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COMPARATIVE ANALYSIS OF LONG TERM OCCUPATIONAL EXPOSURE ON PULMONARY FUNCTION AMONG NON SMOKING FEMALE SWEEPERS AND HOUSEHOLD WORKERS: A CROSS -SECTIONAL STUDY

Lavanya Kumar[1], Aravind Shanmugam[2]*, Vijayavardhini B[3], Pooja E[4], Prathap S[5]

[1]Postgraduate, Saveetha Collage of Physiotherapy, Saveetha Institute of Medical & Technical Sciences(SIMATS), Chennai, Tamil Nadu, India.
Orchid ID: 0009-0007-91511314
[2]Assistant Professor, Saveetha Collage of Physiotherapy, Saveetha Institute of Medical & Technical Sciences(SIMATS), Chennai, Tamil Nadu, India.
Orchid ID: 0009-00081142-4059
[3]Postgraduate, Saveetha Collage of Physiotherapy, Saveetha Institute of Medical & Technical Sciences(SIMATS), Chennai, Tamil Nadu, India.
Orchid ID:0009-0001-8164470X
[4]Postgraduate, Saveetha Collage of Physiotherapy, Saveetha Institute of Medical & Technical Sciences(SIMATS), Chennai, Tamil Nadu, India.
Orchid ID:0009-0005-13019805
[5]Principal , Saveetha Collage of Physiotherapy, Saveetha Institute of Medical & Technical Sciences(SIMATS), Chennai, Tamil Nadu, India.
Orchid ID: 0000-0002-1491266X
*Corresponding Author: Aravind Shanmugam

ABSTRACT

Background: This research explore the impact of occupational exposure on Respiratory function and pulmonary health among non- smoking female domestic workers and street sweepers.

Methods: This cross-sectional investigation involved 100 non-smoking women between 29 and 60 years of age who had been employed in their respective occupations for 10 -12 years. The participants were allocated into two equal groups consisting of 50 street sweepers and 50 household workers. Respiratory symptoms were assessed using the Clinical COPD Questionnaire (CCQ), while pulmonary function was evaluated by measuring Peak Expiratory Flow Rate (PEFR) and comparing spirometric parameters with predicted reference values adjusted for age, sex and anthropometric characteristics. Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 25.0. Statistical significance was established at a p-value below 0.05.

Results: The two occupational groups showed differences in lung function and respiratory symptoms. The standardized mean differences for PEFR, 1.9200 in household workers and 2.2600 in sweepers; for CCQ, 1.9200 in household workers and 1.6200 in sweepers. The FEV1 predicted values were 1.9600 for household workers and 2.3000 for sweepers; FVC predicted values were 1.7600 and 2.2000 respectively. The FEV1/FVC ratio was 1.8200 in household workers and 2.1800 in sweepers. FEF25-75 predicted values were 2.0000 for household workers and 2.3600 for sweepers.

Conclusion: this study concluded that both groups were affected, household workers showed slightly greater impairment in pulmonary function and reported more respiratory symptoms. Continuous exposure to dust and untreated respiratory symptoms may further increase the risk of developing chronic respiratory conditions over time. These findings highlight the importance of regular health screening, early treatment of symptoms and preventive measures to protect respiratory health.

KEYWORDS: Street sweepers; Household workers; Lung function; Air contamination

INTRODUCTION

Chronic respiratory illnesses are one of the main causes of death and disability worldwide, making them a significant health concern. These illnesses were thought to be the third most common cause of death globally in 2017 and since 1990, their frequency has risen by over 40%[1]. Occupational respiratory diseases represent a significant public health issue, particularly affecting individuals exposed to hazardous substances at work[2] . Sweepers are exposed to airborne dust, which arises from sweeping with brooms, vehicular movement and other human activities[3]. Such exposure is consistently identified as a significant occupational hazard and a common contributor to respiratory diseases. This repeated exposure can result in both acute and long-term declines in lung function. Sweepers are continuously exposed to a complex mixture of airborne pollutants, including soil particles and bio-aerosols of biological origin such as pollen, plant-based organic compounds and particulate matter arising from vehicle emissions and movement[4]. During street sweeping, fine dust particles become airborne and are inhaled deeply into the respiratory tract and these particles can deposit throughout the airways including the small bronchi and alveoli[5].

These interactions ultimately result in the release of several cytokines which cause inflammation and tissue damage[6]. Airway narrowing due to inflammation and remodelling results in thickened airway walls and reduced airflow. Mucus hyper secretion happens by goblet cell hyperplasia which increases mucus production, contributing to airflow obstruction[7].While brief exposure to dust can result in serious harm as well as prolonged exposure over months or years can induce long-term diseases or injuries. Those who are exposed to dust at work are more likely to have sneezing, coughing, eye irritation, lung tissue oedema and throat infections. Furthermore, occupational lung disorders may result from the symptoms of compromised lung function[8]. A progressive, irreversible loss of lung function is a defining feature of the natural history of COPD. Under normal circumstances, lung function reaches its peak between the ages of 20 and 25, after which it gradually declines as people age[9]. COPD is marked by persistent inflammation in the lungs, involving elevated numbers of neutrophils, macrophages and a predominance of CD8 T lymphocytes over CD4 T lymphocytes. The severity of lung inflammation increases in proportion to the degree of airflow limitation[10]. Irreversible airflow obstruction is often accompanied by dyspnoea, persistent cough and phlegm, which are characteristic of COPD and is mainly associated with smoking and other possible factors including indoor air pollution, outdoor air pollution and occupational exposure[11].

COPD in non-smokers may account for as much as 25 % - 45%of cases in low- and middleincome countries[12]. The effect of indoor household factors causing respiratory difficulties mostly among women has been underappreciated in evaluating the global burden of lung conditions[13]. One-third of all people worldwide use solid fuels like coal or biomass for daily activities including lighting, heating and cooking. Common methods of combustion include open flames or simple stoves, which do not burn the fuel completely and lack proper ventilation. As a result, they generate significant amounts of pollutants in the air inside buildings. Household air pollution is a major global health concern and is considered the leading environmental cause of death, contributing to an estimated 3.5 to 4 million deaths each year[14]. In low- and middle-income countries, household air pollution is connected to several health issues, including tuberculosis, asthma, respiratory infections in adults and children, chronic obstructive pulmonary disease and respiratory-related deaths[15]. A recently published large-scale population-based cohort study from the United Kingdom found that cleaners are among the occupations with the greatest risk of developing COPD as identified through spirometry testing method[16]. Several studies have examined the correlation between air pollution in homes and respiratory illnesses[17]. Household workers are routinely exposed to chemical cleaning agents such as bleach, ammonia and sprays, often in poorly ventilated environments, which poses a serious risk to their respiratory health[18].

Inhalation of pollutants from household air pollution, including Particulate Matter 2.5, Carbon monoxide and Nitrogen Dioxide , triggers immune cell activation, which in turn releases inflammatory cytokines along with enzymes that harm lung tissue, resulting in chronic inflammation of the respiratory tract. These pollutants also produce reactive oxygen species, causing oxidative stress that impairs lung cell function and contributes to airway tissue remodelling. Over time, prolonged exposure results in structural changes to the airways, including wall thickening, fibrosis and increased mucus production, all of which contribute to airflow obstruction and the development of COPD symptoms[19]. Symptoms including frequent coughing, excessive phlegm, wheezing and shortness of breath appear more frequently in people living in environments with indoor air pollution[20]. The newly revised COPD classification in the 2023 Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines has prompted healthcare professionals to consider a broader range of potential risk factors, including exposure to occupational hazards, biomass fuel, air pollution, genetic predispositions, low birth weight, childhood respiratory conditions, low socio-economic status, male sex, asthma and respiratory infections[21].

The effects of exposure to polluted air in the home on respiratory health, specifically variations in peak expiratory flow rate (PEFR) were the focus of this research. Measuring PEFR and tracking respiratory symptoms were among the evaluations included to determine how such exposure affected lung function[22]. Peak Expiratory Flow Rate (PEFR) has been widely used as a measure of ventilatory capacity due to its simplicity and minimal patient effort[23]. Pulmonary function tests (PFTs) in this study use the predicted values of FEV1, FEV and FVC. PFTs are safe, non-invasive procedures that evaluate lung performance and capacity, recommended for individuals showing respiratory symptoms or those at risk of lung disorders[24]. The Clinical COPD Questionnaire (CCQ) is one approach to evaluate how well COPD patients are managing their condition. The ten-item survey covers symptoms, functional status and mental health. Items are evaluated on a 7-point scale where 0 indicates no impairment and 6 indicates significant impairment; scores are calculated by averaging all elements, with a greater number indicating a worse health state[25].

Occupational exposure negatively affect respiratory health, particularly among workers involved in cleaning-related occupations. Street sweepers are exposed to road dust and vehicular emissions, while household workers encounter indoor pollutants such as cleaning agents, dust and poor ventilation . Previous studies have reported reduced lung function and increased respiratory symptoms among street sweepers due to prolonged exposure to road dust, vehicular emissions and environmental pollutants. Similarly, domestic workers may be exposed to indoor pollutants such as cleaning agents, cooking fumes, dust and poor ventilation, which can adversely affect respiratory health. However, most available studies have included mixed populations of smokers and non-smokers, making it difficult to determine the independent effects of occupational exposure and the relative impact of indoor versus outdoor occupational exposure is still debated. Furthermore, evidence focusing exclusively on nonsmoking female workers is limited, despite the large number of women employed in these occupations Therefore, this study aimed to compare pulmonary function and respiratory health among non-smoking female street sweepers and household workers, while also promoting awareness of occupational respiratory risks, the importance of personal hygiene and preventive health practices.

METHODS

The Saveetha Institute of Medical and Technical Sciences Institutional Scientific Review Board approved this study on 02/08/2025 under the ISRB reference number
002/08/2025/ISRB/PGSR/SCPT. Informed consent was obtained from all participants prior to enrolment.

This study was conducted as a comparative, cross-sectional investigation to assess and compare pulmonary function and respiratory health between street sweepers and household workers. The study included only female participants because street sweeping and household work are primarily undertaken by women in the selected population. Only non-smoking female participants were recruited to evaluate the impact of occupational dust exposure alone on pulmonary function and respiratory symptoms. A total of 100 non-smoking women aged 29 to 60 years were enrolled and allocated into two equal groups of 50 participants they are street sweepers and household workers. All participants had been continuously employed in their respective occupations for 10 to 12 years at the time of assessment. Purposive sampling was employed to identify individuals with sufficient occupational exposure duration to permit evaluation of long-term respiratory effects. Participants were eligible for inclusion if they were female non-smokers within the specified age range and free from pre-existing severe respiratory diseases unrelated to occupational exposure. Individuals were excluded if they reported a history of smoking, presented with acute respiratory infection at the time of evaluation or had any major systemic illness known to independently affect pulmonary function. For the purpose of subgroup analyses, participants were stratified into three age categories: 29 - 40, 41- 50 and 51 - 60 years.
Pulmonary function was assessed objectively using standard spirometry. Recorded parameters included Forced Expiratory Volume in one second as a percentage of the predicted value (FEV_1% predicted), Forced Vital Capacity as a percentage of the predicted value (FVC% predicted), the FEV1/FVC ratio and Forced Expiratory Flow between 25% and 75% of forced vital capacity (FEF_{25-75}% predicted). All spirometric values were compared against predicted reference values normalised for age, sex and anthropometric characteristics of the study participants.
Respiratory symptoms were assessed using the Clinical COPD Questionnaire (CCQ), a validated self-reported instrument that quantifies symptom burden, functional status and mental health in individuals with respiratory conditions. While pulmonary function was evaluated by measuring Peak Expiratory Flow Rate (PEFR).
Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 25.0 (International Business Machines Corporation, Armonk, New York, USA).Descriptive statistics, including measures of central tendency and dispersion were computed for all continuous variables. The normality of data distributions was assessed using the KolmogorovSmirnov and Shapiro-Wilk tests. As the data did not satisfy the assumption of normality, the Mann-Whitney U test was applied for non-parametric between-group comparisons. The independent-samples t-test was additionally employed where applicable. To account for the confounding effect of age on respiratory outcomes, multivariate analysis of covariance and univariate analysis of covariance were conducted, with age entered as a covariate in all adjusted models. The level of statistical significance was set at $p < 0.05$ for all comparisons.

RESULT

The study evaluated respiratory health and pulmonary function among 50 non-smoking street sweepers and 50 household workers using Peak Expiratory Flow Rate (PEFR), the Clinical COPD Questionnaire (CCQ), and spirometric parameters including predicted FEV_1, FVC, FEV_1/FVC ratio, and FEF_{25-75}. Preliminary normality testing using the Kolmogorov–Smirnov and Shapiro–Wilk tests indicated that the data were not normally distributed in either group. Consequently, non-parametric statistical methods were applied where appropriate. The Mann– Whitney U test revealed significant differences between street sweepers and household workers across all measured variables. Significant variations were observed in PEFR ($p = 0.046$), FVC ($p = 0.011$), FEV_1 ($p = 0.039$), FEV_1/FVC ratio ($p = 0.037$), FEF_{25-75} ($p = 0.041$), and CCQ scores ($p = 0.011$).
Further comparison using independent samples t-tests showed that street sweepers demonstrated higher mean values in most spirometric measures, reflecting better lung volume and airflow performance. In contrast, household workers recorded higher CCQ scores, suggesting a greater burden of respiratory symptoms and a lower perceived respiratory health status.
Age-stratified analysis indicated that the differences between the occupational groups were more evident among younger and middle-aged participants. Significant differences in CCQ scores were observed in the 29–40-year age group, while FVC and FEF_{25-75} values differed significantly in workers aged 41–50 years. Among participants aged 51–60 years, these differences were no longer statistically significant, indicating that the disparity between groups decreased with advancing age.
To determine whether age influenced these findings, a Multivariate Analysis of Covariance (MANCOVA) was performed with age as a covariate. After adjustment, street sweepers continued to exhibit significantly higher PEFR, FVC, and FEV_1/FVC ratio values, whereas household workers maintained significantly higher CCQ scores. These results suggest that occupational factors and the nature of environmental exposures contribute independently to respiratory health outcomes beyond the effects of age.
Overall, the findings demonstrate that occupation plays a significant role in respiratory function and symptom experience, highlighting the importance of workplace environmental conditions as determinants of respiratory health.

Comparative analysis of long Term occupational exposure on pulmonary function among Non smoking Female sweepers and Household workers: A Cross -Sectional study Figures

Figure 1: Comparative overview of mean and standard deviation of Pulmonary parameters

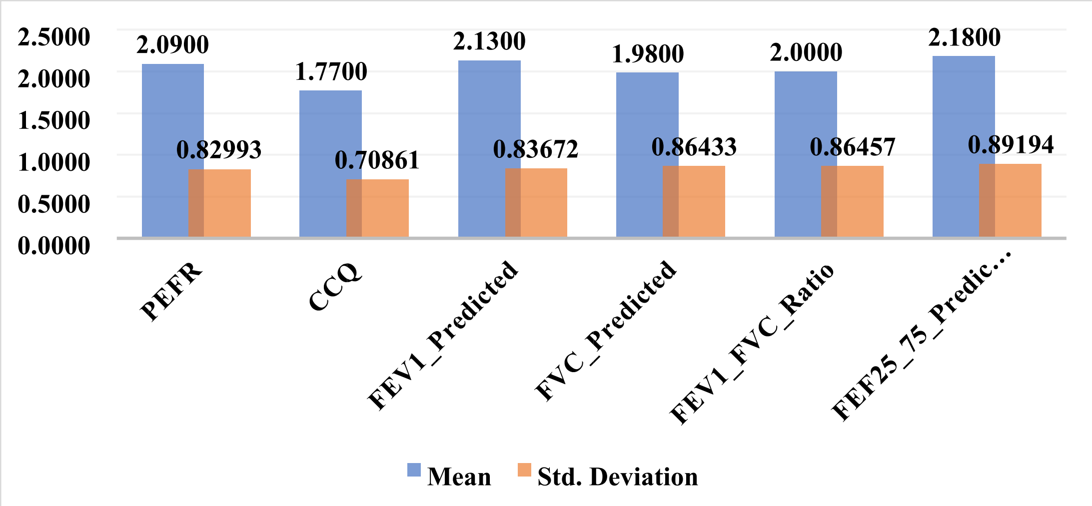


Figure 2: Comparison of Normality Test Results between Household Workers and Sweepers

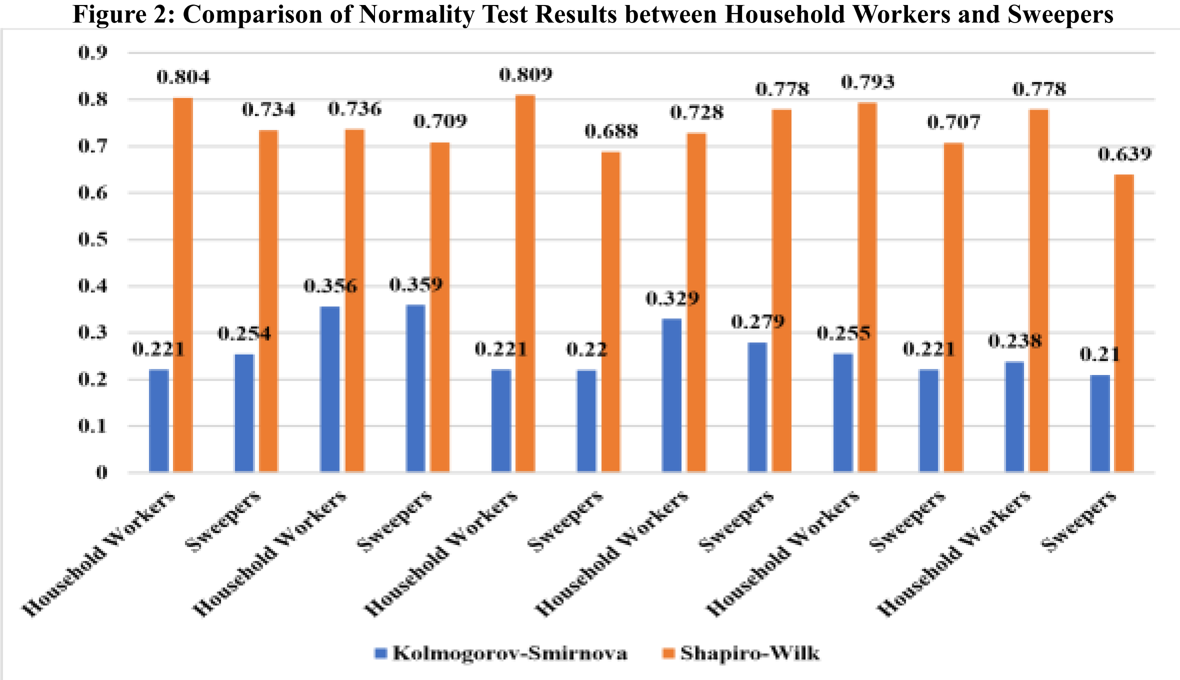


Figure 3: Non-Parametric Comparison of Pulmonary Function and Respiratory Symptoms

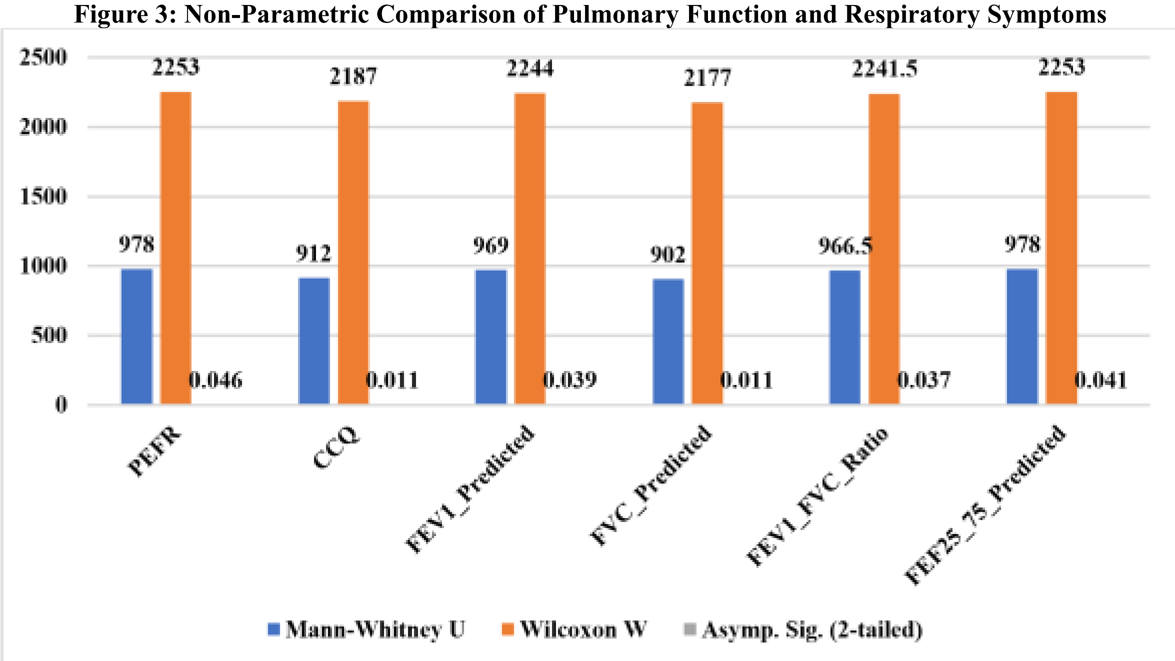


Figure 4:Mean Distribution of Respiratory Parameters Among Household Workers and Sweepers

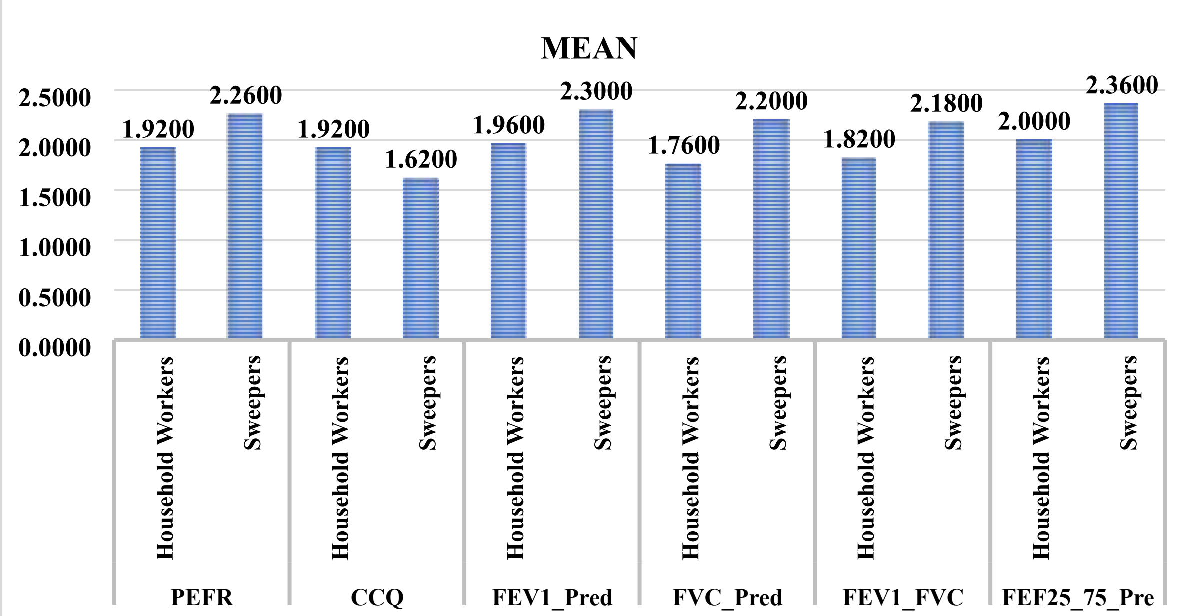
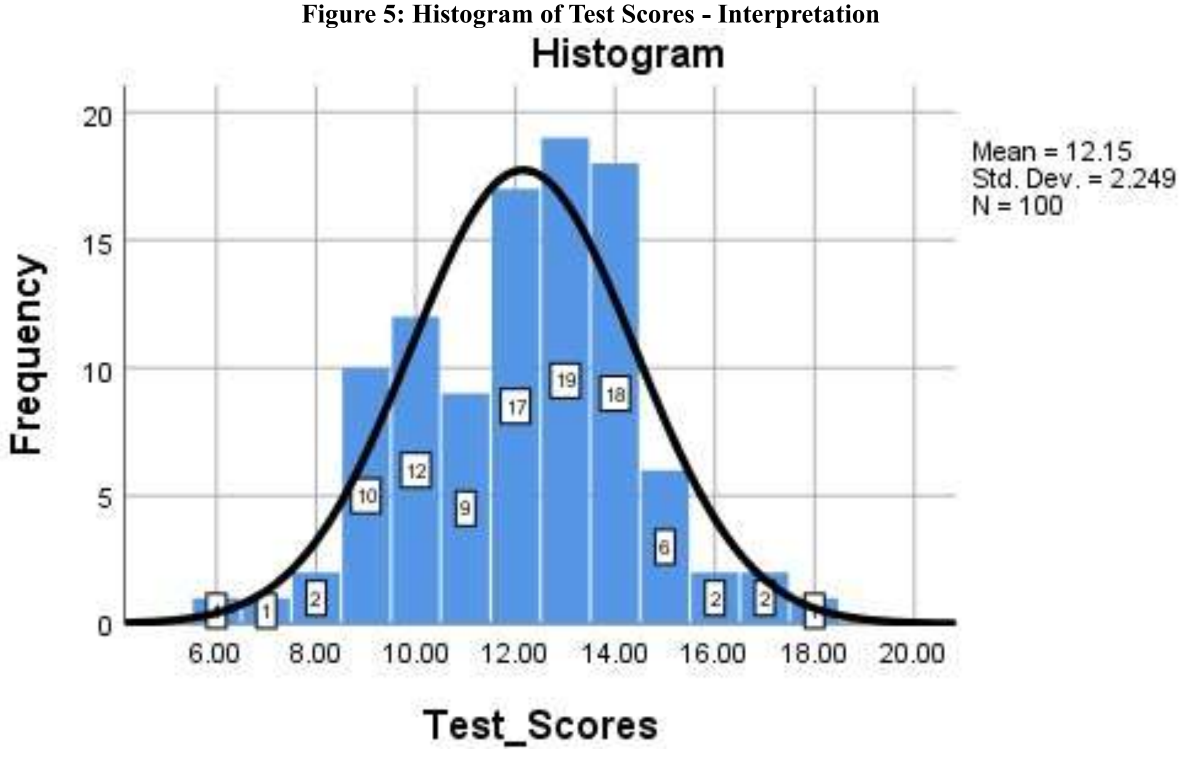


Figure 5: Histogram of Test Scores - Interpretation



DISCUSSION

An investigation on the effects of occupational exposure upon pulmonary functioning as well as respiratory health of non-smoking street sweepers and household workers. The findings suggest that the nature and the setting of occupational exposure do have a great implication on respiratory outcomes. The mucus hyper secretion and airway inflammation observed in sweepers are consistent with findings by Kasper et al[6] and Larsson[7] who described how prolonged exposure to irritants results in airway remodelling and obstruction. Habybabady et al[8] also verified that respiratory symptoms and reduced pulmonary function due to occupational dust exposure were associated with lower PEFR, consistent with findings of the present study. The lack of protective measures among street sweepers and associated respiratory complaints were confirmed by Chotigadachanarong et al[11]

The GOLD 2023 report[12] identified occupational exposure as a significant non-smokingrelated risk factor in COPD, highlighting the need for preventative interventions for these workers. Gordon et al[14] and Qiu et al.[15] indicated that household workers, despite comparatively slightly better PEFR scores, remain exposed to indoor pollutants from biomass fuel and cleaning agents and stated that chronic indoor air pollution may lead to wheezing, coughing, and airway inflammation. Equivalent results were found by Svanes et al[16] and Simkovich et al[17] who demonstrated that poor ventilation and household cleaning routines are related to respiratory diseases and poor lung performance. The CCQ scores in the present study agreed with Lin et al[25] who validated the CCQ as a reliable indicator of respiratory health. These findings collectively highlight the necessity of protective masks, health education and regular pulmonary check-ups to prevent respiratory disorders in both occupational groups.

TABLES AND FIGURES

Table 1: Descriptive Statistics of pulmonary function and Respiratory health parameters

Parameters	Mean	Std. Deviation
PEFR	2.0900	0.82993
CCQ	1.7700	0.70861
FEV_1 Predicted	2.1300	0.83672
FVC Predicted	1.9800	0.86433
FEV_1/FVCRatio	2.0000	0.86457
FEF_{25-75} %Predicted	2.1800	0.89194

Expansion: Std.Deviation - standard Deviation , PEFR - Peak Expiratory Flow Rate, CCQ- Clinical COPD Questionnaire, Predicted FEV_1-Predicted Forced Expiratory Volume in One Second, FVC Predicted -Predicted Forced Vital Capacity, FEV_1/FVC Ratio - Ratio of Forced Expiratory Volume in One Second to Forced Vital Capacity, FEF_{25-75} % Predicted - Predicted Forced Expiratory Flow between 25% and 75% of Forced Vital Capacity.

Table 2: Kolmogorov–Smirnov and Shapiro–Wilk Analysis of pulmonary function parameters

	Groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
PEFR	Household Workers	.221	50	.000	.804	50	.000
	Sweepers	.254	50	.000	.734	50	.000
CCQ	Household Workers	.356	50	.000	.736	50	.000
	Sweepers	.359	50	.000	.709	50	.000
FEV1 Predicted	Household Workers	.221	50	.000	.809	50	.000
	Sweepers	.220	50	.000	.688	50	.000
FVC Predicted	Household Workers	.329	50	.000	.728	50	.000
	Sweepers	.279	50	.000	.778	50	.000
FEV_1/FVC Ratio	Household Workers	.255	50	.000	.793	50	.000
	Sweepers	.221	50	.000	.707	50	.000
FEF25-75% Predicted	Household Workers	.238	50	.000	.778	50	.000
	Sweepers	.210	50	.000	.639	50	.000

Expansion: Kolmogorov-Smirnova[a] - power (a) denotes Lilliefors significance correction, Statistic- Test Statistic, df- degree of freedom , Sig.- Significance value. All other abbreviations and their full forms are provided in Table 1.

Table 3: Non-Parametric Analysis and Asymptotic Significance (Two-Tailed) of Respiratory Parameters Between Household Workers and Sweepers

	PEFR	CCQ	FEV_1 Predicted	FVC Predicted	FEV_1/FVC Ratio	FEF25-75% Predicted
Mann-Whitney U	978.000	912.000	969.000	902.000	966.500	978.000

Wilcoxon W	2253.000	2187.000	2244.000	2177.000	2241.500	2253.000
Z	-1.993	-2.534	-2.065	-2.556	-2.082	-2.043
Asymp. Sig. (2-tailed).	.046	.011	.039	.011	.037	.041

Expansion: Asymp. Sig. (2-tailed) - Asymptotic Significance (Two-Tailed).All other abbreviations and their full forms are provided in Table 1.

Table 4: Independent Samples t-test Analysis of PEFR, CCQ and Predicted Spirometric Parameters Between Household Workers and Sweepers

Parameters	**Groups**	**N**	**Mean**	**Std. Deviation**	**Sig**
PEFR	Household Workers	50	1.9200	0.77828	0.040
	Sweepers	50	2.2600	0.85261	
CCQ	Household Workers	50	1.9200	0.56569	0.034
	Sweepers	50	1.6200	0.80534	
FEV_1 - Predicted	Household Workers	50	1.9600	0.75485	0.042
	Sweepers	50	2.3000	0.88641	
FVC- Predicted	Household Workers	50	1.7600	0.87037	0.010
	Sweepers	50	2.2000	0.80812	
FEV_1/FVC Ratio	Household Workers	50	1.8200	0.77433	0.037
	Sweepers	50	2.1800	0.91896	
FEF_{25-75}% Predicted	Household Workers	50	2.0000	0.85714	0.043
	Sweepers	50	2.3600	0.89807	

Expansion: N- number of sample size. All other abbreviations and their full forms are provided in Table 1.

Table 5: Quartile Analysis - Interpretation

Test Scores		
Mean		12.1500
Std. Deviation		2.24902
Minimum		6.00
Maximum		18.00
Percentiles	25	10.0000
	50	12.0000
	75	14.0000

Table 6 : Comparison of PEFR, CCQ and Predicted Spirometric Parameters by Age Group - Interpretation

		Household Workers(N=50)	**Sweepers(N=5)**	
Age	**Parameters**	**Mean ± SD**	**Mean ± SD**	**Sig**

29-40 Years	PEFR	2.25± 0.866	2.5± 0.5477	0.531
	CCQ	1.75± 0.4522	1.1666± 0.4082	0.019
	FEV_1 -Predicted	1.666± 0.778	1.333± 0.8164	0.412
	FVC- Predicted	1.833± 0.9374	1.5± 0.5477	0.357
	FEV_1/FVC Ratio	1.5833± 0.9003	2.333± 1.0327	0.132
	FEF_{25-75}%Predicted	2.25± 0.6215	1.833± 0.9831	0.285
41-50 Years	PEFR	1.730± 0.7243	2.04± 0.9345	0.194
	CCQ	2.115± 0.5883	1.72± 0.8906	0.070
	FEV_1 -Predicted	2.0769± 0.7442	2.44± 0.8205	0.104
	FVC - Predicted	1.7307± 0.8744	2.4±0.8164	0.007
	FEV_1/ FVC Ratio	1.9230± 0.7442	2.2± 0.8660	0.226
	FEF_{25-75} % Predicted	1.7692± 0.9080	2.56± 0.8205	0.002
51-60 Years	PEFR	2.0000± 0.7385	2.4736± 0.772	0.102
	CCQ	1.666± 0.4923	1.631± 0.7608	0.877
	FEV_1 Predicted	2.0000± 0.73854	2.4210± 0.837	0.165
	FVC Predicted	1.75± 0.866	2.157± 0.7647	0.180
	FEV_1/ FVC Ratio	1.833± 0.7177	2.105± 0.994	0.385
	FEF_{25-75}%Predicted	2.25± 0.866	2.263± 0.9334	0.969

Expansion: N- Number of participants , All other abbreviations and their full forms are provided in Table 1.

Table 7: MANCOVA Analysis of Pulmonary Function Measures Controlling for Age

Dependent Variable	Household Workers (Adjusted Mean ± SE)	Sweepers (Adjusted Mean ± SE)	F (1,97)	p-value	Partial η²
PEFR	1.919 ± 0.117	2.261 ± 0.117	4.193	0.043*	0.041
CCQ	1.926 ± 0.100	1.614 ± 0.100	4.776	0.031*	0.047
FEV_1 Predicted	1.994 ± 0.115	2.266 ± 0.115	2.718	0.102	0.027
FVC Predicted	1.767 ± 0.120	2.193 ± 0.120	6.16	0.015*	0.06
FEV_1/FVC Ratio	1.822 ± 0.122	2.178 ± 0.122	4.194	0.043*	0.041

FEF25–75 % Predicted	2.004 ± 0.126	2.356 ± 0.126	3.849	0.053	0.038

Expansion: SE- Standard Error, F (1,97)- F-statistic with 1 and 97 Degrees of Freedom, pvalue-Probability Value, Partial η^2 - partial Eta Squared (Measure of Effect Size)

Table 1: Descriptive Statistics of pulmonary function and Respiratory health parameters
This is presents the descriptive statistics of the pulmonary function and respiratory health parameters measured among the study participants. The mean Peak Expiratory Flow Rate (PEFR) was 2.09 with a standard deviation of 0.83, indicating variation in expiratory airflow among individuals. The Chronic Cough Questionnaire (CCQ) score showed a mean value of 1.77 and a standard deviation of 0.71, suggesting relatively lower variability in respiratory symptom scores. The predicted Forced Expiratory Volume in one second (FEV_1) had a mean of 2.13 and a standard deviation of 0.84, while the predicted Forced Vital Capacity (FVC) recorded a mean of 1.98 with a standard deviation of 0.86. The FEV_1/FVC ratio demonstrated a mean value of 2.00 and a standard deviation of 0.86. Among all variables, the predicted FEF_{25}75% showed the highest mean value (2.18) and the largest standard deviation (0.89) indicating greater variability in mid-expiratory flow rates. Overall, the findings reflect differences in pulmonary function measures among the participants.

Table 2: Kolmogorov-Smirnov and Shapiro-Wilk Analysis of pulmonary function parameters
Presents the results of the normality tests conducted for PEFR , CCQ and predicted spirometric scores among Household Workers and Sweepers. The distribution of the data was assessed using both the Kolmogorov–Smirnov test with Lilliefors correction and the Shapiro-Wilk test. For all variables examined, including PEFR, CCQ, FEV_1 predicted, FVC predicted, FEV_1/FVC ratio and FEF predicted, the significance values were less than 0.001 in both occupational groups. These findings indicate that the data were not normally distributed. Since the assumption of normality was not satisfied, non-parametric statistical methods were considered more appropriate for further analysis and comparison between the two occupational groups.

Table 3: Non-Parametric Analysis and Asymptotic Significance (Two-Tailed) of Respiratory Parameters Between Household Workers and Sweepers
This table shows the Mann-Whitney U test results comparing Household Workers and
Sweepers. Significant differences were found for all variables, as all p-values were below 0.05. PEFR showed U = 978.000, W = 2253.000, Z = -1.993 and p = 0.046. CCQ recorded U = 912.000, W = 2187.000, Z = -2.534 and p = 0.011. FEV_1 predicted had U = 969.000, W = 2244.000, Z = -2.065, and p = 0.039. FVC predicted showed U = 902.000, W = 2177.000, Z = -2.556 and p = 0.011. The FEV_1/FVC ratio recorded U = 966.500, W = 2241.500, Z = -2.082, and p = 0.037, while $FEF_{25\text{-}75}$%predicted showed U = 978.000, W = 2253.000, Z = -2.043 and p = 0.041. Among all parameters, FVC predicted (Z = -2.556) and CCQ (Z = -2.534) showed the largest differences between groups. Since all p-values ranged from 0.011 to 0.046, the findings indicate significant differences in respiratory symptoms and pulmonary function between Household Workers and Sweepers.

Table 4: Independent Samples t-test Analysis of PEFR, CCQ and Predicted Spirometric Parameters Between Household Workers and Sweepers
The findings indicate statistically significant differences between the two occupational groups across all measured variables as all significance values are below 0.05. Sweepers recorded a slightly higher mean Peak Expiratory Flow Rate (PEFR) (2.26 ± 0.85) than Household Workers (1.92 ± 0.78), suggesting better expiratory airflow capacity among Sweepers. Similarly, the mean values of FEV_1 Predicted (2.30 ± 0.89), FVC Predicted (2.20 ± 0.81), FEV_1/FVC Ratio (2.18 ± 0.92) and $FEF_{25\text{-}75}$% Predicted (2.36 ± 0.90) were higher among Sweepers compared with Household Workers, indicating superior pulmonary function and airway performance. In contrast, Household Workers showed a significantly higher CCQ score (1.92 ± 0.57) than
Sweepers (1.62 ± 0.81), reflecting burden of respiratory symptoms and health-related concerns. These results suggest that respiratory function and overall lung health differ notably between the two occupational groups.

Table 5: Quartile Analysis - Interpretation
This table shows the distribution of test scores for the 100 participants. The average score was 12.15, with a standard deviation of 2.25 indicating some variation in performance among the participants. Scores ranged from 6 to 18 reflecting differences in individual achievement levels. The first quartile value of 10.00 indicates that 25% of the participants scored 10 or below, while the median score of 12.00 shows that half of the participants scored at or below this level. The third quartile value of 14.00 indicates that 75% of the participants obtained scores of 14 or less. Since the middle 50% of scores fall between 10 and 14 the results suggest that most participants performed within this range. Overall, the score distribution appears balanced, with no marked concentration of scores at either the lower or higher end of the scale.

Table 6: Comparison of PEFR, CCQ and Predicted Spirometric Parameters by Age Group - Interpretation compares pulmonary function parameters and CCQ scores between household workers and street sweepers across three age groups 29-40, 41-50 and 51-60 years. In the 29-40 years age group, a statistically significant difference was observed

only in the CCQ score (p = 0.019), indicating variation in respiratory health status between the two groups. No significant differences were found in PEFR, FEV1 predicted, FVC predicted, FEV_1/FVC ratio and $FEF_{25}75$ % predicted values.

Among participants aged 41-50 years, significant differences were noted in FVC predicted (p = 0.007) and FEF_{25-75} %predicted (p = 0.002), with sweepers showing higher mean values than household workers. The remaining parameters, including PEFR, CCQ, FEV1 predicted and FEV1/FVC ratio did not show statistically significant differences.

In the 51- 60 years age group, no significant differences were observed between household workers and sweepers for any of the measured parameters ($p > 0.05$). Overall, the findings indicate that differences between the two occupational groups were evident only for selected parameters within the younger and middle-aged groups, while pulmonary function measures were largely comparable in the older age group.

Table 7 :MANCOVA Analysis of Pulmonary Function Measures Controlling for Age

It presents the results of the Multivariate Analysis of Covariance (MANCOVA) comparing pulmonary function parameters between household workers and sweepers after adjusting for age. The analysis revealed significant differences between the two occupational groups for several respiratory outcomes. Sweepers demonstrated higher adjusted mean values for Peak Expiratory Flow Rate (PEFR), Chronic Cough Questionnaire (CCQ) score, Forced Vital Capacity (FVC % predicted) and FEV_1/FVC ratio compared with household workers. No statistically significant differences were observed for Forced Expiratory Volume in one second

(FEV_1 % predicted) and Forced Expiratory Flow at 25-75% of the vital capacity (FEF_{25-75} % predicted) although the latter approached statistical significance. The partial eta-squared (η^2) values indicated small to moderate effect sizes, suggesting that occupational category accounted for a modest proportion of the variation in these pulmonary function measures after controlling for the influence of age. Overall, the findings indicate that occupation had a significant association with selected respiratory parameters, while the magnitude of these effects remained relatively moderate.

Figure legends

Figure 1: Comparative overview of mean and standard deviation of Pulmonary parameters

Illustrates the mean values and standard deviations of six pulmonary and respiratory health parameters assessed in the study. The average values ranged from 1.77 for the CCQ score to 2.18 for the predicted FEF_{25-75}% The predicted FEV_1 and PEFR showed mean values of 2.13 and 2.09 respectively, while the predicted FVC and FEV_1/FVC ratio recorded mean values close to 2.00. The standard deviations varied between 0.71 and 0.89, indicating differences in the spread of measurements across the variables. The CCQ score exhibited the lowest variability, whereas the predicted FEF_{25-75}% demonstrated the highest variability among the measured parameters. These results highlight the distribution and consistency of respiratory function measures within the study population.

Figure 2: Comparison of Normality Test Results between Household Workers and Sweepers

This figure illustrates the normality test statistics obtained from the Kolmogorov-Smirnov and Shapiro -Wilk tests for Household Workers and Sweepers. The Shapiro-Wilk test values were generally higher, ranging from 0.639 to 0.809 while the Kolmogorov-Smirnov values ranged from 0.210 to 0.359. The highest Shapiro-Wilk statistic was observed for the FEV_1 predicted parameter among Household Workers (0.809), whereas the lowest value was recorded for FEF_{25-75}% predicted among Sweepers (0.639). The consistently significant results across both tests suggest deviations from normality in all measured variables. The figure provides a visual comparison of the test statistics and supports the decision to use non-parametric approaches in subsequent analyses.

Figure 3: Non-Parametric Comparison of Pulmonary Function and Respiratory Symptoms

This figure provides a visual presentation of the Mann-Whitney U test results for the respiratory and pulmonary function parameters assessed in the study. The chart displays the MannWhitney U values, Wilcoxon W values, and corresponding p-values for each variable. The Wilcoxon W statistics were consistently higher than the Mann-Whitney U values across all parameters. The p-values ranged from 0.011 to 0.046 and remained below the threshold of 0.05, indicating statistically significant differences between Household Workers and Sweepers. The figure highlights that variations existed across all measured respiratory outcomes, suggesting that occupational exposure may have influenced respiratory health and lung function in the two Occupational groups.

Figure 4:Mean Distribution of Respiratory Parameters Among Household Workers and Sweepers

Illustrates the mean values of six respiratory and clinical parameters among Household Workers and Sweepers. The graphical comparison shows that Sweepers achieved higher mean scores in most spirometry indicators, including PEFR, FEV_1 Predicted, FVC Predicted, FEV_1/FVC Ratio and FEF_{25-75} % predicted. Among these variables, $FEF_{25–75}$% Predicted demonstrated the highest mean value for Sweepers (2.36), while Household Workers recorded a lower mean value of 2.00. This pattern indicates comparatively better lung capacity, airflow efficiency and small airway function among Sweepers. The only parameter displaying an opposite trend was the CCQ score, where Household Workers reported a higher mean value (1.92) than Sweepers (1.62) suggesting more respiratory complaints and reduced respiratory well-being in this group. Overall, the figure highlights clear differences in respiratory health profiles between the two occupations, with Sweepers exhibiting more favorable pulmonary outcomes across most measured parameters.

Figure 5 : Histogram of Test Scores - Interpretation
It presents the distribution of test scores for 100 participants using a histogram with a normal curve. Most participants scored between 10 and 14 with the highest frequencies observed near the mean score of 12.15. The distribution appears fairly symmetrical, indicating that the scores are evenly spread around the average value. Lower frequencies were observed at the extreme scores of 6 - 8 and 16 -18. The normal curve closely matches the histogram pattern, suggesting that the data are approximately normally distributed. Overall, the figure shows that most participants achieved scores close to the average, with relatively few scoring at the lower or higher ends of the scale.

Abbreviations
All abbreviations used in this manuscript and below the tables are presented in their full form when first introduced and are subsequently used in their abbreviated form throughout the text. As each abbreviation has been clearly defined at its initial occurrence, a separate list of abbreviations has not been included.

Units of measurements
1.PEFR is measured using a Peak Expiratory Flow Meter and expressed in litters per minute (L/min). It reflects the maximum speed of expiration.
2. CCQ is reported as a unit less score ranging from 0 to 6, where higher values indicate poorer health status and greater symptom burden.
3. Spirometry measurements are reported using standard respiratory units and are also expressed as predicted values (% predicted). Forced Expiratory Volume in 1 second (FEV_1) and Forced Vital Capacity (FVC) are measured in litters (L) but reported actual values in percentage of predicted values (% predicted) in this study. The FEV_1/FVC ratio is presented in percentage. Forced Expiratory Flow at 25-75% (FEF_{25-75}%) is originally measured in litters per second (L/s), but it is expressed as % predicted, In this study, it is reported as a unit less parameter derived from predicted reference values.

Names of devices
In this study, respiratory function was assessed using a peak expiratory flow meter for measuring Peak Expiratory Flow Rate (PEFR). Spirometric parameters were obtained using standard spirometry and were expressed as predicted values (% predicted) based on appropriate reference equations for the study population.

CONCLUSION
This study suggests that long-term occupational exposure may affect lung function and respiratory health in both non-smoking female sweepers and household workers. Although both groups were affected, household workers showed slightly greater impairment in pulmonary function and reported more respiratory symptoms. Poor workplace hygiene, continuous exposure to dust and pollutants, and untreated respiratory symptoms may further increase the risk of developing chronic respiratory conditions such as COPD over time. These findings highlight the importance of regular health screening, early treatment of symptoms, improved workplace hygiene, and preventive measures to protect respiratory health. Further studies with larger sample sizes and more detailed clinical evaluations are needed to better understand the long-term effects of occupational exposure on lung function and respiratory disease risk.

ABBREVIATIONS
PEFR: Peak Expiratory Flow Rate, FEV_1: Forced Expiratory Volume in one second, FVC: Forced Vital Capacity, FEV_1/FVC – Ratio of forced expiratory volume in one second to forced vital capacity, FEF_{25-75}: Forced Expiratory Flow between 25% and 75% of lung volume, CCQ:
Clinical COPD Questionnaire

ACKNOWLEDGEMENT
The authors express their sincere gratitude to all the participants for their cooperation and willingness to be part of this study. We also thank the supporting staff and authorities who facilitated data collection and provided the necessary permissions to conduct this research.

DECLARATION OF ARTIFICIAL INTELLIGENCE (AI) ASSISTANCE
The authors declare that the research concept, data and manuscript writing are original and not AI-generated. The use of AI tools was strictly limited to Grammar for English language and grammar refinement. The authors take full responsibility for the content.

CONFLICT OF INTEREST
The authors declare that there is no conflict of interest regarding the publication of this manuscript.

ETHICAL APPROVAL
The Saveetha Institute of Medical and Technical Sciences Institutional Scientific Review Board gave its stamp of approval to this study on 02/08/2025 under the ISRB reference number 002/08/2025/ISRB/PGSR/SCPT.

FUNDING
This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

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