Green Medical Journal Vol.8 Issue: 1 (April, 2026): 23-35
E-ISSN: 2686-6668
DOI: 10.33096/03prn178

Green Medical Journal
Volume 8 Issue 1

Original Article Open Access

Spirometry-Based Screening for Pulmonary Function Abnormalities in Dukuh Kupang: A Pilot Cross-Sectional Study

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ABSTRACT

Introduction: Pulmonary function abnormalities are often underrecognized in the community, particularly in their early stages. This pilot study aimed to describe spirometry findings in a community setting and examine their associations with age, sex, body mass index (BMI), and smoking history.
Methods: A pilot cross-sectional study was conducted among residents of Dukuh Kupang, Surabaya, during a community-based spirometry program. Fifty-eight participants were recruited consecutively. Variables included age group, sex, BMI category, smoking history, and spirometry results (normal, obstructive, restrictive, or mixed), which were further classified as normal versus abnormal. Data were obtained through structured interviews, anthropometric measurements, and spirometry testing. Associations were analyzed using the chi-square or Fisher–Freeman–Halton test, as appropriate.
Result: Abnormal spirometry findings were identified in 32 of 58 participants (55.2%). Obstructive patterns were found in 36.2%, restrictive patterns in 13.8%, and mixed patterns in 5.2%. Abnormal results were significantly associated with age ($p < 0.001$), sex ($p < 0.001$), smoking history ($p < 0.001$), and BMI category ($p = 0.009$).
Conclusion: This pilot community-based study identified a substantial proportion of pulmonary function abnormalities among residents of Dukuh Kupang, Surabaya. The findings support the potential value of spirometry as an early community-level tool for identifying pulmonary function abnormalities and informing targeted respiratory health strategies and follow-up planning.

Keywords: Community-based screening; pulmonary function abnormalities; spirometry

GREEN MEDICAL JOURNAL
E-ISSN 2686-6668

Article history:
Received: 28 February 2026
Accepted: 23 April 2026
Published: 30 April 2026

Published by:
Faculty of Medicine
Universitas Muslim Indonesia

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Introduction

Chronic respiratory diseases, including chronic obstructive pulmonary disease (COPD), asthma, interstitial lung disease, post-infectious sequelae, and environmentally or occupationally related lung disorders, continue to impose a substantial burden on global health [1]. These conditions may lead to measurable abnormalities in pulmonary function, which can be identified by spirometry as obstructive, restrictive, or mixed ventilatory patterns, sometimes even before overt clinical symptoms become apparent [2]. Recent global statistics indicate that chronic respiratory diseases affected 468.3 million individuals in 2021, while asthma affected approximately 262 million people and COPD accounted for 3.5 million deaths worldwide [3,4].

The decline in pulmonary function and the development of chronic respiratory disease are shaped by the cumulative and interacting effects of multiple risk factors, particularly tobacco use, indoor and outdoor air pollution, household biomass smoke, and occupational exposure to dust, fumes, and chemical vapors, as well as age, body mass index (BMI), and sex [5]. Among these, tobacco exposure remains a major concern, especially in low- and middle-income countries. Globally, approximately 1.25 billion adults continue to use tobacco [6,7]. In Indonesia, tobacco exposure also remains substantial, with 70.2 million adults reported to use tobacco, while daily smoking among individuals aged ≥15 years remains common [8]. In such settings, objective pulmonary health assessment at the community level becomes increasingly relevant, and spirometry may help identify individuals with pulmonary function abnormalities at an earlier stage.

Despite the established role of spirometry in respiratory assessment, community-based data describing spirometric patterns and their associations with commonly encountered individual characteristics remain limited. In particular, evidence from local community settings is still insufficient regarding how spirometry findings are distributed according to age, sex, BMI, and smoking history. Such information is important for informing targeted early detection strategies and referral pathways. Therefore, this pilot cross-sectional study aimed to map the distribution of spirometry findings (normal, obstructive, restrictive, and mixed patterns) in a community setting and to examine their associations with age, sex, BMI category, and smoking history. We hypothesized that community-based spirometry screening would identify pulmonary function abnormalities and that the distribution of spirometric patterns would vary according to these individual characteristics. The findings are expected to provide preliminary evidence to support future larger-scale studies and to inform community-based respiratory health interventions.

Methods

This pilot cross-sectional study was conducted in Dukuh Kupang, Surabaya, Indonesia, to obtain a preliminary overview of the distribution of pulmonary function patterns based on spirometry findings in a community setting. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [9].

The target population comprised residents of Dukuh Kupang, Surabaya, who participated in the community screening program. Participants were eligible if they were aged ≥18 years, were able to understand instructions and perform spirometry maneuvers cooperatively, and provided written informed consent before examination. Participants were excluded if they had significant acute respiratory infection or symptoms at the time of screening, contraindications to spirometry, or were unable to produce acceptable and repeatable spirometry maneuvers despite repeated instruction. Spirometry procedures, maneuver quality criteria, and quality assurance were conducted in accordance with the 2019 American Thoracic Society (ATS) and European Respiratory Society (ERS) technical standards [10].

Participants were recruited consecutively during the community-based screening program until the required sample size was reached. The minimum sample size was estimated using the formula for proportions in prevalence studies [11], assuming a 95% confidence level (Z = 1.96), an expected proportion (p) of 0.50, and an absolute precision (d) of 0.13:

$$n = \frac{Z^2 \times p(1-p)}{d^2}$$

$$Z^2 = 1{,}96^2 = 3{,}8416$$

$$p(1-p) = 0{,}5(1-0{,}5) = 0{,}25$$

$$d^2 = 0{,}13^2 = 0{,}0169$$

$$n = \frac{3{,}8416 \times 0{,}25}{0{,}0169} = 56{,}8 \approx 57$$

The minimum required sample size was 57 participants; 58 participants were ultimately included in the study.

Age was categorized into four groups: <20 years, 20–39 years, 40–59 years, and ≥60 years. Sex was classified as male or female. Body mass index (BMI) was categorized as underweight, normal, overweight, or obese. Smoking history was classified dichotomously as yes or no. The primary outcome was spirometry result category, defined as normal, obstructive, restrictive, or mixed. Based on the ERS/ATS interpretative strategy, an obstructive pattern was defined by a reduced ratio of forced expiratory volume in 1 second (FEV_1) to forced vital capacity (FVC) below the lower limit of normal (LLN); a restrictive pattern was defined by FVC below the LLN with a preserved FEV_1/FVC ratio; and a mixed pattern was defined by both a reduced FEV_1/FVC ratio and FVC below the LLN. A restrictive pattern on spirometry was interpreted as presumptive, as definitive confirmation requires measurement of total lung capacity (TLC).

Data were collected through structured interviews, anthropometric measurements, and spirometry testing performed on the same day. Demographic variables included age and sex. Smoking history was recorded as a dichotomous variable, with “yes” indicating current or former smoking and “no” indicating never-smoking. Body weight and height were measured using calibrated instruments, and BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2). BMI categories followed the 2023 Indonesian Health Survey (SKI) criteria for adults: underweight (<18.5), normal (18.5–<25.0), overweight (25.0–<27.0), and obese (≥27.0). Spirometry was performed by trained personnel according to ATS/ERS standards. Recorded parameters included FEV_1, FVC, and the FEV_1/FVC ratio. Spirometry results were interpreted using the Global Lung Function Initiative (GLI) 2012 all-age, multi-ethnic reference equations and LLN-based z-score criteria [12].

Data analysis was performed using IBM SPSS Statistics. All variables were categorical and were summarized as frequencies and percentages. Descriptive analyses were conducted for participant characteristics and spirometry result categories. Associations between participant characteristics (age, sex, BMI category, and smoking history) and spirometry results were assessed using the chi-square test or Fisher–Freeman–Halton exact test, as appropriate. A *p*-value <0.05 was considered statistically significant.

All participants received an explanation of the study objectives, procedures, potential benefits, and minimal risks before participation. Written informed consent was obtained from all eligible participants. Individuals with abnormal spirometry findings received brief counseling and were referred to an appropriate healthcare facility for further clinical evaluation when indicated.

Result

A total of 58 participants were included in the analysis (Table 1). The age distribution showed that individuals aged ≥60 years constituted the largest proportion, with 21 participants (36.2%), followed by those aged 40–59 years (16 participants; 27.6%), 20–39 years (12 participants; 20.7%), and <20 years (9 participants; 15.5%). By sex, the sample was predominantly male (38 participants; 65.5%), while 20 participants (34.5%) were female.

According to BMI categories, obesity represented the highest proportion (18 participants; 31.0%), followed by overweight (16 participants; 27.6%), normal BMI (15 participants; 25.9%), and underweight (9 participants; 15.5%). A history of smoking was reported by 33 participants (56.9%), whereas 25 participants (43.1%) had never smoked. Spirometry results indicated that 26 of 58 participants (44.8%)

had normal findings, while 32 of 58 (55.2%) demonstrated pulmonary function abnormalities, consisting of obstructive patterns (21/58; 36.2%), restrictive patterns (8/58; 13.8%), and mixed patterns (3/58; 5.2%).

Table 1. Screening sample characteristics (N = 58)

Variable	Category	n (%)
Age group	< 20	9 (15.5)
	20-39	12 (20.7)
	40-59	16 (27.6)
	≥60	21 (36.2)
Sex	Female	20 (34.5)
	Male	38 (65.5)
Body Mass Index	Underweight	9 (15.5)
	Normal	15 (25.9)
	Overweight	16 (27.6)
	Obese	18 (31.0)
History of smoking	No	25 (43.1)
	Yes	33 (56.9)
Spirometry result	Normal	26 (44.8)
	Obstructive	21 (36.2)
	Restrictive	8 (13.8)
	Mixed	3 (5.2)

Bivariate analysis demonstrated significant differences in the proportion of abnormal spirometry results (obstructive, restrictive, and mixed patterns) across age groups, sex, smoking history, and BMI categories (Table 2). The proportion of abnormal spirometry increased progressively with age, from 0.0% in the <20-year group to 33.3% in those aged 20–39 years, 68.8% in the 40–59-year group, and 81.0% among participants aged ≥60 years. These patterns are further illustrated in Figures 1–4. As shown in Figure 1, the proportion of abnormal spirometry increased across older age groups. Figure 2 demonstrates a higher frequency of abnormal findings among males, while Figure 3 shows a corresponding increase across higher BMI categories. Figure 4 further highlights the greater proportion of abnormal spirometry among participants with a history of smoking.

Moreover, as several cells had expected counts <5, the association between age group and spirometry status was analyzed using the Fisher–Freeman–Halton exact test, revealing a highly significant association

($p < 0.001$) with a strong effect size (Cramer's V = 0.591).

Table 2. Bivariate analysis of participant characteristics in relation to pulmonary function abnormalities

Variable	Category	Spirometry Result		p-value	Effect size
		Normal (n%)	Abnormal (n%)		
Age	<20	9 (100.0)	0 (0.0)	<0.001*	0.591
	20–39	8 (66.7)	4 (33.3)		
	40–59	5 (31.3)	11 (68.8)		
	≥60	4 (19.0)	17 (81.0)		
Sex	Female	15 (75.0)	5 (25.0)	<0.001#	0.440
	Male	11 (28.9)	27 (71.1)		
History of smoking	No	21 (84.0)	4 (16.0)	<0.001#	0.686
	Yes	5 (15.2)	28 (84.8)		
Body Mass Index	*Underweight*	7 (77.8)	2 (22.2)	0.009*	0.438
	Normal	9 (60.0)	6 (40.0)		
	Overweight	7 (43.8)	9 (56.3)		
	Obese	3 (16.7)	15 (83.3)		

*Fisher-Freeman-Halton with Cramer's V effect size, #Chi-Square with Phi effect size

By sex, males exhibited a substantially higher proportion of abnormal spirometry compared with females (71.1% vs 25.0%). This difference was statistically significant on chi-square testing ($p < 0.001$), with a moderate effect size (Phi = 0.440). Smoking history was also strongly associated with pulmonary function abnormalities; 84.8% of participants with a history of smoking had abnormal spirometry findings, compared with 16.0% among never-smokers. This association was statistically significant ($p < 0.001$) with a strong effect size (Phi = 0.686).

Across BMI categories, the proportion of abnormal spirometry increased from 22.2% in the underweight group to 83.3% in the obese group. Given the presence of cells with expected counts <5, comparisons across BMI categories were conducted using the Fisher–Freeman–Halton exact test, which demonstrated a statistically significant association (p = 0.009) with a moderate effect size (Cramer's V = 0.438).

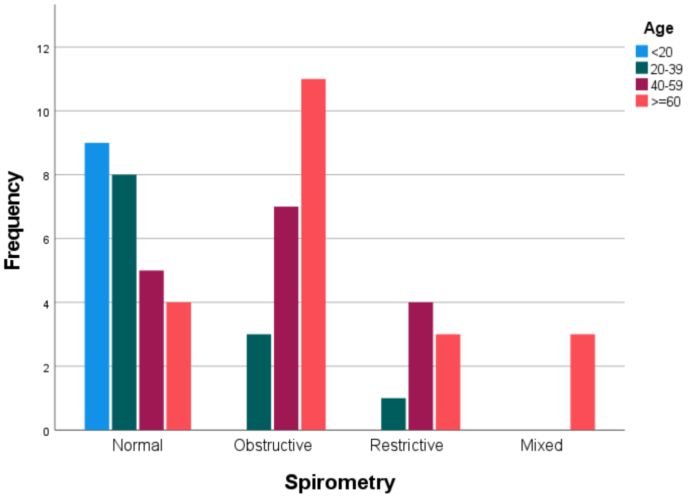

Figure 1. Distribution of spirometry result categories across age groups among residents of Dukuh Kupang Subdistrict, Surabaya, Indonesia (N = 58). The x-axis shows spirometry categories (normal, obstructive, restrictive, and mixed), and the y-axis shows the number of participants. Coloured bars represent age groups: <20 years, 20–39 years, 40–59 years, and ≥60 years.

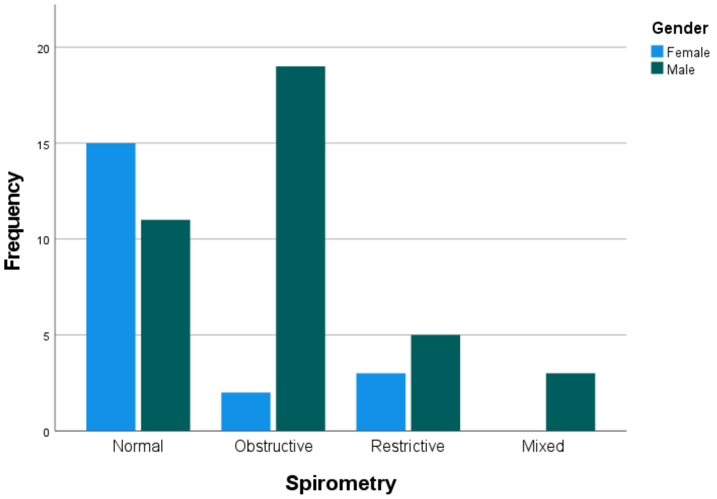

Figure 2. Distribution of spirometry result categories by sex among residents of Dukuh Kupang Subdistrict, Surabaya, Indonesia (N = 58). The x-axis shows spirometry categories (normal, obstructive, restrictive, and mixed), and the y-axis shows the number of participants. Coloured bars represent female and male participants.

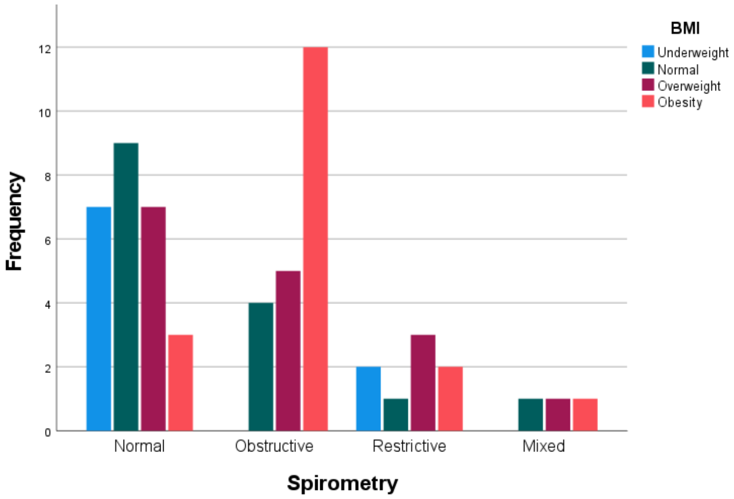

Figure 3. Distribution of spirometry result categories across body mass index (BMI) categories among residents of Dukuh Kupang Subdistrict, Surabaya, Indonesia (N = 58). The x-axis shows spirometry categories (normal, obstructive, restrictive, and mixed), and the y-axis shows the number of participants. Coloured bars represent BMI categories: underweight, normal, overweight, and obesity. BMI, body mass index.

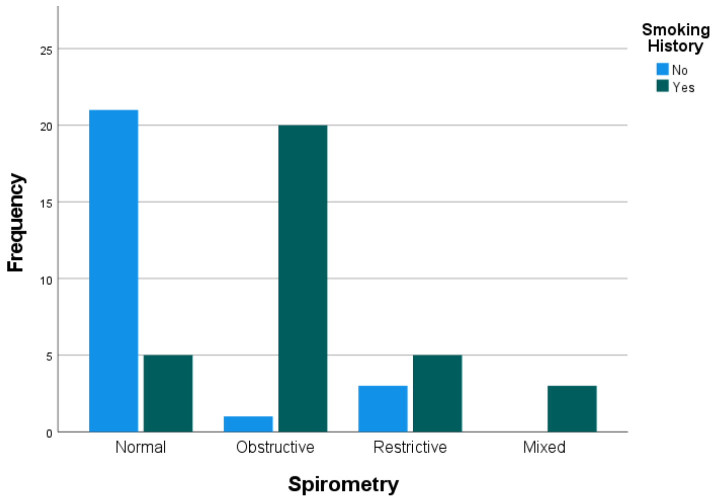

Figure 4. Distribution of spirometry result categories by smoking history among residents of Dukuh Kupang Subdistrict, Surabaya, Indonesia (N = 58). The x-axis shows spirometry categories (normal, obstructive, restrictive, and mixed), and the y-axis shows the number of participants. Coloured bars represent participants with no smoking history (never smokers) and those with a history of smoking (current or former smokers).

Discussion

This pilot study demonstrates that the implementation of spirometry as a community-based screening tool can identify a substantial proportion of individuals with abnormal pulmonary function, while revealing patterns of association consistent with established biological and behavioral determinants reported in previous studies [13–16]. These findings support the feasibility and potential value of spirometry as an early detection strategy at the community level, particularly in populations with significant exposure to respiratory risk factors. From a methodological perspective, the application of spirometry in community-based research requires strict attention to procedural quality, including maneuver acceptability and repeatability, as well as appropriate interpretative strategies. Spirometric results may be influenced by biological variability, maneuver performance, and the classification approach used to define ventilatory patterns. The 2019 ATS/ERS technical standards and the updated ERS/ATS interpretative framework emphasize rigorous quality control and caution in interpreting obstructive, restrictive, and mixed patterns to avoid misclassification and overinterpretation (10).

The strong association between older age groups and abnormal spirometry is consistent with the established understanding that pulmonary function declines physiologically with advancing age, and that such decline becomes more pronounced in the presence of chronic exposures—particularly tobacco smoke—and comorbid conditions. In the epidemiology of chronic respiratory diseases, aging is a well-recognized determinant of abnormal lung function and increased respiratory morbidity across diverse populations (1,3). The findings of this pilot study reinforce the argument that community-based spirometry screening may yield greater clinical utility when targeted toward middle-aged and older adults, given the higher probability of detecting abnormal ventilatory patterns in these age strata.

The higher proportion of abnormal spirometry observed among males may be explained through several interrelated pathways. First, in many settings, males have a greater likelihood of exposure to key respiratory risk factors—particularly tobacco use and occupational inhalational exposures—such that the observed difference may reflect disparities in cumulative exposure profiles. Second, a growing body of evidence supports sex-related differences in lung function and susceptibility to environmental exposures, including the influence of biological and hormonal factors, as well as anatomical and physiological variations that may modify spirometric parameters (17). Given the pilot nature of this study and the use of bivariate analyses, the observed sex differences should be interpreted cautiously as preliminary signals requiring confirmation in larger studies incorporating detailed exposure assessment and multivariable adjustment.

The very strong association observed between smoking history and abnormal spirometry findings represents the most consistent result in relation to the existing body of evidence (18,19). Longitudinal studies have consistently demonstrated that tobacco exposure accelerates the decline in lung function and correlates with the severity of ventilatory impairment, with cumulative exposure—commonly quantified in pack-years—being associated with a more rapid reduction in FEV_1 (20,21). Within the context of community-based screening, this finding underscores the potential added value of integrating spirometry screening with smoking cessation interventions, such as brief counseling and referral to cessation services. Individuals identified with abnormal spirometry results may represent a priority group for targeted behavioral interventions and structured clinical follow-up, thereby enhancing the preventive impact of community respiratory health programs.

In this study, the BMI category was also significantly associated with spirometry status. From a physiological perspective, obesity can alter respiratory mechanics through reductions in functional residual capacity (FRC) and expiratory reserve volume (ERV), increased chest wall load, and decreased lung compliance. On spirometry, these changes are often reflected as reduced FVC and may resemble a restrictive pattern or exacerbate a mixed ventilatory defect (22,23). However, these findings should be interpreted with caution, considering (1) the small sample size inherent to a pilot study, (2) the absence of adjustment for potential confounders such as age and smoking, and (3) the fact that a "restrictive" pattern on spirometry does not equate to true restriction without confirmation by total lung capacity (TLC) measurement. Future studies should incorporate additional measures such as body composition, waist circumference, physical activity levels, and metabolic comorbidities, as these factors may mediate the relationship between BMI and pulmonary function abnormalities.

In addition, BMI classification in this study followed the Indonesian Health Survey (SKI) 2023 criteria, in which obesity is defined at a lower threshold (BMI ≥27 kg/m²) than the conventional WHO definition (BMI ≥30 kg/m²). This classification was used to maintain consistency with nationally relevant public health standards and to improve the local interpretability of the findings. The lower threshold may permit earlier identification of excess adiposity and may influence BMI category assignment when interpreting its association with spirometric abnormalities. Nevertheless, the present study was not designed to directly compare pulmonary function outcomes across alternative BMI classification systems. Future studies should consider comparing national and WHO BMI cut off, together with more detailed adiposity measures, to better define their relationship with pulmonary function abnormalities.

This study also highlights the need to distinguish routine COPD screening in asymptomatic adults from community-based early detection of pulmonary function abnormalities among individuals with potential risk exposures. Several studies do not recommend routine COPD screening in asymptomatic adults due to insufficient evidence of clear clinical benefit in this population (19). In contrast, a number of reviews advocate for a case-finding approach—particularly among individuals with respiratory symptoms and/or established risk factors such as smoking—as a more rational and efficient strategy than universal population screening (24,25). Within this framework, the pilot study conducted in Dukuh Kupang, Surabaya, provides preliminary justification for positioning spirometry as a community-level risk-mapping and triage tool rather than as a standalone diagnostic instrument in the absence of a clinical context. Practically, this approach enables the identification of individuals who may benefit from further clinical evaluation, targeted risk factor education, and structured referral to primary healthcare services.

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional design precludes causal inference; the observed associations reflect relationships at a single point in time. Second, as a pilot study employing consecutive sampling, the results may be subject to selection bias, as individuals who attended the screening may differ systematically from the broader community population. Third, smoking exposure was assessed dichotomously; without information on intensity or cumulative exposure (e.g., pack-years), the analysis was unable to evaluate dose–response relationships.

Thus, future studies should incorporate more detailed smoking exposure assessment to better characterize its association with spirometric abnormalities. Fourth, the classification of a restrictive pattern on spirometry should be regarded as “suspected restriction,” as definitive confirmation requires measurement of lung volumes, particularly total lung capacity (TLC). Finally, the use of exact statistical tests in several analyses reflects limited sample size; larger studies are therefore necessary to obtain more precise estimates and to enable robust multivariable analyses.

Overall, this pilot study provides preliminary evidence that community-level spirometry screening at the subdistrict level can identify pulmonary function abnormalities associated with key determinants, including age, sex, smoking status, and body mass index. These findings offer an empirical foundation for designing larger, more representative studies incorporating more comprehensive exposure assessment and standardized referral pathways. Such efforts are essential to strengthen the development of structured, community-based lung health interventions and to optimize early identification and risk stratification strategies in primary care settings.

Conclusion

This pilot study demonstrates that spirometry screening conducted in Dukuh Kupang Subdistrict, Surabaya, was able to identify pulmonary function abnormalities at the community level. These abnormalities were significantly associated with older age, male sex, and a history of smoking, and also showed a relationship with body mass index (BMI) categories. The findings also support the use of spirometry as an initial risk-mapping tool and provide a foundation for planning larger-scale studies with more comprehensive exposure assessment and analytical adjustment.

Conflicts of Interest

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript.

Funding sources

There is no funding source

Acknowledgments

The authors would like to express their gratitude to all participants who voluntarily took part in the spirometry screening conducted in Dukuh Kupang Subdistrict, Surabaya. Appreciation is also extended to the local administrative officers, community leaders, and community health volunteers/partners for their support in coordinating and facilitating the implementation of the activities. The authors further acknowledge the contributions of the field team members and spirometry examiners for their assistance in data collection and for ensuring that all procedures were conducted in accordance with established protocols.

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