

Occupational Respiratory Dysfunction among Hospital Sanitary Workers: A Cross-Sectional Study in a Tertiary Care Centre in India

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Abstract

Background: Hospital sanitary workers face chronic occupational exposure to biomedical waste, bioaerosols, and cleaning chemicals, yet occupational respiratory health surveillance remains sparse in low- and middle-income countries. **Material and Methods:** A cross-sectional study was conducted among 60 hospital sanitary workers and 60 age- and sex-matched non-exposed controls (age 20–45 years) at a tertiary-care institution. Spirometry was performed following American Thoracic Society guidelines, and spirometric indices (FVC%, FEV₁%, FEF_{25–75}%, PEF%) were compared between groups. Among workers, exposure--response relationships were examined using Pearson correlation and linear regression. **Results:** Sanitary workers had significantly lower FVC% (62.8 ± 9.9 vs. $92.6 \pm 15.0\%$, $p < 0.001$) and FEV₁% (62.1 ± 11.1 vs. $93.7 \pm 15.9\%$, $p < 0.001$) compared with controls. A predominantly restrictive spirometric pattern was observed in 96.7% of workers versus 13.3% of controls ($p < 0.001$). Duration of employment showed strong negative correlation with FVC% ($r = -0.74$, $p < 0.001$) and FEV₁% ($r = -0.65$, $p < 0.001$), with a mean decline of 1.46% FVC and 1.03% FEV₁ per additional year of exposure. **Conclusion:** Hospital sanitary workers demonstrated significant occupationally related respiratory dysfunction with clear exposure--response gradient. Urgent implementation of respiratory health surveillance, engineering controls, and occupational health services is needed to protect this vulnerable workforce.

Keywords: Occupational health; sanitary workers; spirometry; pulmonary function; bioaerosols; occupational respiratory disease; waste management.

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INTRODUCTION

The global burden of healthcare waste (HCW) management continues to escalate as population growth and urbanization increase waste generation.^[1] The World Bank projects global municipal solid waste will rise from 1.3 billion tonnes annually to 2.2 billion tonnes by 2025. In India, whilst biomedical waste comprises only 1% of total waste generated, it requires specialized handling and disposal due to its infectious and chemical hazards.^[2] Hospital sanitary workers form the frontline workforce in infection prevention and environmental hygiene in healthcare facilities. However, these workers—predominantly from low socioeconomic groups and often employed on contract bases—are exposed to multiple occupational hazards including biomedical waste, pathogenic bioaerosols (Staphylococcus aureus, Mycobacterium tuberculosis, hepatitis B and C viruses), chemical irritants (bleach, ammonia, formaldehyde, glutaraldehyde), and particulate matter. Limited access to personal protective equipment (PPE) training and use compounds their vulnerability.^[2,3] Chronic bioaerosol and dust inhalation triggers airway inflammation, epithelial barrier dysfunction, and dysregulated immune responses. Prolonged exposure leads to chronic inflammation, airway remodeling, and progressive lung dysfunction that is often undiagnosed.^[4] Recent systematic reviews demonstrate that respiratory symptoms and pulmonary function impairment

are among the most significant occupational health effects in waste management settings.^[2-9] Despite this evidence, spirometric surveillance of hospital sanitary workers remains underexamined in resource-limited settings, including India.^[10-11] We hypothesized that occupational exposure to biomedical waste and related hazards causes measurable pulmonary function impairment in hospital sanitary workers, with severity correlating with duration of employment.

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional, observational study was conducted in the Department of Physiology, Chengalpattu Medical College and Hospital, Chengalpattu, Tamil Nadu, India. The institution is a tertiary-care government hospital serving a mixed urban and semi-urban population. The study was approved by the

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Institutional Ethics Committee (IEC) and conducted according to the Declaration of Helsinki.

Study Population

Cases: Hospital sanitary workers (n = 60) aged 20--45 years, both sexes, with ≥ 2 years' occupational exposure to biomedical waste collection and disposal.

Controls: Non-occupationally exposed hospital staff (n = 60), age- and sex-matched, employed in administrative or clerical roles without exposure to biomedical waste, particulates, or chemical fumes.

Exclusion criteria (both groups): Pre-existing respiratory disease; smoking or tobacco use; chronic alcohol use; systemic diseases; pregnancy/lactation; HIV seropositivity; thoracic/abdominal surgery (<3 months); unstable cardiac disease; chest wall deformities; or contraindications to spirometry per American Thoracic Society/European Respiratory Society guidelines.^[1]

All participants provided written informed consent prior to enrolment.

Data Collection: Trained personnel administered a structured questionnaire capturing demographics, occupational history (years of service, job duties), work environment details, respiratory symptoms (cough, sputum, dyspnoea, wheezing), chronic cough (≥ 3 months), prior respiratory infections, PPE awareness and use practices, and self-reported occupational health concerns. Anthropometry was measured with participants standing barefoot in light clothing: height (cm) and weight (kg) using standard scales; BMI calculated as weight (kg)/height (m²).

Spirometry Procedure: Spirometry was performed using an Easy One PC ultrasound flow-sensor spirometer (Zurich, Switzerland) calibrated per American Thoracic Society/European Respiratory Society guidelines.^[1] Participants avoided heavy meals (2 hours prior), alcohol (4 hours prior), and bronchodilators (6--12 hours prior). Testing was conducted in the morning (08:00--10:00 hours) in seated position with nose clip. Participants inhaled maximally to total lung capacity and performed a rapid, maximal forced expiration lasting ≥ 6 seconds. At least three acceptable manoeuvres were recorded per acceptability criteria: smooth, cough-free effort; extrapolated volume <5%

FVC or <0.15 L; visible plateau lasting ≥ 2 seconds. Best two FVC and FEV₁ values were required to be within 200 ml.

Spirometric indices recorded and expressed as percentage of predicted values:

- Forced Vital Capacity (FVC%)
- Forced Expiratory Volume in 1 second (FEV₁%)
- FEV₁/FVC ratio (%)
- Forced Expiratory Flow 25--75% (FEF₂₅₋₇₅%)
- Peak Expiratory Flow (PEF%)

Spirometric Pattern Classification

Spirometric patterns were classified per international criteria:^[6]

- Normal: FEV₁% $\geq 80\%$ AND FVC% $\geq 80\%$ AND FEV₁/FVC $\geq 70\%$
- Obstructive: FEV₁/FVC <70% with reduced FEV₁% or normal/reduced FVC%
- Restrictive: FVC% <80% with preserved/elevated FEV₁/FVC ($\geq 70\%$)
- Mixed: FEV₁/FVC <70% AND FVC% <80%

Statistical Analysis: Continuous variables were summarized as mean \pm SD; categorical variables as frequencies/percentages. Independent samples t-tests compared spirometric parameters between groups; chi-square tests compared spirometric patterns. Among sanitary workers, Pearson's correlation assessed relationship between employment duration (years) and spirometric indices. Linear regression quantified rate of decline per year of exposure. Workers were stratified into three exposure categories (<3, 3--5, >5 years) and compared using one-way ANOVA with Bonferroni correction. A p-value <0.05 (two-tailed) was considered statistically significant. Analyses used IBM SPSS version 21.0 (IBM Corporation, Armonk, NY, USA).

RESULTS

Baseline Characteristics: The study included 120 participants: 60 sanitary workers (56.7% male, 43.3% female) and 60 controls (58.3% male, 41.7% female). No significant differences were observed between groups for age, height, weight, or BMI (all p > 0.05). Mean age was 34.2 \pm 7.1 years (workers) and 33.8 \pm 6.9 years (controls). Occupational exposure duration ranged from 2 to 22 years (mean = 9.3 \pm 5.6 years).

Table 1: Demographic and anthropometric characteristics of study groups. Data are mean \pm SD or n (%).

Characteristic	Sanitary Workers (n=60)	Controls (n=60)	p-value
Age (years)	34.2 \pm 7.1	33.8 \pm 6.9	0.72
Male, n (%)	34 (56.7)	35 (58.3)	0.84
Female, n (%)	26 (43.3)	25 (41.7)	0.84
Height (cm)	164.5 \pm 6.2	165.1 \pm 5.8	0.54
Weight (kg)	61.8 \pm 8.9	62.4 \pm 8.2	0.61
BMI (kg/m ²)	22.8 \pm 2.7	22.9 \pm 2.5	0.78
Employment duration (years)	9.3 \pm 5.6	---	---

Spirometric Findings: Spirometric indices were significantly reduced in sanitary workers compared with controls. FVC% predicted was markedly lower in workers (62.8 \pm 9.9% vs. 92.6 \pm 15.0%, p<0.001), representing a mean difference of 29.8% absolute predicted value. FEV₁% predicted was substantially reduced in workers (62.1 \pm 11.1% vs. 93.7 \pm 15.9%, p<0.001), with a mean difference of

31.6% absolute predicted value. FEF₂₅₋₇₅% predicted was lower in workers (71.5 \pm 18.3% vs. 79.9 \pm 8.9%, p=0.002), and PEF% predicted was lower in workers (75.2 \pm 20.0% vs. 81.9 \pm 9.0%, p=0.02). The FEV₁/FVC ratio, though slightly lower in workers, was not statistically significant (98.0 \pm 9.1% vs. 100.5 \pm 5.2%, p=0.06), reflecting the predominantly restrictive dysfunction pattern.

Table 2: Spirometric parameters in sanitary workers and controls. Data are mean \pm SD. FVC = forced vital capacity; FEV₁ = forced expiratory volume in 1 second; FEF₂₅₋₇₅ = forced expiratory flow 25--75%; PEF = peak expiratory flow.

Parameter	Sanitary Workers (n=60)	Controls (n=60)	p-value
FVC% predicted	62.8 \pm 9.9	92.6 \pm 15.0	<0.001
FEV ₁ % predicted	62.1 \pm 11.1	93.7 \pm 15.9	<0.001
FEV ₁ /FVC (%)	98.0 \pm 9.1	100.5 \pm 5.2	0.06
FEF ₂₅₋₇₅ % predicted	71.5 \pm 18.3	79.9 \pm 8.9	0.002
PEF% predicted	75.2 \pm 20.0	81.9 \pm 9.0	0.02

Spirometric Pattern Distribution: Spirometric pattern distribution differed significantly between groups ($\chi^2 = 58.3$, $p < 0.001$). Among sanitary workers, 58 (96.7%) had restrictive pattern, 1 (1.7%) obstructive, and 1 (1.7%) normal. Among controls, 50 (83.3%) had normal spirometry, 8 (13.3%) restrictive, and 2 (3.3%) obstructive.

Exposure--Response Relationship: Among 60 sanitary

workers, stratification by exposure duration showed clear dose--response gradient. Workers with <3 years employment had mean FVC% of 71.2% \pm 8.1%, compared to 54.1% \pm 7.9% with >5 years (difference = 17.1%, $p < 0.001$). FEV₁% declined from 71.3% \pm 9.8% to 53.7% \pm 8.7% (difference = 17.6%, $p < 0.001$).

Pearson's correlation coefficients demonstrated:

FVC% vs. duration: $r = -0.74$, $p < 0.001$ ($R^2 = 0.546$)
FEV ₁ % vs. duration: $r = -0.65$, $p < 0.001$ ($R^2 = 0.423$)
FEF ₂₅₋₇₅ % vs. duration: $r = -0.31$, $p = 0.015$ ($R^2 = 0.096$)
PEF% vs. duration: $r = -0.26$, $p = 0.046$ ($R^2 = 0.068$)

Linear regression revealed that for each additional year of employment, FVC% predicted declined by 1.46 \pm 0.18% per year (95% CI: -1.82 to -1.10), and FEV₁% predicted declined by 1.03 \pm 0.14% per year (95% CI: -1.31 to -0.75).

DISCUSSION

This cross-sectional study of hospital sanitary workers in a tertiary-care setting demonstrates three principal findings: (1) marked reduction in lung volumes (~30% lower in workers), (2) predominantly restrictive spirometric pattern in 96.7% of workers versus 13.3% of controls, and (3) clear exposure--response gradient with approximately 1.5% FVC decline per additional year of employment. The respiratory dysfunction is consistent with chronic bioaerosol and particulate inhalation.^[4,5] Hospital biomedical waste contains high concentrations of bacterial and fungal bioaerosols, endotoxins, and chemical irritants. Chronic inhalation triggers epithelial barrier dysfunction, toll-like receptor 4 (TLR-4) activation on bronchial epithelial cells and alveolar macrophages, and pro-inflammatory cytokine release (IL-6, TNF- α).^[4,7] Prolonged inflammation drives fibroblast activation and excessive extracellular matrix deposition, leading to airway and pulmonary fibrosis with reduced lung compliance manifesting as restrictive pattern.^[8] Recent systematic reviews confirm the occupational respiratory hazard faced by waste and sanitation workers globally.^[2,3,9] A 2024 meta-analysis of occupational respiratory diseases among sanitary workers reported high prevalence of respiratory dysfunction. Vimercati et al. examined 124 waste collection workers in Italy and found significantly reduced mean FEV₁ values in exposed workers.^[10] Recent spirometric evaluations of operating theatre healthcare staff revealed significantly lower pulmonary function compared with unexposed controls, with function declining as exposure duration increased.^[3,12] Bioaerosol exposure in waste management facilities is associated with respiratory symptoms and pulmonary function impairment among workers in composting, waste sorting, and sanitation services.^[5] Our finding of significant negative correlation between employment duration and lung function ($r = -0.74$

for FVC%, $r = -0.65$ for FEV₁%) is consistent with previous occupational cohort studies showing progressive decline with cumulative exposure. The rate of decline (1.46% FVC per year, 1.03% FEV₁ per year) falls within ranges reported in other occupational respiratory disease cohorts.^[13] Strengths of this study include standardized spirometry performed per American Thoracic Society/European Respiratory Society guidelines,^[1] with rigorous quality control, well-matched control group reducing confounding, clear exposure stratification, quantitative exposure--response analysis strengthening causal inference, and cross-sectional design suitable for prevalence estimation.

Limitations include: (1) cross-sectional design preventing causality establishment; (2) lack of direct exposure assessment (air sampling, bioaerosol/endotoxin measurement); (3) convenience sampling potentially limiting generalizability; (4) unmeasured confounders such as second-hand smoke exposure. This study underscores urgent need for comprehensive occupational health interventions: (1) regular spirometric screening with baseline testing at employment and periodic reassessment; (2) improved waste segregation and mechanized handling systems; (3) training and enforcement of consistent PPE use (N95 masks or higher) prioritizing engineering controls over PPE; (4) worker education on occupational hazards and symptom reporting; (5) clinical assessment of workers with spirometric abnormalities for appropriate preventive measures; (6) strengthening enforcement of Biomedical Waste Management Rules 2016 and KAYAKALP guidelines; and (7) expansion of occupational health research and national surveillance databases.

CONCLUSION

Hospital sanitary workers in this tertiary-care setting demonstrated significantly reduced spirometric indices with predominantly restrictive pulmonary dysfunction pattern. A clear exposure--response relationship was evident, with progressive lung function decline correlating with years of occupational

employment. These findings indicate probable occupationally related respiratory dysfunction and support urgent implementation of comprehensive occupational health surveillance, improved engineering controls, and protective measures. Integration of respiratory health screening and occupational health services into hospital waste-management policies is essential to safeguard health and economic productivity of this essential but under resourced workforce.

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Conflicts of interest

There are no conflicts of interest.

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