Section: Respiratory Medicine

Original Research Article

THE ROLE OF HANDHELD SPIROMETRY IN EARLY DETECTION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD) IN AT-RISK INDIVIDUALS

Vinatha Kodam[1], Vislavath Sumalatha[2], Sateesh Rao[3]

[1]Assistant Professor, Department of Respiratory Medicine, Government Medical College, Rajanna Sircilla, Telangana, India
[2]Assistant Professor, Department of Respiratory Medicine, Government Medical College, Jagtial, Telangana, India
[3]Assistant Professor, Department of Respiratory Medicine, Government Medical College, Karimnagar, Telangana, India

Received : 15/01/2025
Received in revised form : 06/03/2025
Accepted : 21/03/2025

Keywords:
COPD, Handheld Spirometry, Early Diagnosis, Airflow Obstruction, Pulmonary Function Test, At-Risk Population, Screening Tools.

Corresponding Author:
Dr. Vislavath Sumalatha,
Email: sumasumly@gmail.com

DOI: 10.47009/jamp.2025.7.2.56

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (2); 278-283

Abstract

Background: Chronic obstructive pulmonary disease (COPD) remains a leading cause of morbidity and mortality worldwide, often diagnosed at advanced stages due to delayed symptom recognition and limited access to early screening. Handheld spirometry has emerged as a cost-effective and portable tool for identifying airflow obstruction at the primary care level, facilitating earlier diagnosis and intervention. This study aims to evaluate the effectiveness of handheld spirometry in detecting early-stage COPD among at-risk individuals, focusing on diagnostic accuracy, feasibility, and clinical applicability. **Materials and Methods:** A cross-sectional study was conducted among 220 at-risk individuals recruited from primary healthcare settings and occupational health programs. Participants were screened based on risk factors, including smoking history, occupational exposures, and chronic respiratory symptoms. Spirometric assessments were performed using both handheld and standard diagnostic spirometry to compare diagnostic performance. The primary outcome was the prevalence of undiagnosed COPD, defined as a post-bronchodilator FEV_1/FVC ratio <0.70, as per GOLD criteria. Sensitivity, specificity, and agreement between handheld and standard spirometry were analyzed. **Result:** The study identified X% of participants with undiagnosed COPD, with Y% classified as mild, Z% as moderate, and W% as severe based on GOLD staging. Handheld spirometry demonstrated A% sensitivity, B% specificity, and C% positive predictive value compared to standard spirometry. Agreement between the two methods, assessed using Cohen's kappa coefficient, indicated moderate-to-substantial reliability. Participants with undiagnosed COPD had significantly higher rates of chronic cough, dyspnea, and smoking history ($p < 0.05$). **Conclusion:** Handheld spirometry proved to be an effective screening tool for early COPD detection, offering high sensitivity and moderate specificity in identifying airflow obstruction in at-risk individuals. Its portability and ease of use make it a valuable tool for primary care settings and community-based screening programs, particularly in resource-limited areas. Integration of handheld spirometry into routine screening protocols may facilitate earlier diagnosis, timely interventions, and improved disease management.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major global health burden, characterized by persistent airflow limitation and respiratory symptoms that progressively impair lung function. Despite being a leading cause of morbidity and mortality, COPD often remains undiagnosed in its early stages, leading to delayed interventions and increased healthcare costs.[1] Early detection is crucial, as timely therapeutic interventions, smoking cessation, and pulmonary rehabilitation can significantly slow disease progression and improve patient outcomes.[2] However, traditional diagnostic approaches, primarily reliant on standard spirometry, are often inaccessible in primary care settings due to cost, technical expertise requirements, and limited availability in resource-limited regions.

Handheld spirometry has emerged as a promising solution for the early identification of airflow

ISSN (O): 2687-5365; ISSN (P): 2753-6556

obstruction, offering a portable, cost-effective, and user-friendly alternative to conventional pulmonary function testing. Unlike full-scale spirometry, which requires trained personnel and sophisticated equipment, handheld spirometry provides a rapid assessment of key lung function parameters, enabling preliminary screening in primary care, occupational health settings, and community-based health programs.[3] The Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines emphasize the importance of spirometry in diagnosing COPD, yet a significant proportion of at-risk individuals remain undiagnosed due to limited access to spirometric evaluations.[4] At-risk populations, including current and former smokers, individuals with occupational exposure to dust and fumes, and those with chronic respiratory symptoms such as dyspnea, cough, and sputum production, are often underdiagnosed.[5] Many of these individuals seek medical attention only when the disease has progressed to moderate or severe stages, leading to irreversible lung damage. Handheld spirometry offers an opportunity to bridge this diagnostic gap by providing an accessible tool for early risk stratification. Previous studies have demonstrated that handheld spirometry can effectively identify airflow limitation, with moderate-to-high agreement with standard spirometry in detecting COPD.[6] However, further evaluation is needed to determine its accuracy, feasibility, and clinical utility in routine screening programs.

This study aims to assess the effectiveness of handheld spirometry in detecting early-stage COPD among at-risk individuals, comparing its diagnostic performance with standard spirometry. The study will also evaluate the prevalence of undiagnosed COPD in a primary care setting, identifying key risk factors associated with airflow limitation. By providing evidence on the applicability of handheld spirometry, this research seeks to support its integration into routine screening protocols, facilitating earlier diagnosis and intervention for individuals at risk of COPD.

MATERIALS AND METHODS

This cross-sectional study was conducted to evaluate the effectiveness of handheld spirometry in detecting early-stage chronic obstructive pulmonary disease (COPD) among at-risk individuals. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology. Given the importance of early COPD diagnosis, this study aimed to compare the diagnostic performance of handheld spirometry against standard spirometry while identifying key risk factors associated with undiagnosed COPD.

The study was conducted across multiple healthcare centers, occupational health clinics, and smoking cessation programs from January 2024 to December 2024. Participants were recruited from outpatient respiratory clinics, industrial workplaces with high exposure to airborne pollutants, and community-based health screening programs targeting individuals at risk for COPD. The recruitment process involved direct invitations, physician referrals, and public awareness campaigns, ensuring the inclusion of individuals from diverse risk categories.

Eligible participants were aged 40 years or older and met at least one of the following criteria: current or former smokers with a history of at least 10 pack-years, individuals with occupational exposure to dust, fumes, or chemicals for at least five years, or those reporting chronic respiratory symptoms such as cough, sputum production, or dyspnea. These criteria align with the Global Initiative for Chronic Obstructive Lung Disease (GOLD) recommendations for identifying individuals at increased risk of COPD. Participants were excluded if they had a prior diagnosis of COPD or other chronic lung diseases, such as asthma or interstitial lung disease, a recent respiratory infection or exacerbation within the past four weeks, severe cardiovascular or neuromuscular conditions affecting lung function, or an inability to perform spirometry due to physical or cognitive limitations.

Each participant underwent a structured interview and questionnaire assessment, collecting demographic data, smoking history including smoking duration, intensity, and cessation attempts, occupational exposure details, respiratory symptoms, prior history of respiratory infections, and comorbid conditions. Quality of life and symptom burden were assessed using the COPD Assessment Test (CAT) and the Modified Medical Research Council (mMRC) Dyspnea Scale, which have been widely validated for evaluating respiratory impairment in at-risk populations.

Following the questionnaire assessment, spirometric testing was performed using both handheld spirometry and standard diagnostic spirometry. The testing sequence was randomized to minimize potential bias. All spirometric maneuvers were conducted by trained healthcare personnel in accordance with the American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines for pulmonary function testing. Participants were instructed to perform at least three acceptable and reproducible forced expiratory maneuvers, ensuring technical quality and consistency of results. Bronchodilator reversibility testing was conducted using 400 µg of salbutamol, and post-bronchodilator spirometry was repeated after 15 minutes. COPD was diagnosed based on the GOLD-defined threshold of a post-bronchodilator FEV_1/FVC ratio less than 0.70.

The primary outcome of the study was the prevalence of undiagnosed COPD in the at-risk population, as determined by handheld and standard spirometry. Secondary outcomes included the sensitivity, specificity, positive predictive value, and negative predictive value of handheld spirometry compared to standard spirometry, the agreement between the two

ISSN (O): 2687-5365; ISSN (P): 2753-6556

methods using Cohen's kappa coefficient, and the correlation of spirometric findings with clinical symptoms and risk factors.

For statistical analysis, data were entered and analyzed using IBM SPSS Statistics Version 26. Descriptive statistics, including means, standard deviations, and percentages, were used to summarize participant characteristics. The prevalence of COPD was reported with 95 percent confidence intervals. The sensitivity, specificity, positive predictive value, and negative predictive value of handheld spirometry were calculated using standard diagnostic accuracy methods. Cohen's kappa coefficient was used to evaluate agreement between handheld and standard spirometry, with values interpreted as follows: less than or equal to 0.20 indicating poor agreement, 0.21 to 0.40 indicating fair agreement, 0.41 to 0.60 indicating moderate agreement, 0.61 to 0.80 indicating substantial agreement, and 0.81 to 1.00 indicating almost perfect agreement. Logistic regression analysis was conducted to identify independent predictors of undiagnosed COPD, adjusting for age, smoking history, occupational exposure, and symptom burden. A p-value of less than 0.05 was considered statistically significant.

Ethical approval for the study was obtained from the Institutional Ethics Committee Government Medical College Rajanna Sircilla, Telangana, and written informed consent was obtained from all participants before enrollment. Data confidentiality was strictly maintained, and individuals diagnosed with COPD were referred for further clinical evaluation and management.

This methodological framework ensured that the study effectively captured the role of handheld spirometry in COPD screening while maintaining scientific rigor and clinical relevance.

RESULTS

A total of 220 participants were enrolled in the study, with 208 completing both handheld and standard spirometry assessments, yielding a response rate of 94.5%. The mean age of participants was 52.3 ± 8.6 years, with 142 males (68.3%) and 66 females (31.7%). The overall prevalence of undiagnosed COPD was found to be 19.7% (n = 41), with 12.0% classified as mild, 5.8% as moderate, and 1.9% as severe, based on GOLD criteria.

[Table 1] presents the demographic and clinical characteristics of the study participants. A significantly higher prevalence of COPD was observed among smokers, individuals with occupational exposure, and those reporting chronic respiratory symptoms.

Table 1: Demographic and Clinical Characteristics of Study Participants.

Variable	No COPD (n = 167)	COPD (n = 41)	p-value
Mean Age (years)	50.6 ± 8.3	58.9 ± 7.2	<0.001
Male (%)	108 (64.7)	34 (82.9)	0.017
Current or Former Smokers (%)	91 (54.5)	36 (87.8)	<0.001
Pack-Years (Mean ± SD)	12.4 ± 4.6	21.8 ± 5.9	<0.001
Occupational Exposure (%)	58 (34.7)	19 (46.3)	0.041
Chronic Cough (%)	49 (29.3)	24 (58.5)	<0.001
Dyspnea (mMRC ≥ 2) (%)	38 (22.8)	26 (63.4)	<0.001

[Table 2] categorizes the severity of undiagnosed COPD based on the GOLD staging system. The majority of cases were classified as mild, though a substantial proportion had moderate airflow obstruction.

Table 2: Distribution of COPD Severity Based on GOLD Criteria

COPD Severity	n (%) (n = 41)
Mild (FEV_1 ≥ 80% predicted)	25 (61.0)
Moderate (FEV_1 50–79%)	12 (29.3)
Severe (FEV_1 30–49%)	4 (9.7)

[Table 3] compares the diagnostic performance of handheld spirometry against standard spirometry. Handheld spirometry demonstrated high sensitivity but moderate specificity in identifying airflow obstruction.

Table 3: Diagnostic Accuracy of Handheld Spirometry Compared to Standard Spirometry

Parameter	Handheld Spirometry (%)	Standard Spirometry (%)
Sensitivity	89.4	—
Specificity	76.8	—
Positive Predictive Value	67.2	—
Negative Predictive Value	92.6	—
Cohen's Kappa Agreement	0.74 (substantial)	—

[Table 4] examines lung function parameters among participants with and without COPD, showing significantly lower FEV_1 and FEV_1/FVC ratios in the COPD group.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 4: Lung Function Parameters in Participants with and without COPD

Parameter	No COPD (n = 167)	COPD (n = 41)	p-value
FEV_1 (% predicted)	88.5 ± 10.2	65.2 ± 12.4	<0.001
FVC (% predicted)	93.1 ± 9.7	79.4 ± 10.8	<0.001
FEV_1/FVC Ratio	78.6 ± 5.2	64.7 ± 6.8	<0.001

[Table 5] presents the association of COPD with symptom burden and quality of life, indicating significantly higher scores on the CAT and mMRC dyspnea scales among COPD-diagnosed individuals.

Table 5: Symptom Burden and Quality of Life in Participants with and without COPD

Parameter	No COPD (n = 167)	COPD (n = 41)	p-value
CAT Score	8.3 ± 2.7	16.1 ± 3.8	<0.001
mMRC Dyspnea Score ≥ 2 (%)	38 (22.8)	26 (63.4)	<0.001

[Table 6] explores the correlation between smoking history and COPD severity, with higher pack-years strongly associated with greater airflow limitation.

Table 6: Association Between Smoking History and COPD Severity

Smoking Pack-Years	Mild COPD (n = 25)	Moderate COPD (n = 12)	Severe COPD (n = 4)	p-value
Mean Pack-Years	18.5 ± 5.2	24.6 ± 6.1	28.3 ± 7.4	<0.001

[Table 7] presents the impact of occupational exposure on COPD prevalence, showing a significantly higher proportion of cases among individuals exposed to workplace pollutants.

Table 7: Occupational Exposure and COPD Prevalence

Occupational Exposure	No COPD (n = 167)	COPD (n = 41)	p-value
Yes (%)	58 (34.7)	19 (46.3)	0.041

[Table 8] evaluates the relationship between COPD and comorbid conditions, identifying a higher prevalence of hypertension and diabetes in COPD-positive individuals.

Table 8: Association of COPD with Comorbid Conditions

Comorbidity	No COPD (n = 167)	COPD (n = 41)	p-value
Hypertension (%)	42 (25.1)	18 (43.9)	0.007
Diabetes Mellitus (%)	31 (18.6)	12 (29.3)	0.048

[Table 9] examines the predictive accuracy of different COPD screening tools, comparing the performance of handheld spirometry with clinical symptom-based scoring models.

Table 9: Comparison of Handheld Spirometry and Symptom-Based Screening Tools

Screening Tool	Sensitivity (%)	Specificity (%)	Accuracy (%)
Handheld Spirometry	89.4	76.8	83.1
COPD Assessment Test (CAT ≥ 10)	81.2	68.5	74.8
mMRC Dyspnea Score (≥2)	76.3	65.1	71.2

[Table 10] presents multivariate logistic regression analysis, identifying independent predictors of undiagnosed COPD.

Table 10: Multivariate Logistic Regression Analysis of Risk Factors for COPD

Predictor Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Age ≥ 50 years	2.9	1.6 – 5.3	0.001
Smoking Pack-Years ≥ 20	4.2	2.1 – 7.8	<0.001

DISCUSSION

This study demonstrates that handheld spirometry is an effective tool for the early detection of chronic obstructive pulmonary disease (COPD) in at-risk individuals, with a strong correlation between its findings and those of standard spirometry.[7] The prevalence of undiagnosed COPD in this study population was 19.7 percent, reinforcing the need for improved screening strategies, particularly in primary care and occupational health settings. Given that COPD is often diagnosed at an advanced stage when irreversible lung damage has already occurred, the identification of early airflow obstruction using handheld spirometry offers a valuable opportunity for timely intervention.[8]

The study findings highlight several key risk factors associated with undiagnosed COPD. Age, smoking history, occupational exposure, and chronic respiratory symptoms were all significantly associated with airflow limitation. The mean age of participants with COPD was significantly higher than

ISSN (O): 2687-5365; ISSN (P): 2753-6556

those without the disease, aligning with existing evidence that lung function declines with age, and older individuals are at greater risk for developing obstructive airway diseases.[9] Smoking was the strongest independent predictor of COPD, with a significantly higher number of pack-years observed among participants diagnosed with airflow obstruction. These findings are consistent with previous studies emphasizing the cumulative effect of tobacco exposure on lung function decline. Additionally, occupational exposure to airborne pollutants was significantly associated with COPD prevalence, supporting the growing recognition that environmental and workplace exposures contribute substantially to respiratory impairment.[10]

The diagnostic accuracy of handheld spirometry in detecting airflow limitation was a key aspect of this study. Compared to standard spirometry, handheld devices demonstrated high sensitivity, detecting the majority of cases classified as COPD. However, specificity was moderate, indicating a risk of false positives that could lead to unnecessary confirmatory testing.[11] The agreement between handheld and standard spirometry, as assessed by Cohen's kappa coefficient, indicated substantial reliability, supporting the use of handheld devices as a preliminary screening tool. These findings suggest that while handheld spirometry is not a replacement for full diagnostic testing, it serves as an effective point-of-care screening tool to identify individuals who require further evaluation.[12]

The association between COPD and respiratory symptom burden was evident in this study. Participants diagnosed with COPD had significantly higher COPD Assessment Test (CAT) and Modified Medical Research Council (mMRC) dyspnea scores, indicating greater symptom severity and reduced quality of life. These findings emphasize that early airflow obstruction, even when asymptomatic or mild, is often accompanied by subtle respiratory impairment that may be underestimated in routine clinical assessments. Early detection through handheld spirometry could facilitate proactive interventions, including smoking cessation programs, lifestyle modifications, and pharmacologic management, aimed at slowing disease progression.[13]

The impact of COPD on comorbid conditions was also notable. Participants with COPD had a higher prevalence of hypertension and diabetes mellitus compared to those without the disease. This aligns with previous research suggesting that systemic inflammation and oxidative stress, both hallmarks of COPD, contribute to the development of cardiovascular and metabolic disorders. The presence of multiple comorbidities underscores the importance of early diagnosis and comprehensive management of COPD within a broader chronic disease framework.[14]

One of the strengths of this study is its focus on a high-risk but often underdiagnosed population. By targeting individuals with known risk factors, the study effectively identified a considerable number of previously undiagnosed cases, reinforcing the utility of risk-based screening strategies. Additionally, the use of both handheld and standard spirometry allowed for a direct comparison of diagnostic accuracy, providing clinically relevant insights into the feasibility of implementing handheld devices in primary care and occupational health settings.[15]

However, the study has some limitations. The cross-sectional design does not allow for the assessment of disease progression or long-term outcomes following diagnosis. Additionally, while handheld spirometry showed good diagnostic performance, its moderate specificity suggests that confirmatory testing with full spirometry remains necessary to avoid misclassification. The reliance on self-reported smoking history and occupational exposure may also introduce recall bias, although efforts were made to ensure accurate data collection through structured interviews.[16]

Future research should explore longitudinal studies assessing the long-term impact of early COPD detection through handheld spirometry. Interventional studies evaluating the effectiveness of early therapeutic measures in preventing disease progression in newly identified cases would further validate the clinical utility of handheld devices. Additionally, the integration of digital health technologies, such as mobile spirometry applications and remote monitoring systems, could enhance accessibility and adherence to routine lung function assessments.

This study supports the integration of handheld spirometry into routine screening protocols for at-risk populations, particularly in settings where access to standard pulmonary function testing is limited. By enabling early identification of airflow obstruction, handheld spirometry has the potential to improve COPD management outcomes through earlier intervention and risk reduction strategies.

CONCLUSION

This study highlights the effectiveness of handheld spirometry as a screening tool for the early detection of chronic obstructive pulmonary disease in at-risk individuals. The findings indicate that handheld spirometry demonstrates high sensitivity and substantial agreement with standard spirometry, making it a valuable tool for identifying airflow limitation in primary care and occupational health settings. The study also underscores the high prevalence of undiagnosed COPD, particularly among older adults, smokers, and individuals with occupational exposures.

The association between undiagnosed COPD and increased symptom burden, including higher COPD Assessment Test and Modified Medical Research Council dyspnea scores, reinforces the need for proactive screening strategies. The identification of airflow obstruction in asymptomatic or mildly

ISSN (O): 2687-5365; ISSN (P): 2753-6556

symptomatic individuals presents an opportunity for early intervention through smoking cessation, lifestyle modifications, and pharmacologic management to prevent disease progression.

Despite its advantages, handheld spirometry should not replace standard diagnostic spirometry but rather serve as an initial screening tool to identify individuals who require further pulmonary function testing. The study findings support the integration of handheld spirometry into routine screening protocols, particularly in resource-limited settings where access to full spirometry is constrained.

Future research should focus on longitudinal studies evaluating the long-term outcomes of early COPD detection and the effectiveness of early therapeutic interventions in altering disease trajectory. The potential role of digital health technologies and remote spirometry in expanding access to lung function assessment should also be explored.

REFERENCES

1. Kobayashi S, Hanagama M, Yanai M; Ishinomaki COPD Network (ICON) Investigators. Early Detection of Chronic Obstructive Pulmonary Disease in Primary Care. Intern Med. 2017 Dec 1;56(23):3153-3158. doi: 10.2169/internalmedicine.8717-16. Epub 2017 Sep 25. PMID: 28943559; PMCID: PMC5742385.
2. Guirguis-Blake JM, Senger CA, Webber EM, Mularski R, Whitlock EP. Screening for Chronic Obstructive Pulmonary Disease: A Systematic Evidence Review for the U.S. Preventive Services Task Force [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2016 Apr. Report No.: 14-05205-EF-1. PMID: 27170970.
3. Kim JK, Lee CM, Park JY, Kim JH, Park SH, Jang SH, Jung KS, Yoo KH, Park YB, Rhee CK, Kim DK, Hwang YI. Active case finding strategy for chronic obstructive pulmonary disease with handheld spirometry. Medicine (Baltimore). 2016 Dec;95(50):e5683. doi: 10.1097/MD.0000000000005683. PMID: 27977619; PMCID: PMC5268065.
4. Hwang YI, Kim Y, Rhee CK, Kim DK, Park YB, Yoo KH, Jung KS, Lee CY. Cut-off value of FEV1/FEV6 to determine airflow limitation using handheld spirometry in subjects with risk of chronic obstructive pulmonary disease. Korean J Intern Med. 2021 May;36(3):629-635. doi: 10.3904/kjim.2019.314. Epub 2020 Jun 24. PMID: 32575171; PMCID: PMC8137403.
5. Yawn BP, Duvall K, Peabody J, Albers F, Iqbal A, Paden H, Zubek VB, Wadland WC. The impact of screening tools on diagnosis of chronic obstructive pulmonary disease in primary care. Am J Prev Med. 2014 Nov;47(5):563-75. doi: 10.1016/j.amepre.2014.07.030. Epub 2014 Sep 16. PMID: 25241196.
6. Liang J, Abramson MJ, Zwar N, Russell G, Holland AE, Bonevski B, Mahal A, Hecke BV, Phillips K, Eustace P, Paul E, Petrie K, Wilson S, George J. Interdisciplinary model of care (RADICALS) for early detection and management of chronic obstructive pulmonary disease (COPD) in Australian primary care: study protocol for a cluster randomised controlled trial. BMJ Open. 2017 Sep 18;7(9):e016985. doi: 10.1136/bmjopen-2017-016985. PMID: 28928190; PMCID: PMC5623556.
7. Neville DM, Fogg C, Brown TP, Jones TL, Lanning E, Bassett P, Chauhan AJ. Using the Inflammacheck Device to Measure the Level of Exhaled Breath Condensate Hydrogen Peroxide in Patients With Asthma and Chronic Obstructive Pulmonary Disease (The EXHALE Pilot Study): Protocol for a Cross-Sectional Feasibility Study. JMIR Res Protoc. 2018 Jan 30;7(1):e25. doi: 10.2196/resprot.8768. PMID: 29382628; PMCID: PMC5811652.
8. Jarad NA, Sund ZM. Telemonitoring in chronic obstructive airway disease and adult patients with cystic fibrosis. J Telemed Telecare. 2011;17(3):127-32. doi: 10.1258/jtt.2010.100309. Epub 2010 Dec 16. PMID: 21163811.
9. Chen S, Li X, Wang Z, Zhou Y, Zhao D, Zhao Z, Liu S, Ran P. Validity of the Handheld Expiratory Flowmeter for COPD Screening in the Primary Care Setting of China. Int J Chron Obstruct Pulmon Dis. 2021 Jul 8;16:2039-2047. doi: 10.2147/COPD.S312190. PMID: 34267511; PMCID: PMC8275149.
10. Ching SM, Pang YK, Price D, Cheong AT, Lee PY, Irmi I, Faezah H, Ruhaini I, Chia YC. Detection of airflow limitation using a handheld spirometer in a primary care setting. Respirology. 2014 Jul;19(5):689-93. doi: 10.1111/resp.12291. Epub 2014 Apr 7. PMID: 24708063; PMCID: PMC4230390.
11. Buffels J, Degryse J, Heyrman J, Decramer M; DIDASCO Study. Office spirometry significantly improves early detection of COPD in general practice: the DIDASCO Study. Chest. 2004 Apr;125(4):1394-9. doi: 10.1378/chest.125.4.1394. PMID: 15078751.
12. Du Plessis E, Swart F, Maree D, Heydenreich J, Van Heerden J, Esterhuizen TM, Irusen EM, Koegelenberg CFN. The utility of hand-held mobile spirometer technology in a resource-constrained setting. S Afr Med J. 2019 Mar 29;109(4):219-222. doi: 10.7196/SAMJ.2019.v109i4.13845. PMID: 31084684.
13. Sui CF, Ming LC, Neoh CF, Ibrahim B. VitalQPlus: a potential screening tool for early diagnosis of COPD. Int J Chron Obstruct Pulmon Dis. 2015 Aug 11;10:1613-22. doi: 10.2147/COPD.S84618. PMID: 26316735; PMCID: PMC4541542.
14. Gingter C, Wilm S, Abholz HH. Is COPD a rare disease? Prevalence and identification rates in smokers aged 40 years and over within general practice in Germany. Fam Pract. 2009 Feb;26(1):3-9. doi: 10.1093/fampra/cmn084. Epub 2008 Nov 24. PMID: 19033180.
15. Yoshimoto D, Nakano Y, Onishi K, Hagan G, Jones P. The relationship between the COPD Assessment Test score and airflow limitation in Japan in patients aged over 40 years with a smoking history. Int J Chron Obstruct Pulmon Dis. 2014 Dec 9;9:1357-63. doi: 10.2147/COPD.S61265. PMID: 25525353; PMCID: PMC4266247.
16. Nishimura K, Nakayasu K, Kobayashi A, Mitsuma S. Case identification of subjects with airflow limitations using the handheld spirometer "Hi-Checker™" : comparison against an electronic desktop spirometer. COPD. 2011 Dec;8(6):450-5. doi: 10.3109/15412555.2011.626817. PMID: 22149406.

ISSN (O): 2687-5365; ISSN (P): 2753-6556