI)**	***P* for difference**
Altitude						
Low altitude areas	Ref.		Ref.		Ref.	
Intermediate altitude areas	1.023(0.833–1.256)	0.830	0.983(0.795–1.215)	0.875	0.912(0.734–1.133)	0.406
High altitude areas	0.538(0.343–0.844)	0.007	0.470(0.289–0.766)	0.002	0.518(0.316–0.848)	0.009

Notes: Data are presented as OR [95% CI]. Model 1 adjusted for gender, age. Model 2 adjusted for gender, age, smoking exposure, central obesity, use of biomass fuels.Model 3 adjusted for gender, age, smoking exposure, central obesity, use of biomass fuels, history of respiratory diseases in childhood, family history of respiratory diseases, coexisting respiratory system diseases, coexisting cardiovascular diseases, coexisting metabolic diseases, and the number of comorbidities

Conversely, the PREPOCOL Study found that high altitude was not a negatively associated factor [28]. A study from Gansu Province, China, identified high altitude as a factor associated with COPD [35]. A meta-analysis also indicated higher COPD prevalence in high-altitude areas, though not as an independent associated factor [6]. Lung function in non-smoking individuals gradually declines, with smoking and childhood lung impairment hastening this decline and raising COPD risk [36-38]. High-altitude populations show a faster rate of lung function decline, potentially due to factors like hypoxia, biomass fuel exposure, and occupational hazards [39, 40]. It is noteworthy that the high-altitude environment itself might also be an important factor affecting the rate of lung function decline [40]. These viewpoints could help explain the higher prevalence of COPD in high-altitude areas found in some studies. However, the link between lung function decline and COPD risk in high-altitude areas needs further research.

In addition to the debate over whether high altitude is an associated or negatively associated factor, a study indicated that after considering individual risk factors, living at high altitude was not associated with differences in COPD prevalence [5]. The reasons for the debate in these studies may be related to different research methodologies, ethnicities, and regions. Therefore, in the future, in addition to conducting in-depth epidemiological studies, it is necessary to carry out studies on the mechanisms of COPD development in high altitude areas to fundamentally explore the relationship between high altitude and COPD prevalence.

In terms of demographic characteristics, COPD patients across all altitude areas were predominantly male, over 60 years old, with low education and high smoking indices, aligning with previous research [8]. This study also found a significant prevalence of COPD among ethnic minorities in high-altitude areas, linked to their predominance there. Notably, biomass fuel use was significantly higher among COPD patients in high altitudes, consistent with the findings from a study in Gansu Province, China [35]. Research from Tibet, China, also found that 88.1% of COPD patients used indoor biomass fuels [41]. The use of coal, wood, and dung for heating and cooking is customary among high-altitude ethnic minorities, leading to increased indoor air pollution and harmful particulate exposure compared to low-altitude areas. Indoor air pollution is a significant public health issue closely related to COPD development [42, 43]. A study identified the highest COPD prevalence and indoor air pollution in high-altitude areas, with a significant, independent correlation between the two [44]. This suggests that indoor air pollution significantly raises COPD incidence in high-altitude populations. Moreover, women, due to prolonged exposure from cooking in poorly ventilated homes, are at a higher risk of COPD from indoor air pollution [29, 45]. It is evident that the issue of indoor air pollution should be given considerable attention, especially at high altitude areas.

This study also found that 10.7% of COPD patients at altitudes above 2000 m were in GOLD Stage III-IV, markedly lower than the 21.5% in 1500–2000 m and 25.6% below 1500 m. Additionally, 71.4% of COPD patients above 2000 m were in GOLD Stage I, indicating less severe lung function impairment. This strengthens the evidence from a different perspective, aligning with this study's conclusion that high altitude is a negatively associated factor for COPD.

This study still has some limitations. Firstly, the use of questionnaires to screen for high-risk populations inevitably omits some COPD patients. Secondly, the number of COPD cases in high-risk individuals at areas with an altitude above 2000 m is relatively small. Lastly, there is a lack of collection of detailed data related to indoor air pollution, which may limit the accuracy of estimation, and we will collect a large number of samples at high altitudes in the future and conduct better representative cohort studies to reduce potential bias and improve the quality of the study. Despite these limitations, this study still indicates that continued attention should be paid to the impact of altitude on COPD, especially the characteristics and influencing factors of COPD in high-altitude areas, to provide a scientific basis for the prevention and treatment strategies of COPD in these regions.

Conclusions

Our study results indicate that the prevalence of COPD in high-risk populations is the lowest in the high-altitude regions of Yunnan Province, and that high altitude is an independent factor negatively associated with COPD. With respect to the demographic characteristics of the COPD patient population, individuals residing in high-altitude regions exhibited a higher prevalence of ethnic minorities and a significant exposure to biomass fuels; however, there was a reduced proportion of patients classified within the more severe GOLD Stage III-IV categories. Additionally, there is a necessity to heighten our focus on the COPD patient population residing in high-altitude area.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12890-025-03565-5.

Supplementary Material 1

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Author contributions

Geyi Wen analyzed and interpreted the data and completed the writing. Jinliang Meng and Huadan Wang organized, analyzed and interpreted the data, and participated in part of the writing. Geyi Wen, Jinliang Meng and Puxian Peng took part in investigation. Yanyan Xu and Ruiqi Wang conducted quality control, collection, collation and analysis of pulmonary function data. Zhengmao Yan, Bangyan Du, Aihan Wen and Guohong Luo cleaned and organized the data. Geyi Wen, Jinliang Meng, Wenlong Cui, Songyuan Tang, and Yunhui Zhang made contributions to conceptualization, participants recruitment, and project management. Songyuan Tang, and Yunhui Zhang guided the methodology and revised the manuscript. All authors have read and approved the final manuscript.

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Data availability

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

Declarations

Ethics approval and consent to participate

The study was conducted in strict accordance with the ethical principles outlined in the Declaration of Helsinki. The study protocol received ethical approval from the Medical Ethics Committee of the First People's Hospital of Yunnan Province (Approval No.: KHLL2022-KY141-C-1). Written informed consent was obtained from all participants prior to their inclusion in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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