ORIGINAL RESEARCH ARTICLE

Behavioral, Environmental, and Socioeconomic Determinants of Chronic Obstructive Pulmonary Disease in a Rural Agricultural Setting: A Case-Control Study in Suphan Buri, Thailand

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ABSTRACT

Background: COPD poses a growing public health burden in Thailand, yet combined personal, behavioral, socioeconomic, and environmental determinants remain insufficiently characterized in agricultural communities. This study conducted to quantify independent factors associated with COPD occurrence among adults in Suphan Buri Province, Thailand.

Methods: A matched case-control study enrolled 114 newly diagnosed COPD cases and 228 frequency-matched controls (1:2 ratio) from district hospitals and community health centers during June-August 2025. COPD was confirmed by post-bronchodilator spirometry (FEV_1/FVC <0.70). A validated structured questionnaire assessed socioeconomic, behavioral, and environmental exposures. Binary logistic regression estimated adjusted odds ratios (aOR) with 95% confidence intervals.

Results: Asthma history showed the strongest association (aOR=9.74; 95%CI: 3.04-31.17), followed by heavy smoking (Brinkman Index ≥400; aOR=5.26), frequent workplace dust/smoke exposure (aOR=4.41), household smoker presence (aOR=4.01), agricultural burning (aOR=3.08), workplace smoking exposure (aOR=2.21), vehicle exhaust (aOR=2.47), and proximity to main roads (aOR=2.26). Higher monthly income was protective (aOR=0.47). Model discrimination was robust (AUC=0.843; overall accuracy=81.3%).

Conclusion: COPD risk in this agricultural population reflects multidomain determinants. Integrated prevention strategies targeting tobacco control, air pollution, socioeconomically vulnerable groups are warranted.

Keywords: Chronic obstructive pulmonary disease, Environmental factors, Smoking, Socioeconomic factors

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major global public health, with chronic airway inflammation and irreversible airflow limitation.[1] Global health authorities recognize COPD among principal mortality causes internationally, with disproportionate death rates observed in nations of limited and moderate economic development.[2]

COPD prevalence is rising in developing countries, including Thailand, driven by aging populations, smoking, and pollution exposure.[3] Disease burden studies show that COPD affects substantial adult populations, creating significant health and economic burdens.[4] In 2021, the South-East Asia Region reported 50.1 million COPD cases (Prevalence 2.49%) and 1.24 million COPD-related deaths. Thailand accounted for 1.78 million cases (Prevalence 2.74%) and 18,478 deaths that year, reflecting substantial national burden.[5]

Cigarette smoking is the most important modifiable risk factor for COPD and has been consistently associated with a substantially increased risk of COPD.[1,3] Evidence now indicates non-smokers account for up to 29% of COPD cases, with critical risk factors including childhood respiratory infection, biomass smoke, and household smoke exposure. Additionally, rural residence and occupational dust or agricultural work significantly elevates disease risk.[6-8] In addition, environmental and socioeconomic factors further influence COPD occurrence, including low socioeconomic status, agricultural burning, industrial activities, and residential proximity to major roads.[9-10] Previous studies have underscored the importance of socioeconomic, behavioral, and environmental contexts in COPD and respiratory health outcomes. Indoor environmental exposures have been associated with COPD.[1,11] while more recent evidence has demonstrated strong associations between smoking and COPD prevalence, highlighting the contribution of behavioral determinants to disease risk.[12] Nevertheless, existing studies have largely focused on individual exposure domains or clinical characteristics, with limited evidence on the combined effects of personal, socioeconomic, behavioral, occupational, and environmental determinants. Suphan Buri Province is a predominantly agricultural area characterized by frequent open field burning and high traffic density, resulting in elevated exposure to ambient air pollution. However, few studies have examined how these risk factors interact in rural Thailand's agricultural communities. This study drew on the World Health Organization (WHO) social determinants of health framework[2] and the Global Initiative for Chronic Obstructive Lung Disease (GOLD) model[1], which recognize COPD as a complex disease shaped by health history, smoking behavioral, socioeconomic status, and environmental exposures.

Accordingly, this study aimed to quantify the independent associations of personal health history, socioeconomic status, tobacco exposure, and environmental pollutant exposure with COPD occurrence among adults in Suphan Buri Province, Thailand, using a matched case-control design.

METHODOLOGY

A case-control design was employed to determine factors related to COPD in Suphan Buri Province, Thailand. The study population consisted of individuals aged 20 years and above who resided in Suphan Buri Province, Thailand, to account for early exposure to behavioral and environmental risk factors that may contribute to COPD development later in life. Participants were divided into two groups: cases and controls. Cases comprised newly diagnosed COPD patients identified from hospital registries of district hospitals (secondary care level) and affiliated sub-district health promoting hospitals (primary care level) in Suphan Buri Province between January and December 2024. These facilities provide healthcare services to residents within defined catchment areas across the district and surrounding communities. Controls comprised individuals from identical villages without COPD diagnosis history. COPD diagnosis was confirmed using GOLD criteria based on post-bronchodilator spirometry showing forced expiratory volume in one second to forced vital capacity ratio (FEV_1/FVC) <0.70 in hospital records.

Sample size was calculated using the Kelsey formula for unmatched case-control studies, with parameters from a prior study[13]: among controls, 18 of 56 were smokers (p_0=32.1%) and OR=5.13 for smokers versus non-smokers. Case exposure prevalence (p_1) was derived using $p_1 = (OR \times p_0)/(1 - p_0 + OR \times p_0)$. We set α=0.05, 90% power, and 1:2 case to control ratio. The minimum required sample was 25 cases and 50 controls. We used 1:2 ratio to balance statistical power with feasibility, as additional controls beyond this add minimal power while substantially increasing field work demands. The calculated sample size represented the minimum required number of participants to detect the expected association with 90% power. In this community-based study, all eligible participants identified during the study period were included rather than stopping recruitment at the minimum number. Therefore, the final sample (114 cases and 228 controls) exceeded the required size, which improves statistical precision.

Cases included all eligible newly diagnosed COPD patients, and controls were selected through systematic random sampling from village population registries within identical communities and frequency matched by sex and age (±5 years).

Eligibility criteria: Participants were required to be aged 20 years or older and to have resided in Suphan Buri Province for at least one year, alongside willingness to participate voluntarily and ability to complete the questionnaire. Cases were individuals new-

ly diagnosed with COPD in 2024 according to GOLD criteria, while controls had no prior COPD diagnosis and were frequency matched to cases by sex and age within five years. Individuals with severe illness or psychiatric disorders, as well as those unable to communicate clearly or provide complete information, were excluded from both groups.

Research instrument: A structured questionnaire was specifically designed by the researcher to obtain information from both case and control participants. Its content and structure were formulated according to the conceptual framework on COPD outlined by WHO[2] and the risk factor classification system recommended by the GOLD.[1] Relevant literature from both domestic and international sources was reviewed to ensure content validity. The questionnaire consisted of four sections with a total of 45 items, as follows:

Section 1: Personal and general health information incorporated demographic and health-associated variables including age, sex, marital status, education, asthma history, pulmonary tuberculosis, childhood respiratory infections, and family history of COPD. This section comprised 8 closed-ended questions.

Section 2: Socioeconomic factors included occupation and average monthly income (2 items), presented as a checklist format.

Section 3: Health behavior variables encompassed smoking patterns, smoking duration in years, daily cigarette quantity, engagement in outdoor physical activity, and utilization of personal protective equipment (5 items). The questions employed a three-point ordinal scale yielding numerical responses. The Brinkman Index (BI) was calculated by multiplying daily cigarette quantity by total smoking years. BI values were subsequently categorized into two groups, light (BI < 400) and heavy (BI ≥ 400).[14]

Section 4: Environmental and housing factors included exposure to household and workplace smokers, vehicle exhaust, workplace dust or smoke, agricultural burning, chemical fumes, type of cooking fuel, air conditioning, and residential proximity to industrial areas and major roads. This section comprised 12 closed-ended questions. Environmental exposure was assessed using predefined frequency categories: vehicle exhaust, workplace dust or smoke, and chemical fumes were measured weekly, whereas agricultural burning and other air pollutants were assessed using monthly to weekly categories.

Validity and reliability testing: Content validity assessment of the questionnaire was conducted by a multidisciplinary expert panel comprising a physician, a registered nurse, and a public health officer. They assessed each item for its clarity, relevance, and consistency with the study's objectives. The Index of Item-Objective Congruence (IOC) scores ranged between 0.67 and 1.00, confirming acceptable content validity.

A pilot investigation was subsequently implemented among 30 individuals from neighboring communities who shared comparable demographic and socioeconomic characteristics with the investigation population. The instrument showed good reliability with a Cronbach's alpha coefficient of 0.87.

Data collection procedures: Ethical approval received authorization from the University of Phayao Human Ethics Committee (HREC-UP-HSST 1.2/114/68) on May 29, 2025, prior to data collection. Data collection occurred between June and August 2025. The process comprised the following steps.

1. Coordination with local health agencies: The researcher collaborated with hospitals and sub-district health promoting hospitals in Suphan Buri Province to secure official authorization and retrieve the listing of newly diagnosed COPD patients from hospital databases.

2. Training of data collectors: Enumerators received training on the study objectives, interview techniques, research ethics, and appropriate data recording procedures to guarantee consistency and quality of data collection.

3. Participant recruitment: Selected participants were contacted by data collectors who explained the study's purpose, procedures, participants' rights to withdraw, and confidentiality protections. All participants furnished written informed consent before participation in the interview.

4. Field data collection: Data collection was conducted through in person interviews using a validated questionnaire. Each interview took approximately 10-20 minutes. Interviewers read each question aloud and recorded the participants' responses directly.

5. Data verification and security: Researchers reviewed finished questionnaires to ensure they were complete and accuracy. All documents and electronic files were securely stored with restricted access to maintain data confidentiality.

The research team addressed potential bias sources throughout the design and execution phases. Differential recall of historical exposures between case and control groups may have introduced recall bias. To minimize this, standardized questionnaires were used and interviews were conducted by trained data collectors following uniform procedures. Selection bias was reduced by recruiting controls from the same communities as cases and applying frequency matching by sex and age. Information bias related to self-reported exposure data was addressed through structured questions with predefined response categories to improve consistency and reduce misclassification.

Data analysis: Descriptive statistics (frequencies, percentages, means, standard deviations) summarized participant characteristics across demographic, socioeconomic, behavioral, and environmental domains. Inferential statistics evaluated relationships between predictor variables and COPD incidence at a significance level of $p < 0.05$. Variables that demonstrated significant associations in bivariate analysis were subsequently incorporated in a binary logistic regression model to estimate adjusted odds ratios (aORs) and 95% confidence intervals (95%CI). Multicollinearity among predictor variables received examination using the condition index (< 30) and inter-parameter correlation coefficients (<0.7).[15] The model's goodness of fit received evaluation using the Hosmer-Lemeshow test, and predictive performance received assessment based on overall classification accuracy.

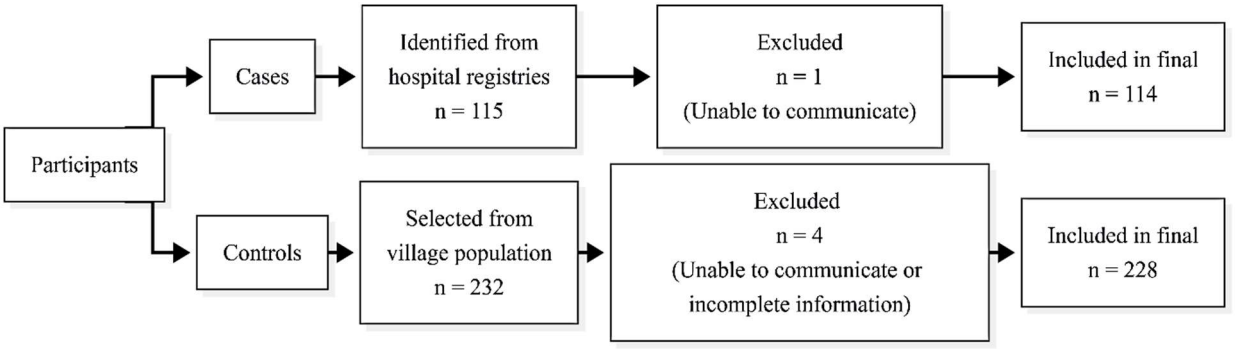

Figure 1: Participant flow diagram

RESULTS

The final study population consisted of 114 COPD cases and 228 controls. Hospital registries initially identified 115 COPD cases, from which one individual was excluded due to being unable to communicate. Village population registries provided 232 potential controls, from which four participants were excluded either because of being unable to communicate or incomplete information. The recruitment flowchart is provided in Figure 1.

Baseline characteristics of the participants: Table 1 presents the baseline characteristics of cases and controls. Most participants were male (73.7%) and aged ≥40 years. The mean age was 62.20 ± 11.00 years among cases and 62.00 ± 11.50 years among controls, reflecting the frequency matching by age and sex. The majority were married and had completed secondary education or lower.

Table 1: Descriptive characteristics of the participants

Factor	Case (n=114) (%)	Control (n=228) (%)
Sex		
Male	84 (73.68)	168 (73.68)
Female	30 (26.32)	60 (26.32)
Age		
< 40 years	4 (3.51)	7 (3.07)
≥ 40 years	110 (96.49)	221 (96.93)
Marital status		
Single	9 (7.89)	22 (9.65)
Married	87 (76.32)	158 (69.3)
Widowed/Divorced/ Separated	18 (15.79)	48 (21.05)
Education level		
Below secondary	39 (34.21)	87 (38.16)
Secondary or higher	75 (65.79)	141 (61.84)

Socioeconomic, Behavioral, and Environmental Factors: Descriptive comparisons showed that asthma history was more prevalent among cases than controls. Cases similarly demonstrated higher frequencies of reduced monthly income, current or previous tobacco use, and elevated cumulative smoking burden. Household and workplace smoke exposure were more frequently reported among cases. Environmental exposures including frequent vehicle exhaust, workplace dust or smoke, agricultural burning, and living close to a main road (≤50 meters) were reported more often among cases. Detailed distributions are presented in Table 2.

Factors associated with chronic obstructive pulmonary disease: Table 2 demonstrates bivariate relationships between various risk determinants and chronic obstructive pulmonary disease occurrence, assessed through Chi-square statistical testing. The associations between examined variables are presented in Table 2. A monthly income below 10,000 Baht was significantly associated with COPD ($p = 0.001$), and asthma history showed a strong associated with COPD ($p < 0.001$). Smoking behavior was significantly associated with COPD ($p < 0.001$), particularly among heavy smokers (Brinkman Index ≥ 400; $p < 0.001$). Household and workplace smoke exposure was also associated with COPD, as participants living with household smokers ($p < 0.001$) or working in environments with smokers ($p = 0.001$) had higher odds of developing COPD. Environmental exposures, including frequent exposure to vehicle exhaust ($p = 0.001$), workplace dust or smoke ($p < 0.001$), and agricultural burning ($p < 0.001$), and living close to a main road (≤50 meters) ($p < 0.001$), were significantly associated with COPD. Other variables, including sex, age, marital status, education, occupation, pulmonary tuberculosis, childhood respiratory infection, family history of COPD, protective

equipment use, physical activity, chemical fumes exposure, cooking fuel type, air conditioner installation, and proximity to factory or rice mill, were not statistically significant ($p > 0.05$). Subsequently, variables achieving bivariate significance underwent incorporation into multivariable logistic regression modeling for adjusted effect estimation.

Table 3 presents the results of the multivariable binary logistic regression analysis examining factors independently linked to COPD. Following adjustment for potential confounders, multiple predictors retained independent significance. Medical history revealed that asthma history demonstrated the strongest association (aOR = 9.74, 95% CI: 3.04-31.17, $p < 0.001$).

Table 2: Bivariate analysis of factors associated with chronic obstructive pulmonary disease

Factor	Case (n=114)(%)	Control (n=228)(%)	χ^2	p-value
Sociodemographic factors				
Occupation				
Non-risk occupation	95 (83.33)	192 (84.21)	0.043	0.835
High-risk occupation	19 (16.67)	36 (15.79)		
Monthly income (Baht)				
<10,000	72 (63.16)	102 (44.74)	10.319	0.001
≥10,000	42 (36.84)	126 (55.26)		
Asthma history	23 (20.18)	5 (2.19)	32.695	<0.001
Pulmonary tuberculosis	1 (0.88)	4 (1.75)	0.406	0.524
Childhood respiratory infection	1 (0.88)	5 (2.19)	0.763	0.668
Family history of COPD	2 (1.75)	5 (2.19)	2.537	0.111
Behavioral factors				
Smoking status				
Never	39 (34.21)	156 (68.42)	34.516	<0.001
Current/Former	75 (65.79)	72 (31.58)		
Smoking duration (Year)				
<20	40 (35.09)	158 (69.3)	34.708	<0.001
≥20	74 (64.91)	70 (30.7)		
Cigarettes per day				
<5	39 (34.21)	169 (74.12)	58.505	<0.001
≥5	75 (65.79)	59 (25.88)		
Brinkman Index (BI)				
light (BI < 400)	72 (63.16)	204 (89.47)	33.794	<0.001
Heavy (BI ≥ 400)	42 (36.84)	24 (10.53)		
Use of protective equipment				
Never-Sometimes	91 (74.56)	179 (78.51)	0.079	0.778
Regular	23 (20.18)	49 (21.49)		
Outdoor exercise				
Never-Sometimes	105 (92.11)	214 (93.86)	0.373	0.541
Regular	9 (7.89)	14 (6.14)		
Environmental factors				
Household smoker	47 (41.23)	35 (15.35)	27.92	<0.001
Smokers in the workplace	38 (33.33)	41 (17.98)	10.082	0.001
Exposure to vehicle exhaust				
Never-Sometimes	93 (81.58)	212 (92.98)	10.243	0.001
Frequent	21 (18.42)	16 (7.02)		
Exposure to workplace dust/smoke				
Never-Sometimes	85 (74.56)	209 (91.67)	18.43	<0.001
Frequent	29 (25.44)	19 (8.33)		
Exposure to Chemical fumes	4 (3.51)	6 (2.63)	0.206	0.65
No	110 (96.49)	222 (97.37)		
Exposure to agricultural burning				
Never-Sometimes	88 (77.19)	211 (92.54)	16.293	<0.001
Frequent	26 (22.81)	17 (7.46)		
Cooking fuel type				
Electric/Gas stove	89 (78.07)	188 (82.46)	0.95	0.33
Charcoal/Wood stove	25 (21.93)	40 (17.54)		
Air conditioner in household	57 (50)	118 (51.75)	0.094	0.76
Distance from home to main road				
≤50 m	73 (64.04)	99 (43.42)	12.919	<0.001
>50 m	41 (35.96)	129 (56.58)		
Proximity to factory/rice mill				
> 5 km / none	81 (71.05)	155 (67.98)	0.335	0.563
≤ 5 km	33 (28.95)	73 (32.02)		

Note: High-risk occupation includes construction workers, welders, painters, and carpenters.

Table 3: Binary logistic regression analysis of factors associated with chronic obstructive pulmonary disease

Factor	cOR	95%CI	p-value	aOR	95%CI	p-value
Monthly income ≥10,000 Baht (X1)	0.47	0.30-0.74	0.001	0.47	0.27-0.84	0.010
Asthma History (X2)	11.27	4.16-30.56	<0.001	9.74	3.04-31.17	<0.001
Brinkman Index ≥ 400 (X3)	4.96	2.81-8.76	<0.001	5.26	2.63-10.51	<0.001
Household smoker (X4)	3.87	2.30-6.50	<0.001	4.01	2.11-7.62	<0.001
Smokers in the workplace (X5)	2.28	1.36-3.82	0.002	2.21	1.17-4.16	0.014
Distance from home to main road <50 m (X6)	2.32	1.46-3.69	<0.001	2.26	1.27-4.03	0.006
Frequent exposure to vehicle exhaust (X7)	2.99	1.49-5.99	0.002	2.47	1.01-6.04	0.047
Frequent exposure to workplace dust/smoke (X8)	3.75	1.99-7.05	<0.001	4.41	2.02-9.63	<0.001
Frequent exposure to agricultural burning (X9)	3.67	1.89-7.09	<0.001	3.08	1.33-7.13	0.009

Note: cOR = Crude odds ratio; aOR = adjusted odds ratio; CI = confidence interval.

Heavy smokers (Brinkman Index ≥ 400) exhibited substantial independent prediction of COPD (aOR = 5.26, 95% CI: 2.63-10.52, p < 0.001). Secondhand smoke exposure manifested through two distinct pathways. Household smoker presence yielded elevated disease odds (aOR = 4.01, 95% CI: 2.11-7.62, p < 0.001), while smokers in the workplace similarly increased disease likelihood (aOR = 2.21, 95% CI: 1.17-4.16, p = 0.014). Environmental determinants demonstrated multiple significant pathways. Frequent exposure to workplace dust/smoke exhibited pronounced association (aOR = 4.41, 95% CI: 2.02-9.63, p < 0.001). Frequent exposure to agricultural burning similarly predicted disease (aOR = 3.08, 95% CI: 1.33-7.13, p = 0.009). Frequent exposure to vehicle exhaust showed independent relationship (aOR = 2.47, 95% CI: 1.01-6.04, p = 0.047). Geographic proximity, living close to a main road (≤50 meters), independently increased odds (aOR = 2.26, 95% CI: 1.27-4.03, p = 0.006). Economic circumstances revealed protective effects, whereby Monthly income ≥10,000 Baht inversely associated with COPD (aOR = 0.47, 95% CI: 0.27-0.84, p = 0.010). Statistical diagnostics validated model adequacy. The Hosmer-Lemeshow goodness of fit test indicated acceptable calibration (χ^2 = 11.164, df = 8, p = 0.193). The Nagelkerke R^2 achieved 0.542, denoting explained variance proportion in COPD occurrence. Multicollinearity diagnostics revealed no problematic collinearity among predictor variables, with highest inter-parameter correlation coefficient at 0.1, supporting multicollinearity absence. Discriminatory performance achieved robust levels, evidenced by area under the receiver operating characteristic (ROC) curve (AUC) of 0.843 (95% CI: 0.80-0.89; p < 0.001). Applying probability threshold of 0.5, sensitivity reached 65.6% and specificity 92.1%, respectively, producing overall classification accuracy of 81.3%.

DISCUSSION

This investigation identified factors associated with COPD, including low incomes, asthma history, heavy smokers, secondhand smoke exposure, and environmental air pollutants. These findings align with global evidence indicating that personal behaviors and environmental conditions, along with socioeconomic factors, interact to determine COPD risk.[16-17]

Smoking behavior was associated with the development of COPD[1,3], consistent with global evidence demonstrating the cumulative effects of prolonged tobacco exposure on airway inflammation and lung function decline. Participants with heavy smoking exposure (Brinkman Index ≥ 400) showed reduced peak expiratory flow rate, emphasizing the cumulative effect of prolonged cigarette smoke exposure on lung function deterioration.[18] In addition, exposure to secondhand smoke in both domestic and occupational environments significantly increased COPD risk, particularly among non-smokers.[19]

Asthma history was the strongest predictor in the multivariable model. In this investigation, asthma was defined based on self-reported prior physician diagnosis and was analyzed as a concurrent condition among COPD cases. Therefore, asthma-COPD overlap may be present in some cases and cannot be entirely excluded. This strong association likely occurs because asthma and COPD share similar clinical and biological characteristics.[20] Nevertheless, prior research has demonstrated that long-standing asthma is associated with accelerated lung function decline and may increase the risk of persistent airflow limitation later in life.[21] Thus, the strong association observed in this study likely reflects both shared pathophysiological mechanisms and potential disease overlap.

Environmental exposures were critical determinants of COPD, highlighting the contribution of ambient and occupational air pollution, particularly in agricultural and traffic-dense settings. Frequent exposure to vehicle exhaust and living close to a main road were both significantly associated with COPD occurrence, consistent with evidence indicating that traffic-related air pollution elevates the incidence of chronic respiratory diseases.[22] Similarly, workplace exposure to dust or smoke was strongly linked to increased COPD risk, particularly among individuals engaged in occupations involving combustion or fine particulate matter.[23] Agricultural burning smoke also increased COPD risk, contributing to oxidative stress and pulmonary inflammation, in agreement with findings from Thailand and other Southeast Asian countries.[24]

In terms of socioeconomic determinants, participants with a monthly income below 10,000 Baht

were significantly more likely to develop COPD than those with higher incomes. This finding supports previous studies indicating that low socioeconomic status is independently associated with higher COPD prevalence, potentially reflecting unequal exposure to environmental hazards and healthcare barriers.[11]

The logistic regression model demonstrated good discrimination and calibration. Nagelkerke R^2 was 0.542, indicating substantial explanatory power. This performance is comparable to previously published COPD risk prediction models.[25] Discriminatory performance was excellent (AUC = 0.843, 95% CI: 0.80-0.89), consistent with recently published COPD prediction tools (AUC = 0.84-0.91).[25] At a probability threshold of 0.5, the model achieved 81.3% overall accuracy, with sensitivity of 65.6% and specificity of 92.1%, demonstrating strong capability for identifying COPD in at-risk populations. Consequently, this matched case-control investigation furnishes contextually relevant evidence for analogous agricultural populations in resource-limited settings

Limitations

The present investigation encounters certain methodological constraints. First, recall bias may have occurred, as individuals with COPD may have differentially reported past exposures compared with controls, potentially inflating the observed associations. Second, due to the case-control design, temporal relationships between cumulative exposures and disease onset cannot be definitively established. Third, several exposure variables were self-reported and may be subject to misclassification, resulting in potential information bias. Fourth, hospital-based case identification may have introduced selection bias by preferentially including more severe cases, thereby underrepresenting milder or undiagnosed cases in the community. Finally, residual confounding cannot be excluded, as certain variables such as body mass index and detailed lifetime occupational history were not included in the final model.

Conclusion

The present investigation revealed multiple interconnected personal, behavioral, and environmental determinants linked to COPD in Suphan Buri Province. An asthma history, heavy smokers, secondhand smoke exposure, vehicle exhaust exposure, occupational dust exposure, agricultural burning, and residence near major roads were significantly associated with increased COPD risk, whereas higher income was associated with reduced COPD risk. The statistical model demonstrated good performance, suggesting that these determinants collectively contribute to COPD occurrence in this population.

These findings support the need for integrated prevention strategies targeting tobacco exposure, air pollution control, and health promotion among socioeconomically vulnerable groups and individuals with asthma. In particular, targeted COPD screening and preventive interventions should be prioritized for low-income populations through primary healthcare and community-based services.

However, as with all case-control studies, causal inference cannot be established, and prospective cohort studies are needed to confirm the temporal relationships of these associations.

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Individual Authors' Contributions: MP contributed to conceptualization, data collection, and manuscript writing. **PJ** performed the statistical analysis, supervised the study, and conducted the final revision of the manuscript. **WP** and **SL** contributed to validation and review.

Availability of Data: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Non-use of Generative AI Tools: This article was prepared without the use of generative AI tools for content creation, analysis, or data generation. All findings and interpretations are based solely on the authors' independent work and expertise.

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