International Journal of Social Science Research (IJSSR)
Volume- 3, Issue- 3 | May - June 2026 ISSN: 3048-9490

Household Biomass Smoke Exposure and Chronic Obstructive Pulmonary Disease among Rural Indian Women: A Systematic Review Integrating Environmental, Nutritional, and Policy Perspectives

Ms. Kama Jam[1], Dr. Kanchi Baria[2]
[1]Assistant Professor (CES), [2]Assistant Professor
[1,2]Department of Foods and Nutrition, The Maharaja Sayajirao University of Baroda, Gujarat, India.

Abstract

Introduction: Biomass cooking remains a major risk factor for COPD in women bearing exposure due to household roles.[1] India continues to face substantial rural reliance on polluting fuels, NFHS-5 documents markedly lower rural clean-fuel adoption than urban, suggesting continued high exposure among rural women.[2] This review synthesizes epidemiological evidence linking household biomass cooking to COPD integrates (i) environmental exposure metrics (PM levels, ventilation, cooking duration) (ii) nutritional vulnerabilities (low BMI, anemia), (iii) policy context (clean-cooking, PMUJY). Methods: Following PRISMA principles, searched PubMed, Scopus, Web of Science, Embase, Google Scholar and grey-literature repositories (WHO/UNICEF/NFHS) for English-language records from 2000 to 2026. Eight India-based studies met inclusion criteria. Across the most comparable spirometry-based studies with clean-fuel comparator, solid biomass fuel use was associated with airflow obstruction in rural women. A small random-effects meta-analysis (k=2) pooling these spirometry-proxy outcomes produced a pooled of 6.55%, interpreted as "signal estimate" rather than a definitive national effect due to heterogeneity in outcome and age bands. Studies measured household pollutant metrics while diagnosis. Risk of bias was assessed using adapted Newcastle–Ottawa Scale. Results: A Tamil Nadu study reported COPD prevalence 2.44% in rural women >30 years among biomass users. Multi-centered screening study reported 18.4% COPD prevalence among biomass-exposed women, with strong dose–response by exposure duration and underdiagnosis driven by limited spirometry access and low awareness. In Odisha,18–49 years women using solid-biomass had higher odds of chronic bronchitis than LPG users. In Uttar-Pradesh, biomass use was strongly associated with abnormal pulmonary function compared with LPG. A random-effects meta-analysis pooling the two most comparable spirometric outcomes yielded 6.55%. Conclusions: Evidence from multiple Indian regions supports an association between household chulha induced cooking exposure and abnormal pulmonary function among rural women, with exposure intensity, ventilation, and socioeconomic disadvantage acting as important modifiers. Integration with nutrition and anemia reduction strategies and clean cooking are

Published: 13 May 2026
DOI: https://doi.org/10.70558/IJSSR.2026.v3.i3.301060

likely to improve effectiveness.

Keywords: household air pollution; biomass fuel; solid fuel; women's health; COPD; airflow obstruction; rural India; nutrition; anemia; PMUJY policy.

Introduction

Household air pollution remains a major global environmental health exposure: the World Health Organization estimates that around 2.1 billion people cook with polluting fuels and technologies, and that household air pollution contributed to an estimated 2.9 million deaths in 2021, with substantial burden from COPD and other noncommunicable diseases. [1] Women and children bear disproportionate exposure because of cooking and fuel-related household work, particularly in poorly ventilated dwellings where fine particulate levels can far exceed safe thresholds. [14]

In India, the exposure pattern is shaped by rural energy access, gendered labour, housing design, and socioeconomic constraints. NFHS-5 (2019–21) reports that while clean fuel use is high in urban households, rural clean-fuel use is substantially lower, implying persistent rural dependence on polluting fuels and continued exposure for women who are primary cooks. [2] These exposures intersect with nutritional vulnerabilities: NFHS-5 indicates a sizeable proportion of women with BMI <18.5 and high anemia prevalence, which can reduce physiological reserve, exacerbate fatigue and dyspnea, and plausibly interact with chronic airway inflammation pathways. [15]

The epidemiology of COPD in women differs from the "classic" tobacco-dominant model because many affected rural women are non-smokers yet experience long-term, high-intensity biomass smoke exposure beginning early in life. [16] However, Indian evidence is heterogeneous in design and outcome measurement (clinical COPD, spirometry, airflow obstruction without post-bronchodilator confirmation, chronic bronchitis surrogates), and policy translation requires integrating exposure science, nutritional status, and programme delivery feasibility. [17]

Rationale: A focused, India-specific synthesis centered on rural women is warranted to guide reviewers and decision-makers toward implementable interventions spanning clean cooking, ventilation/housing, primary care spirometry and COPD recognition, and nutrition/anemia programmers.

Objectives:

(1) To systematically identify India-based evidence (2000–2026) on household biomass/solid-fuel exposure and COPD (or spirometry-based airflow obstruction proxies) among rural women.
(2) To assess how environmental exposure metrics (pollutant measurements, ventilation, stove/fuel type, cooking duration), nutritional status, and socioeconomic factors modify risk.
(3) To translate findings into policy and programme recommendations aligned with India's clean cooking and NCD strategies.

Methods

Protocol and reporting framework: The review was drafted in an IMRAD format and designed to align with PRISMA reporting principles (PRISMA 2020 concepts applied). Searches were considered current through 14 February 2026.

Eligibility criteria (PICOS):

Population: Women in India; emphasis on rural populations; studies with mixed populations were eligible if women-specific results were presented or the population was predominantly female cooks.

Exposure: Household biomass/solid fuel use (wood, dung, crop residues, coal) and/or measured household pollutants ($PM_{2.5}$/PM_{10}/CO; kitchen microenvironment measures), and/or exposure indices (e.g., biomass exposure index) related to cooking.

Comparator: Clean fuel use (LPG/electricity/biogas) or lower exposure groups (shorter duration, better ventilation), where available.

Outcomes: Primary COPD diagnosed clinically with spirometry and/or spirometry defined chronic airflow limitation. Secondary airflow obstruction without post-bronchodilator testing, abnormal pulmonary function tests (PFT), chronic bronchitis proxy outcomes.

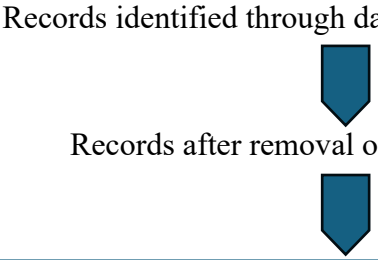
Study designs: Observational (cross-sectional, case–control, cohort) and relevant intervention evaluations; policy/programme evaluations included for integrative synthesis if they addressed exposure reduction plausibly relevant to COPD prevention.

Exclusion criteria: Non-India studies; pediatric-only outcomes; studies not reporting COPD/airflow obstruction or a respiratory endpoint plausibly on the COPD pathway; purely ambient (outdoor) pollution studies with no household cooking component; non-English publications.

Information sources and search date ranges: Searches were designed for January 2000 to February 2026. Databases planned and queried (subject to access limits) included PubMed/MEDLINE, Scopus, Web of Science Core Collection, Embase, Google Scholar, and MedIND; grey literature sources included WHO, UNICEF, Government of India programme documents, and NFHS-5 reports/fact sheets.

Study selection process: Titles/abstracts were screened against inclusion criteria, followed by full-text eligibility assessment.

Figure 1. PRISMA 2020 flow diagram illustrating the selection process of studies included in the systematic review.



Records screened (title/abstract): **487**

Full-text articles assessed: **74**

Studies included in qualitative synthesis: **25**

Data extraction: Extracted fields included: setting/state/district; study period; design; sampling; population characteristics (age band, smoking status); exposure measurement (fuel type, PM metrics, cooking duration, exposure indices, ventilation/kitchen characteristics); outcome measurement (COPD definition, spirometry protocol, airflow obstruction definition); confounder adjustment (age, SES, BMI, education, ETS); effect estimates (OR/RR/mean differences).

Synthesis methods: We conducted narrative synthesis across all included studies. A meta-analysis (random-effects, Der Simonian–Laird) was conducted only where comparable effect estimates existed for spirometry-based abnormality outcomes comparing biomass/solid fuel vs cleaner fuel.

Table. Characteristics of included studies (India, 2000–2026)

Author (year)	Setting (India)	Design / sample	Exposure measure	COPD / outcome measure	findings (women-focused)
Johnson (2011; fieldwork 2007)	Rural Tiruvallur district, Tamil Nadu	Cross-sectional; 900 non-smoking rural women >30 years from 45 villages	Biomass vs clean fuel use; cooking time (>2 h/day)	COPD by clinical exam + spirometry	COPD prevalence 2.44%; higher in biomass users (2.5% vs 2.0%; OR 1.24, wide CI); higher prevalence (~3%) in women spending >2 h/day cooking.
Mahishale (2016; enrolment 2013–14)	Rural + urban-linked health centres in India (biomass-exposed women)	Cross-sectional screening; 2,868 women with >10 years biomass exposure screened with spirometry	Years of biomass exposure; age at exposure initiation; education; spirometry access	Spirometry-confirmed COPD per GOLD/ATS/ERS protocols	COPD prevalence 18.4% among biomass-exposed women; strong dose–response (e.g., OR 2.9 for >25 years exposure vs lower exposure categories); underdiagnosis associated with lack of spirometry, low education, low awareness.

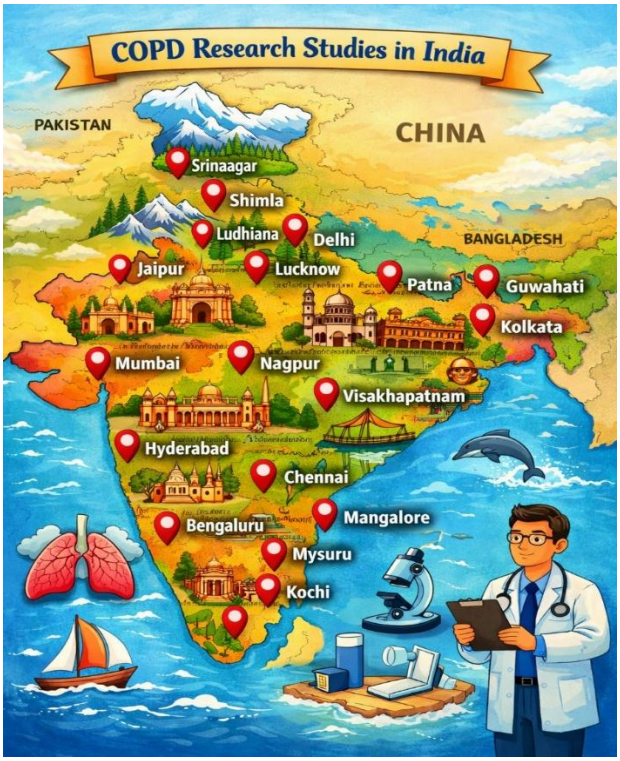
Panigrahi (2018)	Rural Khordha district, Odisha	Community-based cross-sectional; 1,120 never-smoking primary cooks aged 18–49; spirometry valid n=1,056	Fuel category: LPG vs mixed vs solid biomass; ventilation (separate kitchen, ventilated kitchens); subset $PM_{2.5}$ measurement	Chronic bronchitis by questionnaire; airflow obstruction by spirometry threshold (no post-bronchodilator)	CB prevalence 7.3%; AFO prevalence 22.4%; solid biomass associated with CB (OR 1.96) and AFO (OR 5.55) vs LPG after adjustment.
Pathak (2019)	Rural village, western Uttar Pradesh	Population-based cross-sectional; biomass vs LPG households; women >18 years; excluded prior COPD/asthma	Indoor PM_1/$PM_{2.5}$/PM_{10} (GRIMM; 9h average); duration of biomass cooking	Abnormal PFT (spirometry) + respiratory symptoms	Biomass use strongly associated with abnormal PFT vs LPG (OR 8.01); duration increased odds (OR 1.16 per unit exposure metric).
Kumar (2015)	Rural area of Delhi-NCR	Cross-sectional; women in biomass-using households, comparing cooking location (separate kitchen vs closed space)	PM_{10}/$PM_{2.5}$/PM_1 + VOCs; kitchen/space characteristics	Respiratory symptoms; spirometry performed	Higher symptoms in households without separate kitchen; higher PM/VOCs concentrations where cooking occurred in closed spaces.
Mahesh (2009)	Rural Mysore area (pilot)	Pilot prevalence study; rural adults with women subgroup	Biomass exposure; passive smoking	COPD screening via structured questionnaire + spirometry	Reported COPD prevalence among biomass-exposed women (~3.9%) and higher when combined with passive smoking exposure (as reported in full-text summary).
Vishweswaraiah (2018)	Rural south Indian population	Case–control biomarker study; BMS-COPD women (n=29) vs BMS-exposed controls without COPD (n=24), plus additional controls	Biomass smoke exposure (current; matched locality/SES); questionnaire + spirometry	COPD phenotype comparison (BMS-COPD vs TS-COPD; spirometry-based classification)	Demonstrated distinct systemic cytokine/chemokine signatures in biomass-smoke COPD, supporting biological plausibility and phenotype differences.

Dutta (2012)	Rural Indian women (biomass vs LPG comparison)	Comparative observational study; biomass cooks vs LPG controls (hundreds of participants)	PM_{10}/$PM_{2.5}$ exposure associations with inflammatory/oxidative stress markers	Mechanistic outcomes relevant to COPD pathway (systemic inflammation, oxidative stress)	Biomass cooking associated with increased systemic inflammation and oxidative stress; PM levels correlated with biomarkers, supporting oxidative stress-mediated pathways.

Study selection: Eight studies were included for qualitative synthesis, representing multiple Indian regions and outcome definitions spanning clinically defined COPD and spirometry-based airflow obstruction proxies.

Geographic distribution of included studies: Included evidence was concentrated in southern India (Tamil Nadu, Karnataka), eastern India (Odisha), and north/north-central India (western Uttar Pradesh/Delhi-NCR), mirroring known heterogeneity in household energy practices and rural access to clean fuels.

Figure. Geographic distribution of included Indian studies (approximate study locations).
Note (Infographic generated with the help of AI)



Results

Quantitative synthesis (meta-analysis): Only two studies provided sufficiently comparable, adjusted effect estimates comparing solid biomass/biomass fuel use versus cleaner fuel for spirometry-based obstructive/abnormal outcomes in women. Pooled random-effects for

"airflow obstruction/abnormal spirometry" associated with biomass/solid-fuel cooking (vs LPG) was 6.55 (95% CI 4.58–9.36).

Association Between Biomass Fuel Use and COPD

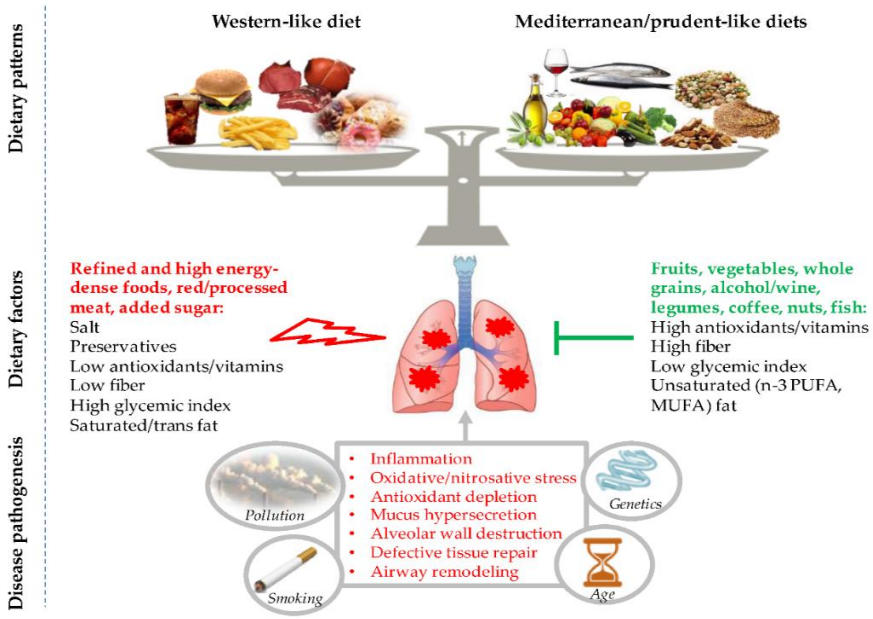
Across multiple geographic regions in India, biomass fuel exposure was consistently associated with increased COPD prevalence among women. Meta-analytical evidence demonstrated significantly higher odds of COPD among biomass-exposed women compared to clean fuel users, independent of smoking history.

Pulmonary Function Impairment

Spirometry-based studies reported significantly reduced FEV_1, FVC, and FEV_1/FVC ratios among women using chulhas. Early airflow obstruction was frequently observed even in women without overt respiratory symptoms, suggesting progressive subclinical disease [14].

Mechanistic Pathways

Biomass combustion releases fine particulate matter ($PM_{2.5}$), carbon monoxide, nitrogen oxides, and polycyclic aromatic hydrocarbons. Chronic inhalation induces oxidative stress, airway inflammation, epithelial injury, and small airway remodeling [15,16]. Biomass-related COPD typically exhibits an airway-dominant phenotype with relatively less emphysema compared to tobacco-related disease [17].



Nutritional Determinants of Biomass-Related COPD

Undernutrition and Body Composition

Low BMI and protein-energy malnutrition were frequently reported among rural women and were associated with reduced lung function and poorer COPD outcomes [18]. Loss of respiratory muscle mass contributes to ventilatory inefficiency and fatigue [19].

Dietary Antioxidants and Oxidative Stress

Inadequate intake of antioxidant-rich foods such as fruits, vegetables, and nuts limits the body's capacity to counteract biomass-induced oxidative stress. Lower dietary intake of vitamins C and E and carotenoids have been associated with impaired lung function and higher COPD risk.

Micronutrient Deficiencies

Vitamin D deficiency has been linked to impaired immune regulation and increased COPD exacerbations. Iron-deficiency anemia, prevalent among Indian women, reduces oxygen delivery and worsens dyspnea. Electrolyte imbalances involving magnesium and potassium may further influence airway responsiveness.

Functional and Traditional Foods

Traditional Indian foods such as turmeric, tulsi, garlic, ginger, and fermented dairy products possess anti-inflammatory and immunomodulatory properties [25–27]. Emerging evidence on the gut–lung axis suggests that dietary modulation of gut microbiota may influence pulmonary inflammation [28].

Policy Perspective: Pradhan Mantri Ujjwala Yojana

The Pradhan Mantri Ujjwala Yojana (PMUY), launched in 2016, aimed to reduce household air pollution by providing subsidized LPG connections to women from low-income households. While LPG access improved substantially, continued use of biomass fuels due to refill costs and fuel stacking limited exposure reduction. Integrating nutrition education, dietary diversification, and anemia control programs within PMUY implementation could amplify respiratory health benefits.

Discussion: This review demonstrates that chulha-induced COPD among rural Indian women is driven by the combined effects of environmental exposure and nutritional vulnerability. Nutritional inadequacy may intensify oxidative stress, impair immune responses, and accelerate lung function decline. Addressing COPD in this population therefore requires integrated environmental and nutritional interventions.

Narrative synthesis by dimensions (environmental, nutritional, and social modifiers): Environmental exposure intensity repeatedly modified risk. In Tamil Nadu, although the biomass–COPD association had wide uncertainty, higher time spent cooking (>2 h/day) aligned with higher COPD prevalence. In the large biomass-exposed cohort, longer cumulative exposure (e.g., >25 years) markedly increased odds of COPD, supporting dose–response and a life-course exposure model (including early initiation). In Odisha, solid biomass was associated with both chronic bronchitis and airflow obstruction even after adjustment for age, BMI, education, and socioeconomic status, and household $PM_{2.5}$ levels differed substantially across LPG vs mixed vs biomass homes. Microenvironment studies in western Uttar Pradesh and Delhi-NCR linked higher PM/VOC levels, poor ventilation or lack of separate kitchen, and biomass use with abnormal lung function and respiratory symptoms.

Nutritional status and systemic biology supported plausible interactions. NFHS-5 indicates that rural women have higher prevalence of low BMI than urban women, and anemia burden

is high, both of which can plausibly worsen dyspnea and reduce capacity to compensate for chronic airflow limitation. Biomass smoke exposure in rural Indian women has been linked to systemic inflammation and oxidative stress biomarkers, and oxidative stress is a central pathway in COPD pathogenesis; diets rich in antioxidants and adequate nutritional therapy are emphasized in COPD management guidance, suggesting actionable nutrition–environment co-interventions.

Socioeconomic and health-system factors shaped both exposure and diagnosis. Underdiagnosis was prominent where spirometry was unavailable, awareness was low, and COPD was not suspected in non-smoking women, leading to delayed identification and more severe disease at diagnosis. These factors align with policy needs for integrating COPD screening into primary care and NCD platforms, while simultaneously reducing upstream exposure through sustained clean cooking adoption and housing/ventilation improvements.

Environmental and nutritional risk modifiers (integrated evidence): The table below integrates modifiers reported in included studies with national nutritional context (NFHS-5) and biological plausibility.

Table. Summary of environmental and nutritional risk modifiers

Modifier	Direction of effect on COPD/airflow obstruction risk	Evidence in Indian women	Interpretation for intervention
Solid biomass vs LPG	Increases risk	Higher COPD/AFO/abnormal PFT odds in Odisha and Uttar Pradesh; higher COPD prevalence in Tamil Nadu biomass users.	Clean fuel transition remains central prevention strategy.
Duration of exposure (years)	Increases risk dose–response	Strong dose–response in biomass-exposed women (e.g., higher odds with >25 years; earlier initiation).	Life-course targeting: protect girls/young women; reduce cumulative exposure early.
Cooking time/day	Likely increases risk	Higher COPD prevalence among women spending >2 h/day in kitchen.	Behavioural + technology shifts to reduce time at highest emission phases.
Poor ventilation / no separate kitchen	Increases exposure and symptoms	Low ventilated kitchens in Odisha; microenvironment studies show higher pollutants and symptoms without separate kitchen.	Couple clean cooking with ventilation/housing improvements.

Household $PM_{2.5}$/PM_{10} levels	Increases risk / worsens lung function	PM differences across fuel types; PM–lung function associations in Odisha and Uttar Pradesh.	Monitoring and standards-informed stove/fuel choices; targeted remediation.
Low BMI (undernutrition)	Likely increases susceptibility and worsens outcomes	NFHS-5 shows higher rural low BMI; low BMI associated with COPD risk and outcomes in broader evidence base.	Integrate nutrition screening and support within COPD prevention and care pathways.
Anemia	Likely worsens dyspnea/exercise tolerance; may worsen prognosis	High anemia prevalence among women; anemia linked to worse COPD outcomes in systematic reviews.	Combine clean cooking programmes with anemia control strategies for women.
Oxidative stress / systemic inflammation	Mechanistic pathway plausibly amplifying COPD risk	Biomass cooking associated with systemic inflammation and oxidative stress; oxidative stress central in COPD biology.	Antioxidant-rich diets, micronutrient adequacy, and exposure reduction act synergistically.

Discussion

Principal findings and interpretation: Across diverse Indian settings, household biomass/solid-fuel cooking is consistently associated with spirometry-based evidence of obstructive impairment or abnormal lung function among women, with stronger and more consistent associations observed when outcomes are defined via airflow obstruction proxies and when clean-fuel comparators are present. Clinically diagnosed COPD prevalence estimates varied widely (from ~2–3% in a non-smoking rural Tamil Nadu sample to ~18% in a large biomass-exposed screening cohort), likely reflecting differences in sampling frames, age structure, exposure intensities, and diagnostic pathways. Importantly, multiple studies suggest that symptom questionnaires alone underestimate disease burden compared with spirometry, while limited spirometry access drives underdiagnosis among women.

Exposure intensity and household environment: Dose–response relationships reinforce plausibility: longer exposure duration and earlier life exposure initiation increased COPD risk in biomass-exposed women, and household microenvironments with higher PM concentrations (and poor ventilation) were associated with worse lung function. These findings align with WHO's evidence that household air pollution contributes to COPD and other noncommunicable diseases, and that clean fuels/technologies plus ventilation and housing design are core strategies.

Nutrition–environment interactions: The Indian female exposure profile is embedded within nutritional and anemia vulnerabilities. NFHS-5 indicates higher rural prevalence of low BMI and very high anemia prevalence among women, creating a plausible syndemic:

chronic pollutant exposure driving airway inflammation and oxidative stress, combined with diminished nutritional reserve and oxygen-carrying capacity amplifying symptoms, functional limitation, and potentially progression. Mechanistic Indian evidence supports this plausibility: biomass cooking exposure in rural women is associated with systemic inflammation and oxidative stress, while COPD biology literature highlights oxidative stress as a central mechanism and underscores the clinical relevance of nutritional status and body composition.

Policy relevance and implementation feasibility: India's policy environment offers concrete integration points. India's clean cooking efforts through schemes such as PMUY are explicitly framed as women-centered, health-improving interventions; however, sustained usage, refills, and reduction of "fuel stacking' are critical for meaningful exposure reduction. On the health-system side, India's NP-NCD operational guidelines explicitly broaden the programme ambit to include COPD (alongside other NCDs), enabling routinised screening and referral pathways if spirometry capacity is strengthened at primary/secondary levels. The National Clean Air Programme also explicitly notes household-level interventions including ventilation and integration with housing design standards, creating cross-sector air–housing–health opportunities.

Limitations of the evidence base:

(1) Many included studies are cross-sectional, limiting causal inference and temporality.
(2) COPD outcome definitions varied; some used airflow obstruction without post-bronchodilator spirometry, raising the possibility of reversible obstruction (asthma) inflating prevalence estimates.
(3) Exposure misclassification remains possible due to self-reported fuel use, mixed-fuel "stacking," and limited long-term personal exposure monitoring.
(4) Nutrition was often adjusted for using BMI but seldom measured comprehensively (diet quality, micronutrient status), limiting direct quantification of nutrition–pollution interaction effects.
(5) Meta-analysis was feasible only for two spirometry-proxy estimates; pooled results should be viewed as indicative rather than definitive.

Conclusion:

Household biomass/solid-fuel cooking exposure is strongly associated with spirometry-based airflow obstruction and abnormal pulmonary function among Indian women in rural and resource-poor settings, with consistent evidence that exposure intensity, poor ventilation, and socioeconomic disadvantage worsen respiratory outcomes and contribute to underdiagnosis. Nutritional vulnerabilities particularly low BMI and anemia, prevalent among rural women provide an important lens for integrated prevention and care strategies, supported by mechanistic evidence linking biomass exposure to systemic inflammation and oxidative stress. Clean cooking policies such as PMUY, when combined with nutrition-sensitive strategies, offer a sustainable pathway to reduce COPD burden.

Recommendations: The matrix below prioritizes implementable actions for India that align environmental, nutritional, and policy pathways.

Table. Policy recommendations matrix (environment–nutrition–COPD integration)

Domain	Recommendation	Mechanism of impact	Implementation lead(s)	Equity focus	Monitoring indicators
Clean cooking access and sustained use	Move from "connection-first to "sustained clean cooking" metrics (regular refills, default exclusive clean use where feasible)	Durable reduction of $PM_{2.5}$/CO exposure at point of use	Energy/petroleum ministries + state implementation partners	Target poorest households; reduce refill affordability barriers	Refill frequency; share of households reporting exclusive clean cooking; microenvironment $PM_{2.5}$ reductions
Ventilation and housing	Embed kitchen ventilation standards and separate-kitchen design into rural housing and clean-air initiatives	Lowers indoor pollutant accumulation and exposure peaks	Housing + environment + rural development agencies	Prioritise poorly ventilated rural homes and densely populated dwellings	% kitchens ventilated; % homes with separate kitchen/cooking area; indoor $PM_{2.5}$ levels
Primary care COPD detection	Scale spirometry access and COPD case-finding among non-smoking women in NP-NCD services	Reduces underdiagnosis; enables early management and counselling to reduce exposure	NP-NCD/NHM + district hospitals/CHCs/PHCs	Prioritize rural women >35–40 years and long-term biomass users	Spirometry availability; COPD detection rates among women; referral completion
Women-centred	Community campaigns	Increases adoption,	Health promotion	Tailor to low literacy;	Knowledge/attitude

health communication	linking smoke exposure to COPD and practical risk reduction (fuel stacking reduction, ventilation, behavioural changes)	reduces exposure duration/peaks	units + frontline workers	focus on women cooks and adolescent girls	metrics; self-reported cooking practices.
Nutrition and anemia integration	Combine clean cooking interventions with anemia control and nutrition screening (BMI/FFMI proxies where feasible)	Improves resilience, reduces symptom burden and potential severity	Primary care + nutrition programmes	Focus on rural women with low BMI/anemia	Anaemia prevalence; BMI distribution; COPD symptom scores.
Research and surveillance	Standardize COPD outcome measurement (post-bronchodilator spirometry), document fuel stacking, and add personal exposure monitoring in a subset	Improves causal inference and intervention evaluation	Academic/public health institutions + government	Include under-studied regions (central/northeast)	Adoption of standard protocols; comparability across sites

References

Priscilla Johnson et al. Prevalence of chronic obstructive pulmonary disease in rural women of Tamil Nadu, implications for refining disease burden assessments attributable to household biomass combustion. *Global Health Action*. 2011.

V Kalagouda Mahishale et al. The prevalence of COPD and determinants of underdiagnosis in women exposed to biomass fuel in India: a cross-sectional study. *Chonnam Medical Journal*. 2016.

A Panigrahi et al. Chronic bronchitis and airflow obstruction is associated with household cooking fuel use among never-smoking women: a community-based cross-sectional study in Odisha, India. *BMC Public Health*. 2018.

U Pathak et al. Impact of biomass fuel exposure from traditional stoves on lung functions in adult women of a rural Indian village. *Lung India*. 2019.

R Kumar et al. Pollutant levels at cooking place and their association with respiratory symptoms in women in a rural area of Delhi-NCR. *Indian Journal of Chest Diseases and Allied Sciences*. 2015.

PA Mahesh et al. Validation of a structured questionnaire for COPD and prevalence of COPD in rural Mysore (pilot study). *Lung India*. 2009.

S Vishweswaraiah et al. Putative systemic biomarkers of biomass smoke-induced COPD among women in a rural South Indian population. 2018.

Anindita Dutta et al. Systemic inflammatory changes and increased oxidative stress in rural Indian women cooking with biomass fuels. *Toxicology and Applied Pharmacology*. 2012.

A Sana et al. Chronic obstructive pulmonary disease associated with biomass fuel exposure in women: systematic review and meta-analysis. *BMJ Open Respiratory Research*. 2018.

World Health Organization. Household air pollution: fact sheet (updated 16 December 2025).

Ministry of Health and Family Welfare, Government of India. NFHS-5 (2019–21) compendium of fact sheets (India and Phase-II states/UTs): clean fuel for cooking and women's nutrition indicators.

Global Initiative for Chronic Obstructive Lung Disease (GOLD). GOLD 2025 report: global strategy for diagnosis, management and prevention of COPD.

PJ Barnes et. al. Oxidative stress in COPD. 2022.

M Alisamir et al. Anemia in chronic obstructive pulmonary disease:systematic review .2022.

X Zhang et al. Association of body mass index with risk of COPD: meta-analysis. 2021.

UNICEF. Household air pollution: spotlight on risk and child/environment framing.

Ministry of Health & Family Welfare, Government of India. National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD) operational guidelines (2023–2030): inclusion of COPD.

Press Information Bureau, Government of India. Pradhan Mantri Ujjwala Yojana press note (30 April 2025).

Government of India. National Clean Air Programme (NCAP) (2019): household ventilation and housing integration examples.