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Proportion and number of chronic obstructive pulmonary disease cases attributable to potentially modifiable risk factors in Morocco

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Abstract

Chronic obstructive pulmonary disease (COPD) is a major global health issue, especially in low- and middle-income countries, with significant mortality and economic impact. The study focuses on estimating the population attributable fraction (PAF) for modifiable risk factors, including smoking, secondhand smoke, occupational dust exposure, underweight, and tuberculosis history. The study aims to provide a rigorous assessment of these factors' contributions to COPD onset. Using national prevalence data and relative risk estimates from high-quality studies, the study calculated the PAF for modifiable COPD risk factors, including smoking and occupational dust exposure, applying Levin's and Smoking-Attributable Mortality, Morbidity, and Economic Costs formulas. Confidence intervals were determined through the simulated Wald interval method. In Morocco, the PAF for tobacco-related COPD was 47% for men and 5% for women, with over 1.2 million preventable cases in men and about 54,000 cases in women. The PAF for second-hand smoke at home was estimated at 4% in men and 5% in women. In the workplace, this fraction was higher in men (7%) than in women (4%). Occupational exposure to dust accounts for 13% of COPD cases in men and 12% in women, totaling 335,000 and 142,000 avoidable cases, respectively. Underweight contributes to 5% of cases in men and 2% in women, while tuberculosis accounts for over 1% of cases in both genders. COPD is largely influenced by modifiable risk factors like smoking and occupational exposure to dust. By targeting these risk factors, policymakers can significantly reduce future COPD cases.

Key words: COPD, population attributable fraction, modifiable risk factors, SAMMEC, Levin's formula.

Introduction

Chronic obstructive pulmonary disease (COPD) is a progressive lung disease characterized by persistent and not fully reversible obstruction of the airways. It can be associated with chronic bronchitis and emphysema [1]. Symptoms of COPD include coughing, with phlegm sometimes, breathing problems, wheezing and fatigue [2]. COPD is not a curable disease, but it can be controlled through measures such as avoiding tobacco, protecting oneself from risk factors, and getting vaccinated to prevent infections [2].

Chronic obstructive pulmonary disease affects more than 380 million people in the world [3]. In Morocco, the prevalence of COPD was estimated at 12.6% according to the BOLD study [4]. COPD is the third most common cause of death worldwide, accounting for 3.23 million deaths in 2019 [1]. low- and middle-income countries account for almost 90% of COPD-related deaths in individuals under 70 [1].

Previous studies have shown that COPD is associated with a significant economic burden, both in terms of direct and indirect costs to healthcare systems [5,6]. In the united states, for example, the direct costs of COPD were estimated at $32 billion in 2010, with indirect costs accounting for a $ 20.4 billion [5]. In France, the average annual healthcare cost for COPD patient has been estimated at 9382 euros, of which 5342 euros are directly related to COPD [7]. In Morocco, the mean annual direct cost of COPD was estimated at $1816.6 ±1582.7 per patient [8].

According to the world health organization [2], the main risk factors for COPD are: tobacco smoke, second-hand smoke, occupational exposure to dusts, indoor air pollution, early life events such as infections in childhood, asthma in childhood, and a genetic condition called alpha-1-antitrypsin deficiency [2]. In addition, several studies demonstrated an association between low BMI , and history of tuberculosis, as risk factors for COPD [9-12]. For instance, Adeloye et al [10], highlighted that low BMI is a significant risk factor for COPD in their global analysis. However, Burney et al [12]. found that a history of tuberculosis significantly contributes to the prevalence of COPD.

In our study we focused on modifiable risk factors which are: tobacco smoke, second hand smoke, occupational exposure to dust, underweight, and tuberculosis history. The choice of these risk factors was justified by their representation among the identified primary contributors, the variety of risk types they represent, the modifiability of the risk factor, resource considerations, and their relevance to public health. This ensures a balanced and rigorous approach in evaluating their impact on respiratory health.

The impact of behavioral and environmental risk factors on health has been extensively studied for many years, and quantifying these impacts is a central objective of public health to guide prevention policies [13]. A key tool in this approach is the Population Attributable Fraction (PAF), which measures the proportion of a health outcome that could be avoided by reducing a population's exposure to a given risk factor over a given period of time [14].

The population attributable fraction (PAF) is a recognized tool in epidemiological research, used to measure the proportion of cases attributable to specific risk factors. This tool is essential for planning and prioritizing prevention strategies [15]. Smoking is the cause of over 70% of COPD cases in hight income countries, while in countries with lower incomes, it contributes to 30–40% of cases [2]. Occupational exposure is responsible for about 15% of COPD cases [16], and household air pollution contributes to 13.5% of the prevalence of COPD [17].

The aim of this study is to calculate the population attributable fraction of COPD cases that are associated with five potentially modifiable risk factors which are: Tobacco smoke, second hand smoke, occupational dust, tuberculosis history, and underweight. By comparing the burden of COPD disease attributable to these risk factor, the study offers additional support for the implementation of appropriate strategies to prevent future increases in COPD cases. Importantly, this is the first national study in Morocco to estimate the population attributable fraction of COPD associated with modifiable risk factors. This novel contribution provides crucial data to inform public health decision-making and prevention strategies targeting respiratory diseases in the country.

Materials and Methods

Definitions of the different modifiable risk factors

Definitions and classifications of the risk factors are crucial for understanding their contribution to COPD onset. The first risk factor was smoking [18]. It was defined according to the International Union Against Tuberculosis and Lung Diseases guide [19]. We studied the contribution of smoking to the onset of COPD, considering the three types of smokers. Current smokers: were defined as anyone who has smoked at least 100 cigarettes in his life, it includes daily or non-daily (occasional) use. Ex-smoker: defined as anyone who has smoked but had stopped for more than 3 months. Never-smoker: defined as anyone who had smoked less than 100 cigarettes in his life. Only cigarette smoking was considered, excluding water pipes [19].

Secondhand smoke (SHS) is a prevalent indoor air pollutant in many areas, consisting of a blend of side-stream smoke from burning cigarettes and mainstream smoke exhaled by smokers. This combination includes over 4,000 compounds, many of which are carcinogenic and toxic to the respiratory system [20]. When secondhand smoke contaminates the air in enclosed environments, everyone presents, both smokers and non-smokers, inhales these harmful substances [21]. There is no safe level of exposure to secondhand smoke, as it leads to severe cardiovascular and respiratory illnesses, such as coronary heart disease and lung

cancer, resulting in the premature death of approximately 1.3 million people annually [22]. Our study divided secondhand smoke into two main entities. The first relates to secondhand smoke exposure within homes, the second aspect concerns the workplace.
Productive dust refers to solid microparticles produced by human industrial and agricultural activities that can remain suspended in the air of the production environment for extended periods. This type of dust originates from various sectors such as mining, machinery processing, smelting, construction materials, textiles, road construction, hydropower, and food production industries [23]. "Productive dust can be categorized based on its nature into inorganic dust, organic dust, and mixed dust. Inorganic dust includes mineral dust, metal dust, and synthetic inorganic dust, while organic dust encompasses biological dust, plant dust, and animal dust" [23]. Occupational exposure to organic dust is especially pronounced in the farming and wood industries [24]. Occupational exposure to dust was defined as exposure to any types of dust lasting more than one year.
Tuberculosis is a contagious disease primarily impacting the lungs. It is caused by a bacterium called Mycobacterium tuberculosis, which can become airborne through the actions of infected individuals coughing, sneezing, or spitting. Tuberculosis is both preventable and treatable[25]; however, several studies have shown a significant association between tuberculosis and the onset of COPD [18,26]. Tuberculosis history was defined on the basis of self-reported history. People will know if they have been treated for TB, some communities may be reluctant to admit the diagnosis.
Finally, underweight was defined as a BMI of less than 18.5 kg/m^2 [12,27].

Statistical analysis

We calculated the attributable fraction of each risk factor in the development of COPD using literature data (RR) and national prevalence estimates for each risk factor.
We determined the PAF with its confidence interval. for each risk factor (excluding tobacco) using Levin's formula, the most commonly employed method for estimating PAF [28] :

$$PAF = \frac{Pe(RRe - 1)}{(Pe[RRe - 1] + 1} \qquad (29)$$

where P_e is the prevalence of the risk factor e in the population and RRe is the relative risk of the association between COPD and risk factor e. This PAF is defined in the total population as "the fraction of all cases (exposed and unexposed) that would not have occurred if exposure had been prevented" [29].
In addition, we used the SAMMEC (Smoking-Attributable Mortality, Morbidity, and Economic Costs) method to estimate the smoking-attributable fraction (PAF) in individuals aged 35 years and older [30]. This method, developed by the Centers for Disease Control and Prevention

(CDC), is specifically designed to estimate the burden of diseases attributable to smoking. It improves on simpler PAF formulas by incorporating age-specific risks and differentiating between current smokers, ex-smokers, and never smokers. The method considers that the risk of developing smoking-related diseases like COPD varies by smoking status and increases with age [30].

The equation used is as follows:

$$PAF1 = \frac{[(P0\ +\ P1\ \times\ RR1)\ +\ (P2\ \times\ RR2\ -\ 1)]}{[(P0 + P1 \times RR1) + (P2 \times RR2 - 1)]} \qquad [30]$$

where P0, P1 and P2 represent the prevalence of non-smokers, current-smokers and ex-smokers, respectively. RR1 and RR2 refer to the COPD risk of current-smokers and ex-smokers, respectively, from a tobacco-related pathology compared with a reference population of non-smokers. This approach provides a more accurate estimation of smoking's contribution to COPD by accounting for the dynamic smoking history of the population, rather than assuming a binary exposure.

For comparison, we also used the usual Levin's PAF estimate for the population as a whole (including people aged under 35) , In this formula, RR is the relative risk of the association tobacco smoke/COPD and P is the prevalence of smoking in the overall population.

Number of COPD cases

To calculate the number of COPD cases attributable to each risk factor in men and women; the number of COPD cases in the Moroccan population in 2019 was multiplied by the attributable fraction (PAF) to that risk factor. the number of COPD cases in the Moroccan population in 2019 was obtained by multiplying the size of the Moroccan population in 2019 by the prevalence of COPD in the same year.

Confidence intervals

Confidence intervals were calculated using the Method of Confidence Interval Estimation by Simulated Wald Interval [31], which allows estimating confidence intervals for an attributable fraction (PAF) using simulations based on the same normal (Gaussian) approximations as those used to construct the ordinal confidence intervals, particularly to integrate the uncertainty regarding prevalence rates. the formula is as follows:

$$95\%CI\ PAF\ =\ 1 -\ exp\,\{Lp\ \pm\ z\ \alpha/2\ (SD\ Lp.)\}$$

$SD_{LP} = \sqrt{(Oo*RR*SDr)^2 + (Oo/T)\{(RR\text{-}1)^2 + (RR*SDr)^2\}} * (1 - PAF) / (1 + Oo)$

$L_p = \ln(1 - PAF)$

$z\ \alpha/2 = 1.96$

T = is the survey sample size

RR =is the relative risk

Oo = prevalence rates =P0/ (1 - P 0) were P0 =the prevalence of exposure to the risk factor

SDr = standard deviation of RR =ln (RRupper/RRlower)/2* z $\alpha/2$

Data sources

PAF relies on the strength of the relationship between the risk factor and the outcome (relative risk), as well as the prevalence of exposure to the risk factor [28], that why we used reports/articles… published by PubMed to identify potentially modifiable risk factors with evidence for causing COPD and for which risk factor exposure and COPD outcome data were available (Table 1). When a risk factor was evaluated more than once, we prioritized the Moroccan prevalence study, then Meta-analysis, then Cohort, ….. A list of potentially modifiable risk factors that were considered in this analysis is provided in Table 1.

Prevalence of COPD (Table 1)

In this study we used the GOLD definition to estimate prevalence of COPD which defined COPD "as airflow limitation not fully reversible via spirometry using post-bronchodilator FEV_1/FVC ratio of less than 0·7 (GOLD-COPD) or less than lower limit of normal (LLN-COPD)" [10]. We estimated the regional prevalence of COPD in people aged between 30 and 79 years and for both sexes, based on a large systematic review and modelling analysis [10]. To calculate the number of COPD cases, we used the size of the Moroccan population in the same year (2019).

Prevalence of exposure to each risk factor (Table 1)

In our study we focused on modifiable risk factors to estimate the population attributable Fraction (PAF) which are: Tobacco smoke, Second hand smoke, Occupational Exposure to dust, underweight, and tuberculosis history.

National specific prevalence estimates of each risk factor with confidence intervals are based on data from 4 different cross-sectional surveys : MARTA national survey (2006) for tobacco smoke exposure [32], the multinational Burden of Obstructive Lung Disease study (BOLD),for Occupational Exposure to dust and tuberculosis history [4]. For Secondhand smoke exposure and body mass index [27], we used 2 approaches. In the first approach, we used prevalence of recent exposures from the national survey on common risk factors for non-communicable diseases (steps, 2017-2018) [27], and we estimated the attributable fraction in the years following exposure. In the second approach, we used prevalence of old exposures from the BOLD study [4].

COPD ocurrence: the relative risk (RR) data (Table 1)

we used adjusted relative risk (RR) which measures the association between COPD and each risk factor. Most of this RR have been taken from a high quality study [12] who estimated Local adjusted relative risks using a Bayesian hierarchical model borrowing information from The Burden of Obstructive Lung Disease study [33] Based on data from 28.459 participants of men and women, aged 40, in a globally distributed sample of 41 urban and rural sites , (in view of the unavailability of recent meta-analysis with relative risks as a measure of association).

The Adjusted relative risk (RR) of the association between Tobacco smoke exposure and COPD was taken from a "meta-analysis of the epidemiological evidence relating smoking to COPD, chronic bronchitis and emphysema"[34], separately for men and women and for each smoking status.

A flowchart summarizing the key steps of the methodology used to estimate the population attributable fractions (PAF) for COPD risk factors in Morocco is presented in Figure 1.

Results

Taking into account the prevalence of smokers, ex-smokers and non-smokers by gender and age group (35-44 / 45-54 /55-64 / 65), the attributable fraction of tobacco-related COPD varies from 56% to 61% for men, while for women, this PAF is around 5 %, this fraction decreases with age (0% prevalence in women over 65) (Table 2).

In the Moroccan population as a whole, regardless of age and irrespective ex-smoker status, PAF was estimated at 47% in men and 5% in women. which means that Around 1233637 cases of COPD in men, could be avoided. This number remains much lower for women, 53698 cases of COPD that could be prevented (Table 3).

For second hand smoke exposure at home the PAF was estimated at 4% in men and 5 % in women. Around 110557 cases of COPD in men, and 52845 in women could be avoided.

this fraction is higher in men who was exposed at work (7%) than women (4%), with 199213 cases of COPD in men could be prevented if smoking is prohibited in the workplace (Table 3).

Occupational exposure to dust emerges as a significant factor in the onset of COPD, with prevalence of exposition in the Moroccan population at 66.3% in men and 22.7% in women (Table 1). Among men, 13% of COPD cases are linked to this exposure, while among women, the figure is slightly lower at 12%. This accounts for 335076 cases among men and 141723 among women that could be avoided if we can control this exposure (Table 3).

Regarding BMI and tuberculosis history, the population attributable fraction of COPD due to underweight is 5% in men and 2% in women, which corresponds to 145832 cases of COPD in men and 25609 cases in women (Table 3). and over 1 % can be attributable to tuberculosis (32446 cases in men and 16836 cases in women) (Table 3).

Concerning the second approach of calculating the attributable fraction for passive smoking, low educational level, and low body weight, using prevalence of old exposures, the attributable fractions to each risk factor was respectively 2%, 27%, 2% for men and 6%, 29%, 1% for women (Table 3).
Figures 2 and 3 summarize the attributable fraction for each risk factor, separately for women and men.

Discussion

The objective of this study is to estimate the population attributable fraction of COPD cases linked to five potentially modifiable risk factors which are: tobacco smoke exposure, secondhand smoke exposure, occupational dust exposure, a history of tuberculosis, and underweight. Smoking was identified as the leading risk factor, accounting for 47% of cases in men and 5% in women. The next most significant risk factor was occupational exposure to dust, followed by passive smoking, low body mass index, and a history of tuberculosis. However, the contribution of these risk factors varied considerably according to the prevalence of exposure to the risk factor and the strength of the association with the disease (RR).
Smoking was the most influential risk factor, particularly in men. The population attributable fraction (PAF) ranged between 47% and 61% for men across different age groups, in the 35-54 age group, the PAF was 61%, and for those aged 55 the PAF was 56%. However, the overall PAF for men, regardless of age, was 47%. For women the PAF was around 5% in a cross all age groups. This difference is partly explained by the higher prevalence of tobacco consumption among men compared to women in our Moroccan context. The result vary considerably between countries. A study found that 5.2% of men and 2.2% of women suffer from COPD due to tobacco smoke [12]. In South Africa, the PAF was 11.7% for men, while in the USA, it was 9.5% for women [12]. In population-based studies, most of them have been conducted in European and Asian countries, the PAF attributed to smoking in the population ranged between 9.7% and 97.9% [18].
For second hand smoke exposure (SHS), the PAF was estimated at 4% at home and 7% at workplace in men. Among women Although the prevalence of active smoking is low (3.3%), the population attributable fraction (PAF) related to second-hand smoke exposure in women remains moderate, around 5%. This can be explained by two main factors. First, the national prevalence of exposure to second-hand smoke among women, although not negligible, is relatively moderate (13.8% at home and 12.3% in the workplace) based on the most recent national surveys. Second, the relative risk (RR) associating second-hand smoke with COPD in women is moderate (RR = 1.36; 95% CI: 1.20–1.55). Since the PAF depends both on the prevalence of exposure and the strength of association, the combination of a moderate

exposure prevalence and a modest RR leads to a limited attributable fraction. These results underscore the need for comprehensive public health interventions that include both smoking cessation and the reduction of passive exposure, especially in domestic and occupational settings. Moreover, in the Moroccan context, social norms tend to discourage smoking at home or in the workplace, which may contribute to limiting women's exposure to SHS. An large population-based studies have shown that SHS exposure in the workplace can be related to 9% of COPD cases [35]. Another multinational study estimated that more than 1% of women suffered from COPD attributable to second hand smoke in Kashmir (India), Lexington, Adana (Turkey), Salzburg (Austria), Kentucky (USA) and Uitsig and Ravensmead (South Africa) [12]. All these differences in the PAF between studies could be explained by the variations in the prevalence of exposures between countries, and the strength of the association between exposure and the disease. The variation in the prevalence can be explained by a complex combination of factors such as: Socio-economic factors, the prevalence of tobacco use is higher in low and middle-income countries compared to hight-income countries. Of the 1.3 billion smokers worldwide, approximately 80% live in low-or middle-income countries [36], but according to WHO, tobacco smoking accounts for over 70% of COPD cases in high-income countries, and 30-40% of COPD cases in low and middle-income countries [2]. Although smoking is relatively higher in low and middle-income countries, COPD is often associated with other major risks, such as household air pollution and exposure to harmful work environments. This means that, although smoking remains an important factor, other sources of pollution may be equally or even more contributory to COPD. In addition countries that have implemented stricter tobacco control policies such as tobacco taxation tend to have lower smoking rates, which reduces the population attributable fraction in disease like COPD [37]. Furthermore, the availability of smoking cessation programs or substitution therapies can also influence smoking rates and, consequently, the PAF [38].

Our results have shown that about 13% of COPD cases was attributed to occupational exposure to dust; which represents 335076 cases in men and 141723 in women. The American Thoracic Society and European Respiratory Society have indicated that exposure to vapors, gases, dusts, and fumes in the workplace plays a role in the development and progression of COPD, contributing to 14% of cases according to their population-attributable fraction estimates [39]. Another Swedish study found a PAF of 5.9% in people exposed to dust [40]. The 2016 GBD (Global Burden of Diseases) Study analysis showed that exposure to particulate matter, gases, fumes, and secondhand smoke had a population attributable fraction (PAF) of 15.6% [41]. in the US population the fraction of COPD attributable to work was estimated at 19.2% [42]. The differences in the PAF between studies can be explained by several factors, including differences in exposure levels and duration, population characteristics, the types of work environments included and methodologies used in studies [43]. Countries with stricter occupational health and safety regulations have implemented measures to limit workers' exposure to harmful dusts and fumes. In these countries, protective equipment and workplace ventilation systems may reduce exposure and, therefore, the population attributable fraction. On the other hand, countries with weaker regulations or enforcement may experience higher exposure, leading to a higher PAF [44]. Occupational COPD is often under-diagnosed, as it lacks specific features to differentiate it from general COPD, complicating diagnosis in the clinical setting [45].

In our study, we estimate that 5% and 2% of COPD cases in men and women successively are attributable to low BMI. A subsequent study, estimated that over 1% of COPD cases in men, in Sri Lanka, Philippines, Malawi and South Africa are related to underweight [12]. Although a low BMI may be a controversial factor in the disease [46], but more and more studies have shown a causal association between underweight and the onset of COPD as indicated above [10]. Individuals with underweight may be more susceptible to nutritional deficiencies, particularly in essential vitamins and proteins that are crucial for lung health. It's can compromise the immune system, and muscle wasting, including respiratory muscles, which may affect lung function.

Tuberculosis is one of the 10 leading causes of death worldwide, with 99% of deaths occurring in developing countries. In Morocco, nearly 30.000 cases are recorded every year, including new cases and relapses. The incidence rate is around 87 cases per 100.000 inhabitants [47].

In our study, 1% of COPD cases in men and 1.5% in women are attributed to tuberculosis. In Uitsig and Ravensmead (South Africa), 4% of men and 2.05% of women aged 40 years suffer from COPD attributable to tuberculosis [12]. A study has indicated that having a history of tuberculosis increases the risk of developing COPD, and this effect last for at least six years post-diagnosis [48]. Additionally, there is a dose-response relationship between delays in TB treatment and the risk of developing COPD. These findings have significant clinical implications for managing both tuberculosis and COPD. They suggest that improving tuberculosis control and enhancing the quality of its diagnosis and treatment could potentially prevent some cases of COPD [48].

This study has several limitations. The first one is data availability. In fact, PAF estimates presuppose a causal association between each risk factor and COPD, assuming that this association accurately reflects the true causal effect. If this assumption is incorrect, our PAF estimates might be false (higher or lower than the true value). This risk was mitigated as we used RR which was derived mostly from a cohort study considered as the strongest type of observational studies. On the other hand, our estimates of the burden attributable to the COPD risk factor are limited by the quality of the data on which the analysis is based. For example, prevalence data on certain risk factors such as smoking and second-hand smoke were self-reported. They could be subject to underestimation or recall bias depending on the social perception of smoking, which could have affected the attributable risk estimates. RRs and prevalence of certain risk factors as shown in Table 1 between many countries are almost similar, which may be in the favor of a reliable PAF finding. Also, we have taken into account the overlap of risk factors in the estimation of PAF by using adjusted RRs in the calculation. The mutual adjustment of the RRs in this analysis mitigates the issue of confounding factors but does not entirely eliminate them, nor address the problem of reverse causality. In addition, this study did not include all known risk factors for COPD. Finally, further work is needed to verify whether intervening on these exposures reduces the risk of COPD.

This study has several strengths that contribute to its robustness and relevance: Firstly, we used robust calculation methods, including Levin's formula and the SAMMEC method, to estimate the population attributable fraction (PAF) of various COPD risk factors and considered as the only viable method available to us given our data. The application of these recognized methods reinforces the credibility and accuracy of the results obtained. The study not only calculates overall PAF, but also offers a differentiated analysis by gender and age group. This provides a more detailed understanding of variations in the impact of risk factors according to these variables, which is essential for tailoring prevention strategies. Also, one of the strengths of this study lies in the calculation of confidence interval, which enables more precise estimate to be made by integrating the uncertainty of the prevalence rates, thus offering greater reliability of the results obtained. the study's methodology is grounded in rigorous statistical analysis, ensuring that the findings are both reliable and valid. Secondly, the study uses a comprehensive approach by considering a range of risk factors, including tobacco smoke exposure, occupational exposure to dust, and tuberculosis history, allowing for a more holistic understanding of their impact on COPD. Additionally, the results of this study, particularly in terms of the number of avoidable COPD cases, have direct implications for public health policies. By identifying the most significant risk factors, the study provides a sound basis for guiding COPD prevention and control efforts in Morocco. By focusing on a population-level analysis, the study provides generalizable results that can be applied to diverse settings, enhancing its potential to influence policy and clinical practice.

Conclusions

Our research is dedicated to examining the modifiable risk factors, which are more commonly encountered such as: tobacco smoke, second hand smoke, occupational dust, underweight, and tuberculosis history. Given the significant impact of modifiable risk factors on the prevalence of COPD, it is essential that policymakers focus their efforts on reducing these risks to effectively curb the projected increase in COPD cases. Policymakers should prioritize efforts to reduce the prevalence of smoking, which is currently associated with the majority of COPD cases, they also need to take steps to control occupational exposures, managing tuberculosis, and focus on population education. However, additional risk factors could be included in future studies.

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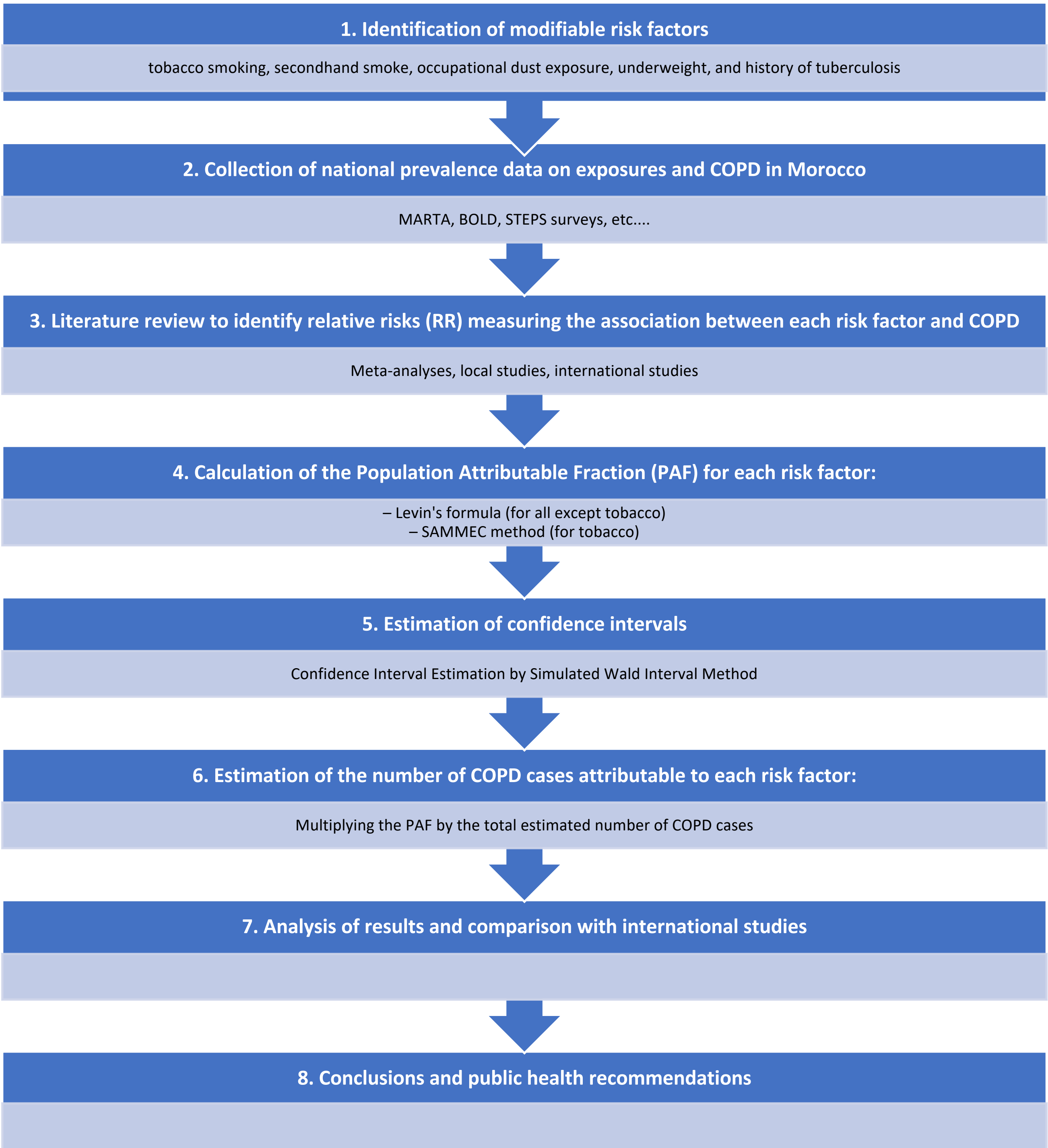

Figure 1. Flowchart of the study design for estimating population attributable fraction of COPD risk factors in Morocco.

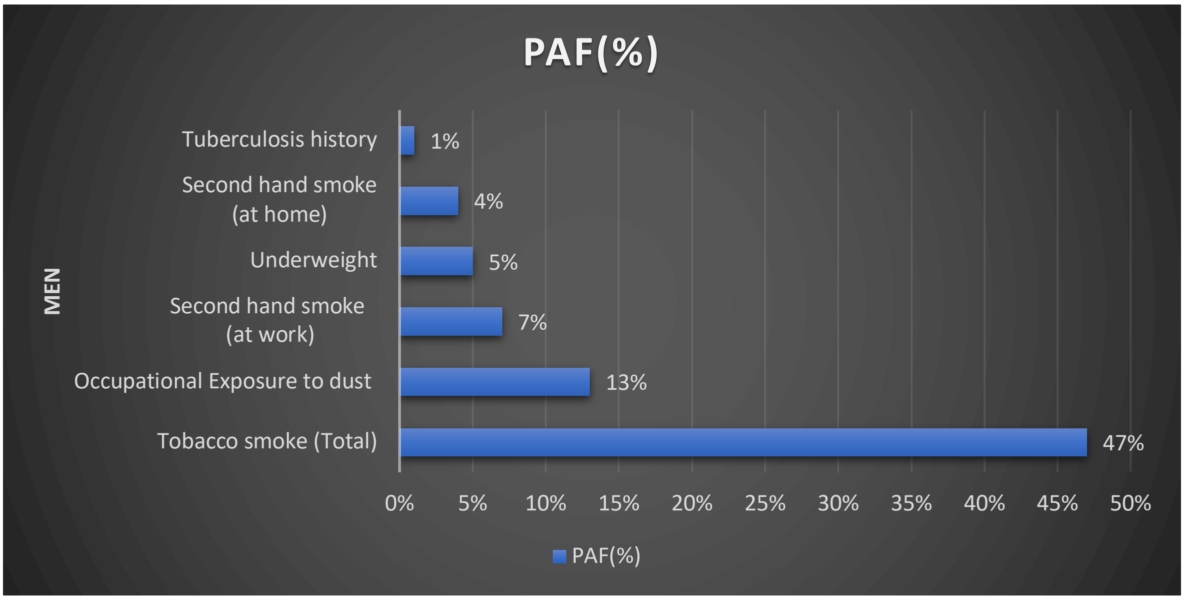

Figure 2. Attributable fraction of risk factors for COPD in men.

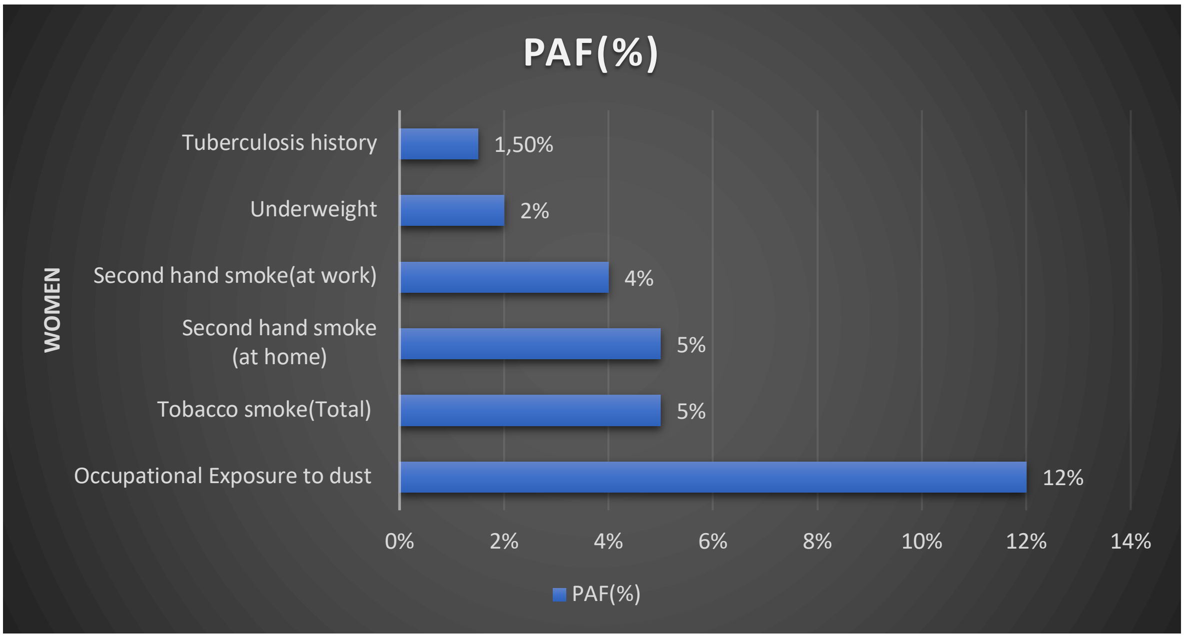

Figure 3. Attributable fraction of risk factors for COPD in women.

Table 1. Factors associated with increased COPD risk considered in this analysis.

	RR (95% CI)		**Prevalence % in Morocco**		**Prevalence of COPD in Morocco**		**Size of Moroccan population in 2019**	
Risk factor	Men	Women	Men	Women	Men	Women	Men	Women
Tobacco smoke exposure (2006)	3.80(3.60-4.02)	2.53(2.39-2.68)	31.5%	3.3%	14.4%	6.2%	18,280,000	18,020,000
Secondhand smoke (at home 2018)	1.23(1.08-1.42)	1.36(1.20-1.55)	19.2%	13.8%				
Secondhand smoke (at work 2018)	1.23(1.08-1.42)	1.36(1.20-1.55)	35.6%	12.3%				
Secondhand smoke (2010)	1.23(1.08-1.42)	1.36(1.20-1.55)	8%	19%				
Occupational Exposure to dust (2010)	1.22(1.11-1.35)	1.64(1.34-2.01)	66.3%	22.7%				
Underweight (2018)	1.85(1.54-2.21)	1.69(1.38-2.09)	6.9%	3.4%				
Underweight (2010)	1.85(1.54-2.21)	1.69(1.38-2.09)	2%	1,2%				
Tuberculosis history (2010)	2.04(1.66-2.51)	1.85(1.46-2.31)	1.2%	1.8%				

Table 2. Relative risk, prevalence and population attributable fraction of smoking-related COPD by age and sex for the Moroccan population over 35.

Smoking status	Current smokers%		Ex-smoker%		Never-smoker%		PAF 1 %	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**
RR	3.80(3.60-4.02)	2.53(2.39-2.68)	2.80(2.64-2.97)	1.92(1.78-2.06)	----		----	
35-44	42	2.3	22	2.5	36	95.2	**61%**	**5,4%**
45-54	36	23	33	2.3	31	95.4	**61%**	**5,3%**
55-64	25	2.5	34	1.5	41	96	**56%**	**4,9%**
65	17	0	47	0	36	100	**56%**	**0%**
TOTAL	36	2.2	30	2.2	34	96	**60%**	**5,4%**

Table 3. Estimated PAF and number of COPD cases with confident interval attributable to potentially modifiable risk factors, by sex in Morocco.

	Men		Women		Total
Risk factor	**Attributable Cases, NO.(95% CI)**	**PAF% (95% CI)**	**Attributable Cases, NO.(95% CI)**	**PAF% (95% CI)**	**Attributable Cases, NO. (95% CI)**
Tobacco smoke (Total) (2006)	**1233637** [1184544 ; 1289836]	**47%** [45; 49]	**53698** [48041 ; 67034]	**5%** [4.3; 6]	**1287336** [1232585 ;1356871]
Second hand smoke (at home2018)	**110557** [26323 ; 184262]	**4%** [1; 7]	**52845** [30165 ; 78206]	**5%** [2.7; 7]	**163402** [56488 ; 262469]
Second hand smoke (at work 2018)	**199213** [42117 ; 315878]	**7%** [1.6 ;12]	**46924** [22344 ; 67034]	**4%** [2; 6]	**246138** [64461; 382912]
Second hand smoke (2010)	**47559** [10529 ; 81601]	**2%** [0.4; 3.1]	**71526** [36868 ;103903]	**6%** [3.3; 9.3]	**119085** [47398 ;185505]
Occupational Exposure to dust (2010)	**335076** [176365 ; 494876]	**13%** [6.7; 18.8]	**141723** [63682 ;198868]	**12%** [5.7; 17.8]	**476799** [240048 ; 693744]
Underweight (2018)	**145832** [78969 ; 187421]	**5%** [3; 7.12]	**25609** [11172; 35528]	**2%** [1; 3.18]	**171442** [90142 ; 222949]
Underweight (2010)	44001 [15793 ; 78969]	**2%** [0.6; 3]	**9174** [1117 ; 15641]	**1%** [0.1; 1.4]	**53175** [16911 ; 94610]
Tuberculosis history	**32446** [1316 ; 52646]	**1%** [0.05; 2]	**16836** [4468 ; 27931]	**1.5%** [0.4; 2.5]	**49282** [5785 ; 80577]