REVIEW ARTICLE

Prevalence and Risk Factors of COPD: A Scoping Review From 2011 to 2021

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ABSTRACT

The aim of this review was to document the recently reported prevalence and risk factors for chronic obstructive pulmonary disease (COPD) in the last ten years. A scoping review of studies released between 2011 and 2021 was done. The main findings on selected studies' prevalence and risk factors were summarised. Thirty-seven studies in total were chosen. The overall data on COPD prevalence was 1.3-36.7%, and the average incidence rate was 9.1%. The risk factors of COPD prevalence were identified as unchangeable risk factors (gender, age, family history of respiratory and cardiovascular disease, high blood pressure, and environmental temperature and humidity) and changeable risk factors (outdoor and indoor air pollution, cigarette smoking, occupational exposure, low education, low household income, obesity, underweight, physical inactivity, and cooking method). The highest changeable risk factors were cigarette smoking, indoor air pollution, and occupational exposure. In contrast, the lowest changeable risk factors were physical inactivity and cooking methods. Changeable risk factors significantly increase COPD risks. The COPD caused by household emissions from biofuel cooking in low-income rural areas deserves attention. Emphasis on healthy lifestyle interventions and economic and educational policies to reduce environmental impacts may prevent COPD.
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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is one of the most popular chronic respiratory diseases caused by lung parenchyma and chronic inflammation of the airways (1). COPD affects roughly 10% of the global population and is growing in Prevalence annually, with an increasing burden on health care costs (2,3). COPD is currently the third leading cause of death and 90% of COPD deaths occur in low-and middle-income countries (LMICs) (4). COPD will continue to be a significant healthcare issue for decades because the number of cases and deaths is expected to rise further, especially in developing nations. It has been reported recently that environmental risk factors are significantly linked with hospital admissions for worsening COPD (5).

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) (6) defines COPD as chronic respiratory symptoms (dyspnea, cough, sputum production) due to abnormalities of the airways (bronchitis, bronchiolitis) and/or alveoli (emphysema) that cause persistent, often progressive, airflow obstruction. Although COPD is a widespread, preventable and treatable disease, the restricted airflow cannot completely be reversed. The restricted airflow may cause shortness of breath and significant systemic inflammation of the lungs, subsequently causing a high rate of hospitalisation and mortality (7).

The complicated reaction between the environment and the lifestyle has been widely reported to influence COPD (8-10). Lifestyles may play an important role in changing the risk of COPD following exposure to environmental particles (11). The most frequently acknowledged risk factor for COPD is cigarette smoking. (12-14). However, occupational exposures, including inorganic and organic dust, fumes and chemical agents, were less widely reported risk factors for COPD (15). Coal, crop residues, wood and animal dung, typically burned in open flames or on inefficient stoves, may lead to a very high risk of indoor air pollution (16-21). Wood, animal dung, crop residues, and coal, typically burned in open fires or poorly functioning stoves, may lead to very high levels of indoor air pollution (16-21). There is mounting evidence that, in many developing nations, exposure to indoor biomass from conventional cooking fuels may increase the risk of women developing COPD. (22,23).

Although urbanisation is increasing, in some rural areas of underdeveloped countries (South Asia, South East Asia, Africa, South America), biofuels such as wood, cow dung and crop straw are still the main cooking fuels, mainly due to: 1) inaccessibility of natural gas equipment due to the remoteness of the area; 2) poverty and inability to afford the cost of gas and natural gas; 3) it is difficult to change the view of being used for cooking with surrounding biofuels for a time. A cross-regional study in 2016 showed that patients with COPD had their symptoms aggravated in Beijing with frequent smog in winter due to low air pressure, strong inversion, weak wind speed, and high humidity, while the symptoms of COPD were significantly reduced in Hainan with better air quality (24).

According to McCormack et al. (25), high indoor temperatures worsen COPD, especially in homes with high levels of air pollutants. Older adults are especially susceptible to heat and are more likely to pass away or end up in the hospital during heat waves. Higher indoor temperatures were amplified by high NO_2 and $PM_{2.5}$ concentrations. With a 10°C rise in temperature, symptoms worsened in a home with $PM_{2.5}$ levels in the 75th percentile. In contrast, there was barely any increase in a home with $PM_{2.5}$ levels in the 25th percentile (25). In these previous reports, environmental factors were positively related to COPD and were included in the GOLD in 2023 (6). There is a need for current data on the risk and prevalence in the current period of increasing urbanisation and development. Although the risks of COPD are well-known with many articles published, to the best of our knowledge, this is the first scoping review to report on COPD's prevalence and risk factors from a global perspective in the last ten years. Hence, the data from this scoping review provides present-day evidence to understand the current knowledge of COPD's prevalence and main risk factors.

METHODOLOGY

This scoping review summarises the findings on the currently available evidence on COPD prevalence and risk factors in the last ten years. This scoping review comprehensively covers the relevant and up-to-date literature on the prevalence and risk factors of COPD, attempting to increase awareness of the burden of COPD. This scoping review followed the methodology outlined by Arksey and O'Malley (26). It included five steps: identifying the research questions, locating pertinent studies, selecting the studies, charting the data, and compiling, summarising, and reporting the findings.

Choosing the research inquiries

The review questions were: (1) What is the prevalence of COPD worldwide in the last ten years?; (2) What are the risk factors associated with COPD in the last ten years?

Search strategy

A search in the electronic databases (PubMed, Scopus, Science Direct, Ebscohost, SPORTDiscus, ProQuest) was conducted. The search was conducted comprehensively on this topic from 1st January 2011 to 30th September 2021. The key terms used for searching articles from the databases are presented in Table I.

Table I: The searched key terms used in the scoping review

Key terms
(COPD OR Chronic Obstructive Pulmonary Disease) AND "Prevalence" AND "Risk Factor"
"COPD" OR "Chronic Obstructive Pulmonary Disease" AND (Incidence OR Occurrence) AND "Risk Factor"
(COPD OR Chronic Obstructive Pulmonary Disease) AND Environmental Risk Factor (Temperature OR Humidity)

Study selection

Only publications from the previous ten years (1st January 2011 to 31st September 2021) were included in the literature search to reflect the recent trends and advancements on the topic of interest. After careful consideration, the identified studies were selected and included in this review if they contained information about: (1) COPD or Chronic Obstructive Pulmonary Disease; (2) prevalence; (3) risk factors (i.e. air pollutants, cigarette smoking, dust, chemicals, fumes, environmental temperature, humidity). Only original studies such as cross-sectional surveys, cohort studies, and retrospective analyses were included in this review. Meta-analyses, meta-syntheses, systematic reviews, narrative reviews, scoping reviews, rapid reviews, critical reviews, and integrative reviews were excluded. Citations retrieved from the initial database search were also excluded: abstracts, conference proceedings, editorials, letters to editors, research letters, short communication, and opinion articles.

Data extraction

After independent examination of the two reviewers' titles, abstracts, and keywords according to the study selection (inclusion and exclusion) criteria, the papers were subjected to full-text screening. A total of 37 studies from 4019 studies were screened and selected for this review. A third reviewer resolved any disagreements. The country or region (-ies or -s), author(s), year of publication, method(s) and the number of participants, outcome measure(s), and the main findings on prevalence and risk factors are summarised.

RESULTS

Four thousand nineteen titles were chosen and screened during the study. Based on Fig.1, 37 articles were identified and included at this review's final stage of the screening procedure. This evidence on the prevalence and risk factors of COPD patients were identified in countries from 5 continents and 26 countries, including Asia (China, Thailand, Iran, Bangladesh, Ukraine, Kazakhstan, Azerbaijan, Korea, Taiwan, Kyrgyzstan, India, and Turkey), Europe (France, Sweden, Finland, Denmark, and Spain), Africa (Uganda and Tanzania), North America (The United States and Canada), and South America (Brazil, Peru, Argentina, Chile and Uruguay). The latest reports on prevalence and risk factors for COPD were published in Canada and China in 2021 (27,28), which explored the prevalence and risk factors among different urban cities in Canada and the prevalence and risk factors in the national minority in poverty areas of Western China, respectively. The majority of this research was cross-sectional survey studies (27 studies, 72.9 %), while the others were retrospective studies (8 studies, 21.6%) and prospective observation studies (2 studies, 5.5%). The number of people involved in the research ranged from 84 to 106,136,000, aged between 15 and 85 years. The extracted data on COPD's prevalence and risk factors is summarised in Table II.

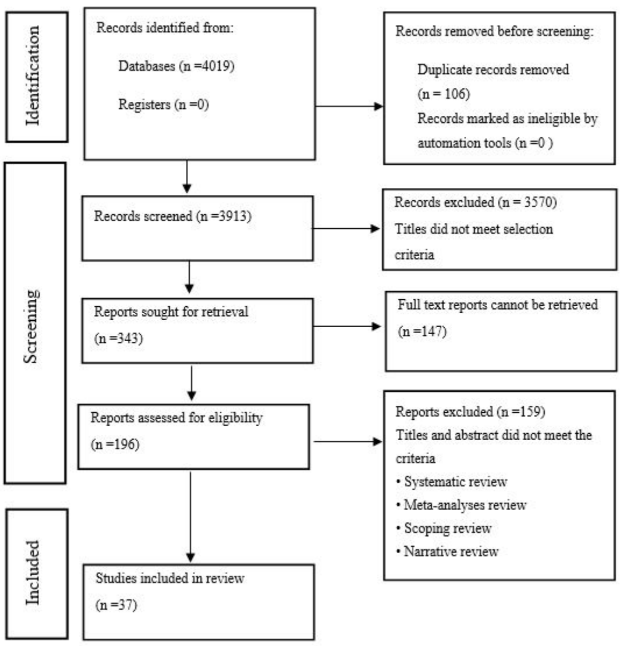

Figure 1: PRISMA flow diagram on the outcomes of the search strategy

Prevalence of COPD

The prevalence of COPD rates ranged from 1.3% to 36.7% across different countries and regions, and the average incidence rate was 9.1%. Overall, developing countries had a higher incidence of COPD than developed countries. Men were more likely to develop COPD than women, and the incidence rate was higher in rural areas than in cities. In direct proportion to age increase, COPD incidence and complications both rose. In this review, the risk factors of COPD were divided into unchangeable risk factors and changeable risk factors. Unchangeable risk factors are gender, age, family history of respiratory disease, high blood pressure and cardiovascular disease. In contrast, the changeable risk factors included occupational exposure, air pollution (indoor and outdoor), lower education, cigarette smoking, obesity, underweight and physical inactivity.

Unchangeable risk factors of COPD

Age

The association between age and COPD prevalence was examined in eight studies (17,18, 27, 28, 30, 38, 46, 51). The lung function is reduced with age (57). Hence, COPD is more prevalent in the elderly. One study demonstrated that risk factors for COPD prevalence vary between participants aged ≤40 and ≥40 years old. With advancing age, the prevalence of COPD significantly rises (33). Two studies reported that patients aged more than 60 years old had a significantly higher incidence of COPD (30, 51). According to Alam et al. (58), people aged 50 to 59 and 60 to 69 had a two- and five-fold higher risk of developing COPD than those aged 40 to 49.

Gender

There was a significant relationship between gender and smoking; men were more likely than women to have COPD, with the men's smoking rate higher than that of women. Three studies have found that men smoked far more than women, leading to a higher prevalence of COPD in men (18, 46, 59).

Family history of respiratory disease and other medical conditions

Independent risk factors for COPD refer to patients with a history of respiratory disease, including chronic cough, asthma, pneumonia, and tuberculosis (20, 27, 33, 56). COPD impairs respiratory function, causing increased susceptibility to pneumonia. Guo et al. (33) confirmed that, compared to younger COPD patients, there was a stronger correlation between a history of tuberculosis and COPD in older patients. Family history of lung disease was related to COPD's increased prevalence (12, 34). This association was found in the common population and non-smokers (12).

Cardiovascular disease was significantly correlated with COPD (56). It has been recognised that cardiovascular disease can contribute to other co-morbid diseases in COPD patients (59). COPD patients were prone to hypoxia, a condition that promotes arteriosclerosis, causing the decline of vascular elasticity, thus rendering COPD patients prone to hypertension (28).

Table II: Prevalence and risk factors of COPD

Country or region	Author, Year	Study method	Sample	Outcome measures	Prevalence	Risk factors	Main Findings
Argentina, Peru, Uruguay, Chile, Uganda, Bangladesh	Siddharthan et al., 2018(29)	Retropective	n=12396 Gender: M/F =6384/6012 Age: 54.9 yo	Data review	13.5%	Household air pollution exposure to biomass materials between low- and middle-income countries	Household air pollution exposure was associated with a higher prevalence of COPD, particularly among women, and it is likely a leading population-attributable risk factor for COPD in resource-poor settings.
Brazil	Sousa et al., 2011(30)	Cross-sectional	n=1441 Gender: M/F = 574/867 Age: 40-49 yo (n=295) 50-59 yo (n=222) 60-69 yo (n=443) 70 yo or more (n=481)	Data review, Interviews	4.2%	Smoking status, age, health conditions, leisure-time and physical activity	The most important risk factor for COPD was cigarette smoking. Individuals aged ≥60 yo had a significantly higher prevalence of COPD. High physical activity can reduce the risk of developing COPD.
Canada	Leung et al., 2021(27)	Cross-sectional, population-based	n=5176 Gender: M/F = 2292/2884 Age: 56.6±0.3 yo	Questionnaire, Spirometry	16.2%	Age, history of physician-diagnosed asthma and childhood hospitalisation for respiratory illness, current smoking status.	Patient characteristics and lifestyle associated with an increased risk of COPD: age; current smoking status; history of physician-diagnosed asthma and childhood hospitalisation for respiratory illness.
Canada	Fuller-Thomson et al., 2018(31)	Retropective	n=113622 Ethnic: non-Hispanic white never-smokers Gender: M/F =37618/76004 Median age: 38 yo	Data review	10.5% (BMI of 40 or higher)	Obesity	Obesity was a potential risk factor for COPD in non-smokers.
China	Li et al., 2021(28)	Cross-sectional	n=2963 Ethnic: Uyghur Gender: M/F = 1268/1695 Age: 55.4±11.1 yo	Questionnaire, Lung function test	17.01%	High age, smoking, lower BMI, high waist circumference, systolic blood pressure, cooking method (frying and barbecuing)	Older age, smoking, low BMI, high waist circumference, high systolic blood pressure, cooking methods such as deep-fry and barbecuing are risk factors for COPD. Vegetable and fruit intake may be a protective factor for COPD.
China	Wang et al., 2020(32)	Cross-sectional	n=66752 Gender: M/F = 33137/33615 Age: 54.9±11.1 yo	Questionnaire, Spirometry	13.68%	Age, sex, education, residence, smoking status, pack-years of cigarette smoking, hospitalisation due to respiratory diseases in childhood, exposure to indoor biomass, exposure to dust or chemical in the workplace, medical history of tuberculosis, family history of respiratory diseases, and body-mass index (BMI)	Smoking and advanced age were identified as risk factors for COPD. Particulate levels ($PM_{2.5}$) was an important indicator for the risk of COPD. Exposure to dust and chemical in the workplace was risk factor for COPD.
China	Guo et al., 2020(33)	Cross-sectional	n=4967 Altitude: 2100-4700m Gender: M/F = 2415/2552 Median age: 38 yo	Questionnaire, Spirometry	8.2%	Aged, household air pollution, low altitudes, low educational level, and a history of tuberculosis	The spirometry-defined COPD is a considerable health problem for residents living at high altitudes (2100-4700m) in Xinjiang and Tibet, and COPD prevalence was inversely correlated with altitude. Household air pollution, a history of pulmonary tuberculosis and educational level were identified as major preventable risk factors for COPD.
China	Zha et al., 2019(17)	Cross-sectional	n=2770 Gender: M/F =1362/1408 Age: 53.8±10.5 yo	Questionnaire, Spirometry	9.8%	Older age, gender, current smoking status, lower education, family history of lung disease, and indoor exposure to coal for cooking or heating	Risk factors for COPD included older age, male sex, current smoking status, primary school or lower education, family history of lung disease, and indoor exposure to coal for cooking or heating.

Table II: Prevalence and risk factors of COPD (continued)

Country or region	Author, Year	Study method	Sample	Outcome measures	Prevalence	Risk factors	Main Findings
China	Wang et al., 2018(34)	Cross-sectional	n=50991 Gender: M/F =21446/29545 Age: M: 43.6±0.8 yo F: 44.0±0.8 yo	Pulmonary function test	8.6%	Cigarette smoking, ambient air pollution, bodyweight, childhood chronic cough, parental history of respiratory diseases, and education	Cigarette smoking, ambient air pollution (heavy exposure to $PM_{2.5}$ pollution), underweight, childhood chronic cough, parental history of respiratory diseases, and low education were major risk factors for COPD.
China	Luan et al., 2018(35)	Retrospective	n=413023 Subjects: death of COPD patients	Data Analysis	Not mentioned	Cold environmental temperature	Cold environmental temperature negatively affected COPD in women and the elderly than hot environmental temperature. A higher number of young and male patients were affected by heat. Low/cold temperature can cause a more serious burden of COPD than higher temperature.
China	Qiu et al., 2018(36)	Retrospective	n=54966 Subjects: COPD patients Gender: M/F =35335/19631 Age: ≥60 yo accounted for 91.8%	Data Analysis	Not mentioned	Ambient air pollution, Temperature	COPD was significantly aggravated by low temperature, $PM_{2.5}$ and SO_2 on hospital admissions in urban Chengdu. The elderly (≥80 years) and males were more vulnerable to these risks.
China	Mu et al., 2017(37)	Cross-sectional	n=82 Subjects: COPD patients Gender: M/F = 51/31 Age: 70±7.5 yo	Questionnaire, Spirometry	Not mentioned	Low temperature (<15.7°C) High humidity (<70%)	Low temperature was a risk factor for COPD patients, and high humidity enhanced its risk for COPD. The indoor temperature should be kept at least on average at 18.2 °C, while the humidity should be less than 70%.
China	Liu et al., 2015(38)	Cross-sectional	n=5880 Occupation: greenhouse farmers Age: 44.76 ±10.66 yo	Questionnaire, Pulmonary function tests	17.5%	Age, current smokers, BMI, education, exposed to mushrooms, flowers and poultry, and living in the mountainous and coastal region.	Age over 50 yo, smoking, planting mushrooms and flowers and living in the mountainous and coastal region were associated with the development of COPD among greenhouse farmers.
China	Yin et al., 2011(39)	Cross-sectional	n=49363 Gender: M/F=23218/26145 Age: 15-29 yo (n=7929) 30-39 yo (n=11536) 40-49 yo (n=12133) 50-59 yo (n=11067) 60-69 yo (n=6698)	Questionnaire	2.9%	Educational attainment, household income	Low educational level and low household income were associated with a significantly higher prevalence of COPD in both urban and rural areas.
Denmark and Sweden	Liu et al., 2021(40)	Cross-sectional	n=98058 Gender: M/F = 33369/64689 Age: 55.8±7.5 yo	Questionnaire, Spirometry	5.02%	$PM_{2.5}$, nitrogen dioxide (NO_2), and black carbon (BC)	Long-term exposure to low-level air pollution was associated with the development of COPD. Traffic-related pollutants NO_2 and BC may be the most relevant.
Finland	Kainu et al., 2013(41)	Cross-sectional	n=628 Gender: M/F = 260/368 Age: 49.0 ±12.95 yo	Spirometry, structured interview	5.9%	Current smoking status, number of smoking pack-years, recurrent or previous history of asthma, age, socioeconomic status and occupation	In addition to smoking, increasing age, and previous asthma condition, the lower socioeconomic were significantly associated with obstruction consistent with COPD in this urban population sample of manual workers and non-manual assistant employees.

Table II: Prevalence and risk factors of COPD (continued)

Country or region	Author, Year	Study method	Sample	Outcome measures	Prevalence	Risk factors	Main Findings
France	Guillien et al., 2016(5)	Cross-sectional	n=3787 Gender: M/F =2371/1416 Age range:40-75 yo	Questionnaire, Spirometry	5.1%	Occupation	The prevalence of COPD in farmers is higher than in non-farming working controls. Compared to controls, four job categories (cattle, swine, poultry breeders and breeders of two or more livestock types) had a higher prevalence of COPD.
France	Jouneau et al., 2019(42)	Cross-sectional	n=1203 Occupation: dairy farmers Gender: M/F = 863/340 Age: 54.6±7.7 yo	Questionnaire, Spirometry	1.3%	Not mentioned	Found little evidence that exposure to the dairy farm environment influences the occurrence of COPD.
India	Sinha et al., 2017(19)	Cross-sectional	n=1203 Gender: M/F =647/556 Age: 30-39 yo (n=439) 40-49 yo (n=356) 50-59 yo (n=172) 60-69 yo (n=135) ≥70 yo (n=102)	Questionnaire, Spirometry	10.1%	Smoking, environmental tobacco smoke, occupational exposure to dust/ smoke, biomass fuel use	Tobacco smoking was the strongest risk factor, followed by environmental tobacco smoke, occupational exposure, age, and biomass fuel.
India	Johnson et al., 2011(21)	Cross-sectional	n=900 Gender: F Age: 30-50 yo (n=598) 51-70 yo (n=302)	Questionnaire Pulmonary function test	2.44%	Biomass fuel smoke	Indoor air pollution is an important risk factor for non-smokers, primarily biomass-user in the rural women population.
Iran	Sharifi et al., 2020(43)	Cross-sectional	n=1007 Gender: M/F = 500/507 Age: age <40 yo (n=459) age≥40 yo (n=522)	Questionnaire, Spirometry	8.3%	Smoking, living conditions, dust and fumes	Smoker had a higher risk compared with non-smokers. Urban inhabitants, in comparison with rural inhabitants, had a lower COPD risk. Participants exposed to dust and fumes had a higher risk compared with the contrary status. Preventive measures to focus on cooking methods and appliances, particularly in rural areas.
Iran	Sharifi et al., 2019(44)	Cross-sectional	n=1062 Gender: M/F = 479/583 Age: 42.96±15.95 yo	Questionnaire, Spirometry	5.0%	Smoking, obesity, gender, and age	The overall COPD prevalence was higher in men (6.4%) than in women (3.9%) The risk for developing COPD is approximately twice in current smokers compared to that in nonsmokers. The prevalence was lower in participants younger than 55 yo (4.2%) and was 50% higher in participants older than 55 yo (6.1%) The prevalence was two times higher in obese compared to normal participants.
Korea	Kim et al., 2020(45)	Prospective and observational	n=6341 Gender: M/F = 2937/3404 Age: 51.3±8.5 yo	Questionnaire, Pulmonary function test	4.4%	Age, sex, BMI, years of smoking, number of cigarettes, WBC count, and lower-income and education status, occupation of farmer, and the residence of rural area	The incidence of COPD was associated with lower educational levels but not with lower household income.
Korea	Oh et al., 2016(46)	Cross-sectional	n=5489 Nonsmokers Gender: M/F = 610/4879 Age range: 40-79 yo	Data analysis	6.9%	Age, gender, low education, and occupational exposures	The risk factors for COPD among non-smoking adults were: 1) older men with a low education; 2) patients for whom a long time had elapsed following the first diagnosis of pulmonary tuberculosis; 3) patients who had been highly exposed to lead.
Korea	Kim et al., 2014(47)	Retrospective	n=8596 Subjects: non-smokers Gender: M/F = 3758/4838 Age: 55.10±0.31 yo	Data analysis	6.67%	Secondhand smoke exposure	Secondhand smoke may not be an important risk factor for COPD development in patients who have never smoked.

Table II: Prevalence and risk factors of COPD (continued)

Country or region	Author, Year	Study method	Sample	Outcome measures	Prevalence	Risk factors	Main Findings
Kyrgyzstan	Brakema et al., 2019(48)	Prospective and observational	n=392 Gender: Lowlands: M/F = 100/93 Age: 44.4±13.6 yo Highlands: M/F =87/112 Age: 50.0±16.3 yo	Questionnaire, Spirometry	Highlanders: 36.7% Lowlanders: 10.4%	Age, $PM_{2.5}$ exposure, the altitude setting, years and frequency of smoking	COPD prevalence and household air pollution were highest in the highlands and was independently associated.
Peru	Jaganath et al., 2015(20)	Cross-sectional	n=2957 Gender: M/F = 1457/1500 Median age: 54.8 yo	Questionnaire, Spirometry	6.0%	Post-treatment tuberculosis, asthma, and daily biomass fuel use	The burden of COPD in Peru was not predominantly explained by tobacco smoking. Daily biomass fuel smoke exposure, particularly in rural sites, was an important cause for this heterogeneity, as compared to differences in tobacco smoking. A history of respiratory disease, including post-treatment pulmonary tuberculosis and asthma, were important risk factors in the urban area.
Sweden	Hagstad et al., 2015(49)	Cross-sectional	n=967 Gender: M/F = 474/493 Mean age: 48.4 yo	Spirometry and Interviews	7.7%	Occupational exposure to gas, dust or fumes	In non-smokers, occupational exposure to gas, dust or fumes was significantly associated with COPD.
Taiwan	Tseng et al.,2013(50)	Retrospective	n=16254 Subjects: COPD exacerbation patients Gender: M/F = 12580/3674 Age: 75.5± 10.2 yo	Data analysis	Not mentioned	Cold temperature in winter (17.9±3.3°C), Low relative humidity in winter (35-50%)	With a 5°C decrease in mean temperature, the cold temperature (28-day average temperature) had a long-term effect on COPD exacerbation. Elderly patients and those without inhaler medication before the exacerbation event were affected significantly by lower mean temperatures. Increased humidity may eliminate the risk of triggering COPD exacerbation.
Tanzania	Magitta et al., 2018(18)	Cross-sectional	n=869 Gender: M/F =442/427 Age: 51.8±10.6 yo	Questionnaire, Spirometry	17.5%	Age, sex, tobacco smoking, exposure to indoor biomass smoke and occupational exposures	The prevalence of COPD in Tanzania is high, with a peak at a relatively young age and a preponderance in males. A history of tuberculosis, cigarette smoking and male sex are important risk factors. Indoor air pollution coupled with the use of biomass fuel for cooking and heating may be an important risk factor for developing COPD in rural Tanzania.
Thailand	Kitjakrancharoensin et al., 2020(51)	Cross-sectional	n=546 Occupation: farmers Gender: M/F = 262/284 Age: 57.1±13.6 yo	Questionnaire, Spirometry	5.5%	Age, smoking, and occupational exposure	The prevalence of COPD was 8.0% in males and 3.2% in females respectively. The risk factors of COPD included age≥60 years old, higher intensity of smoking, swine farm worker, cattle farm worker and home cooking.
The United States	Raju et al., 2019(16)	Retrospective	n=90334 M/F =42818/47516 Age: 58.4 yo	Data review	15.4%	Rural residence, poverty, coal use as a primary heating source	Rural residence and poverty were risk factors for COPD, even among non-smokers. The use of coal for heating was also a risk factor for COPD among non-smokers in rural areas.

Table II: Prevalence and risk factors of COPD (continued)

Country or region	Author, Year	Study method	Sample	Outcome measures	Prevalence	Risk factors	Main Findings
The United States	Syamlal et al., 2019(52)	Retrospective	n=106136000 M/F =52084000/54052000 Age: 18-24 yo (n=17648000) 25-44 yo (n=45914000) 45-64 yo (n=37393000) ≥65 yo (n=5204000)	Data review	2.2%	Workplace exposures (including exposure to dust, vapours, fumes, chemicals, and indoor and outdoor air pollutants)	During 2013–2017, an estimated 2.4 million (2.2%) U.S. working adults aged ≥18 years who never smoked had COPD. The highest COPD prevalence among persons who never smoked was in the information (3.3%) and mining (3.1%) industries and office and administrative support occupation workers (3.3%).
The United States	Halldin et al., 2015(53)	Cross-sectional	n=16912 Gender: M/F = 8159/8753 Age: 55.65 yo	Descriptive and cross-sectional study design was used for secondary data analysis	Not mentioned	Education, smoking, bodyweight, BMI, occupational dust and fumes exposure	Participants who reported occupational exhaust fume exposure had 20% greater odds of lungs airflow obstruction than other participants. Participants reporting occupational exposure had significantly higher odds of all respiratory symptoms and medically-diagnosed conditions than participants who reported no exposure to dust and/ or fume exposure. Those who reported dust exposure had twice the odds of chronic bronchitis symptoms compared with those who reported absence of dust exposure.
Turkey	Ornek et al., 2015(54)	Cross sectional	n=611 Gender: M/F = 260/351 Age: 49.2 ± 15.4 yo	Questionnaire, Spirometry	11.1%	Smoking, biomass exposure, occupational exposure and passive smoking	Smoking was the most common risk factor present in 80.9% of COPD cases, followed by biomass exposure (63.2%), occupational exposure (41.2%) and passive smoking (7.3%).
Uganda	Gemert et al., 2015(55)	Cross-sectional	n=588 Gender: M/F =291/297 Age: 45 ± 13.7 yo	Questionnaire, Spirometry	16.2%	Biomass smoke	Major risk factors were biomass smoke for both genders and tobacco smoke for men. In addition to high smoking prevalence in men, biomass smoke could be a major health threat to men and women in rural areas of Uganda.
Ukraine, Kazakhstan, Azerbaijan	Nugmanova et al., 2018(56)	Cross-sectional	n=2842 Nationality: Ukrainian (n=964) Kazakhs (n=945) Azerbaijanis (n=933)	Questionnaire, Spirometry	3.19% Ukrainian, 6.67% Kazakhs, 3.75% Azerbaijanis	Smoking, dusty work pneumonia, tuberculosis, andcardiovascular diseases	A statistically significant relationship was shown between smoking and COPD in Kazakhstan and Azerbaijan; BMI in Ukraine; tuberculosis in Ukraine; and dusty work in Kazakhstan. Co-morbidities like cardiovascular diseases and a history of pneumonia occurred significantly more frequent in the COPD population.

M/F: male/female; yo: years old; BMI: body mass index; COPD: chronic obstructive pulmonary disease; $PM_{2.5}$: particulate matter; SO_2: sulfur dioxide; BMI: body mass index; WBC: white blood cells

Environmental conditions

According to a previous study, freezing temperatures have been linked to growing respiratory morbidity in COPD (60). Compared to hot temperatures in summer, the cold temperature in winter significantly negatively affected COPD patients. Low temperatures during the colder months have increased respiratory symptoms and hospital admissions (35-37). In addition, the low temperatures seemed to worsen COPD symptoms significantly in the presence of high levels of sulfur dioxide (SO_2) and particulate matter ($PM_{2.5}$) conditions (36). Conversely, up to 70% increased relative humidity may remove the risk of causing COPD exacerbation (37, 50).

Changeable risk factors

Outdoor air pollution

Compared to smokers, exposure to higher levels of $PM_{2.5}$ (annual mean exposure 50-74 g/m^3 and 75 g/

m^3) was significantly linked to a higher prevalence of COPD in non-smokers (34, 40). Liu et al. (40) reported that traffic-related pollutants, nitrogen dioxide (NO2) and carbon emissions were the most significant COPD risk factors. Compared to middle-aged and older adults, the relationship between $PM_{2.5}$ exposure and the prevalence of COPD was stronger in young adults (61, 62). Researchers have indicated that teenagers' lung functions may be more negatively impacted by air pollution than those of older people. (61, 62).

Indoor air pollution
Compared with developed countries, indoor air pollution in developing or underdeveloped countries was more severe due to the use of biofuel and coal. In rural areas of underdeveloped countries, biofuels were mainly used for cooking and heating under poor ventilation settings. Hence the number of COPD patients was significantly higher than that in urban areas, particularly in non-smoking women (16, 21, 29, 48, 63, 64). Passive smoking and exposure to biomass fuel may be contributing factors. One cross-sectional survey in Turkey (54) revealed that the prevalence of passive smoking is significantly higher in women than in men, and it appears to be a major risk factor for developing COPD in women.

According to Alam et al. (58), COPD is more common in rural areas (17.0%) than in cities (9.9%). Compared to users of clean fuels, such as liquefied petroleum gas or natural gas (range: 4.4% to 10.0%), the incidence of COPD was also higher among biomass fuel users, ranging from 16.4% to 17.3%. (62, 65). However, one study by Kim et al. (47) reported no significant distinctions in COPD prevalence between individuals who had never smoked and exposure to secondhand smoke in their research. Thus, exposure to secondhand smoke may not be a significant risk factor for developing COPD in patients who have never smoked. In addition, better indoor air quality is much more important than outdoor air quality for individuals with COPD, as they spend approximately 82% of their time in their homes (66).

Occupational exposure
Eleven studies identified occupational exposure to gas, dust, fumes, or lead without effective protective measures at the workplace were significant independent risk factors for COPD (5, 18, 46, 49, 51-53, 56). Halldin et al. (53) indicated that prolonged dust exposure increased the likelihood of developing chronic bronchitis symptoms twofold. Additionally, according to two out of the nine studies, the prevalence of COPD was significantly higher among farmworkers than among non-farming operational controls, particularly among swine and cattle breeders (5, 51).

Low education level and low family income
Education level and family income were closely related to the incidence rate of COPD (17, 34, 38, 39, 46, 53). Essential determinants of socioeconomic status and access to healthcare are income and education levels. Lack of access to healthcare and low socioeconomic status has been linked to an increased risk of COPD (39, 67, 68). Wang et al. (34) identified a strong relationship between higher education and COPD. Yin et al. (39) reported that both urban and rural areas had significantly higher COPD prevalence regarding household income and educational attainment. Similarly, Kim et al. (45) examined that lower educational attainment was linked to a higher incidence of COPD but not lower household income.

Cigarette smoking
Fifteen studies confirmed that smoking was a significant risk factor for COPD (17-19, 27, 28, 30, 32, 34, 38, 41, 51-54, 56, 69). Wang et al. (34) found that smoking exposure of 20 pack-years or more was linked to a two-fold rise in the prevalence of COPD. Significantly, hours of passive smoking exposure at work or home have been linked in epidemiological studies to COPD (39, 49).

Obesity and underweight
Both obesity and being underweight were risk factors for COPD (28, 31, 34, 53, 56, 70). Halldin et al. (53) discovered that from 2007 to 2010, the prevalence of the normal BMI category (BMI 18.5-24.9 kg/m^2) decreased while the prevalence of COPD in obese patients (BMI>30 kg/m^2) increased by more than 10%. Similarly, a study discovered that subjects with lower BMI (18.5 kg/m2) had a significantly higher prevalence of COPD (39). It was noted that COPD patients frequently lose weight, so it is still unclear whether low BMI is a risk factor for COPD or an effect of the already-present disease (38).

Physical inactivity
Physical inactivity and COPD symptoms are mutually reciprocal causation (30). The COPD patients were less active over the life course than those without the disease (71). COPD patients' tendency to be inactive may occur due to inaccessibility to supervised exercise, which may aggravate their breathing difficulties. However, long-term inactivity may lead to an increased risk of co-morbidity or lung function decline in COPD patients. A case-control study in Japan found that people who were active their entire lives had better lung function than those who were sedentary (71).

Cooking methods
Li et al. (28) reported that cooking methods by frying and barbecuing may be risk factors for COPD. Dangerous chemicals like formaldehyde, benzene, and acrolein may be released into the food during coal fire-roasting and frying, which exposes people who enjoy eating deep-fried foods and barbecued meat to these chemicals (28). These substances have been associated with an elevated risk of lung infections, exacerbating respiratory symptoms and lowering lung function.

DISCUSSION

This scoping review provides a comprehensive summary of COPD patients' prevalence and risk factors. The prevalence rate of COPD was higher in developing, or undeveloped countries than in developed countries, and the COPD rate in urban areas was lower than in rural areas, with men more prone to COPD than women. With the increase of age, the incidence rate and complications increased significantly. This phenomenon may be explained by the fact that as people age, their lung function gradually deteriorates due to structural and physiological changes in the lungs, including decreased elastic recoil and chest wall compliance (72, 73, 74). Additional evidence suggests that ageing-related factors like stem cell exhaustion, cellular senescence, deregulated nutrient sensing, genomic instability, and deregulated nutrient sensing may interfere with the repair and remodelling of structural cells and lung tissues, leading to COPD (74, 75, 76, 77).

Risk factors for COPD patients vary depending on different geographical regions. In general, the prevalence of COPD is higher in rural areas than in urban areas due to the use of biofuels and poor indoor ventilation in rural areas (16, 43). Extreme cold and hot weather combined with high humidity can exacerbate symptoms in people with COPD (35, 36, 37, 50). A number of factors influence high-altitude patients' respiratory symptoms. As the altitude rises, the prevalence of COPD decreases (33). Living at a high altitude exposes one to hypoxic conditions, lower humidity, and colder temperatures. High-altitude residents may experience physiological changes like altered lung volumes or diffusing capacity due to these circumstances (33).

We found that obesity, being underweight, physical inactivity, and cooking methods are risk factors for COPD. Cooking methods by using burning coals or wood releases smoke, therefore is a proposed classification under environmental COPD, specifically, biomass and pollution exposure (COPD-P) in the latest GOLD 2023 (6). However, co-morbidity and lifestyle risk factors are exacerbating factors for COPD, thus more studies should be done to understand obesity, underweight and physical inactivity management to avoid aggravating COPD. Findings from these studies could enhance COPD 2023 guidelines in managing COPD. We also recommended expanding the classification of COPD to include non-smoking related COPD types, so specific studies can be designed and conducted for these different types of COPD.

Prevention of COPD based on risk factors

The primary prevention of COPD should focus on changeable risk factors. Changeability of risk factors should be adequately managed and addressed to control COPD. Thus, to prevent COPD occurrence effectively, the integration of appropriate lifestyle modification and non-pharmacological treatment was emphasised to prevent COPD.

Early diagnosis of COPD is vital in rural populations. The early stages of COPD do not have obvious symptoms. Most patients tend to ignore the early symptoms, leading to progressive deterioration before admission to the hospital, hence delaying the treatment. Regular physical examination and early screening are very important for the early treatment of COPD. The government should strengthen screening for people at high risk of COPD, such as lifelong smokers, those working in dust-exposed environments for long periods, and those exposed to smoke in rural kitchens. Health insurance reimbursement should cover screenings for people who live in areas with severe air pollution, such as yearly lung function tests for people over 40 in these areas.

Prevention measures for high-risk occupations of COPD may include 1) increasing awareness and knowledge about the dangers of high-risk occupations to lungs; 2) adopting new technologies and equipment to improve the production process with less harm to workers, and using clean raw materials to replace materials with severe dust pollution; 3) misting with water can effectively reduce the generation of dust; 4) containing and monitoring the dust by making the production process pipelined, mechanised and automatic to control the escape of dust effectively; 5) workers or farmers exposed to dusty, smoke, and other air pollution workplaces should wear dust masks, observe dust-proof operation procedures, and limit working hours to exposure; 6) strengthen immunity by physical exercise; 7) regular health check-ups for people in high-risk occupations for early detection of COPD, and avoiding the employment of people diagnosed with respiratory illnesses that make them unfit for dust work.

A smoking cessation programme may help rehabilitate respiratory patients, not just COPD patients. Long-term tobacco use is the most significant and extensively researched cause of COPD in the west (39, 49). Compared to smokers, non-smoking COPD patients are more vulnerable to passive smoking exposure (39, 49). A longitudinal study from July 2009 to July 2012 observed that smoking cessation intervention could significantly improve the clinical symptoms of smoking patients with COPD and reduce the number of acute exacerbations (78). Thus, smoking cessation is of great benefit to both smoking patients and passive smoking patients.

This review demonstrates that being underweight is also a risk factor for COPD, even though obesity is well known to be a risk factor for COPD. According to earlier research, malnutrition increases the risk of infection or respiratory muscle wasting, which leads to abnormal pulmonary function (79, 80). In addition, avoiding unhealthy dietary habits such as consuming deep-fried or barbecued foods and increasing sufficient intake of vegetables and fruits are suggested to prevent COPD

(28).

Physical activity and exercise therapy should be implemented as adjunct treatments of COPD. The type of physical activity and exercise therapy is beyond the scope of this review. An appropriate exercise programme should be prescribed according to the patient's physical condition and preferences, as well as to establish a long-term adherence to the programme.

The most important component of COPD prevention is implementing ongoing health education and promotion by the governments. For example, the Chinese government has produced the Health China Action (2019-2030) document, which focuses on COPD prevention and treatment and includes 1) implementing tobacco control initiatives to help individuals and families understand the dangers of smoking and secondhand smoke and to transform communities into smoke-free at all levels; 2) implementing national fitness initiatives to encourage the unrestricted use of public fitness services and to encourage residents to join fitness organisations such as "15-minute fitness circles"; 3) implementing occupational health and safety initiatives to ensure that workers are safe at work and to improve the legal and regulatory system for the treatment and prevention of occupational diseases and strengthen occupational disease protection and 4) measuring of lung function at the first consultation for high-risk groups and the testing of lung function at medical check-ups for people over 40 (81). These measures will positively impact the treatment and prevention of COPD, but their effectiveness remains to be tested.

CONCLUSION

This review comprehensively summarised COPD's prevalence and risk factors in the last ten years. Unchangeable risk factors for COPD confirmed from this review were age, gender, previous history of respiratory disease, family history of lung disease, cardiovascular disease, and high systolic blood pressure. Changeable risk factors of COPD comprised indoor and outdoor air pollution, occupational pollution exposure, low education level, cigarette smoking, obesity, underweight, and physical inactivity. Management of changeable risk factors is emphasised in the prevention of COPD, and healthy lifestyle interventions and education are emphasised to prevent the current of COPD.

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