Turk Thorac J 2022; 23(3): 203-209 DOI: 10.5152/TurkThoracJ.2022.21183

Original Article

Prevalence and Risk Factors of Work-Related Asthma in Hospital Cleaning Workers

Seval Müzeyyen Ecin[1], Abdulsamet Sandal[2], Sultan Pınar Çetintepe[2], Adem Koyuncu[3], Özlem Kar Kurt[4], Ali Naci Yıldız[5], Ahmet Uğur Demir[6]

[1]Unit of Occupational Medicine, Mersin City Training and Research Hospital, Mersin, Turkey
[2]Occupational Diseases Clinic, Ankara Occupational and Environmental Diseases Hospital, Ankara, Turkey
[3]Occupational Diseases Clinic, Atatürk Chest Diseases and Chest Surgery Training and Research Hospital, Ankara, Turkey
[4]Occupational Diseases Clinic, Zonguldak Atatürk State Hospital, Zonguldak, Turkey
[5]Department of Public Health, Faculty of Medicine, Hacettepe University, Ankara, Turkey
[6]Department of Chest Diseases, Faculty of Medicine, Hacettepe University, Ankara, Turkey

Cite this article as: Müzeyyen Ecin S, Sandal A, Pınar Çetintepe S, et al. Prevalence and risk factors of work-related asthma in hospital cleaning workers. *Turk Thorac J.* 2022;23(3):203-209.

Abstract

OBJECTIVE: This study aimed to determine the prevalence and evaluate the risk factors of work-related asthma among professional hospital cleaning workers.

MATERIAL AND METHODS: In total, 278 cleaning workers were interviewed (response rate: 75.7%), and pulmonary function tests were performed. The presence of asthma and its work-relatedness was evaluated. Serial peak expiratory flow measurements were planned according to symptoms increased at work or spirometric findings.

RESULTS: Totally 40 cleaning workers had asthma (14.3%); of these, 17 (6.1%) had work-related asthma, and 23 (8.2%) had non-work-related asthma. Non-work-related asthma and work-related asthma were significantly associated with the females(odds ratio 95% CI: 3.0, 1.1-8.4, and 3.2, 1.0-10.3, respectively). Non-work-related asthma was significantly associated with a family history of asthma (odds ratio 95%CI: 5.1, 2.0-13.2 and 2.8, 0.99-7.9, respectively) and limescale remover use at work (odds ratio, 95% CI: 0.21, 0.04-0.97, and 1.7, 0.5-5.2, respectively). Only 7 (28.0%) of 25 cleaning workers who were suggested serial peak expiratory flow measurements could complete the measurements. Of those, measurements of 2 cleaning workers were consistent with occupational asthma.

CONCLUSION: The negative association between limescale remover use at work and non-work-related asthma suggested health selection bias (avoidance behavior) due to the asthmatic effects of these chemicals.

KEYWORDS: Occupational asthma, work-aggravated asthma, asthma, cleaning product, cleaning workers, cleaners
Received: *July 5, 2021* ***Accepted:*** *December 1, 2021* ***Available Online:*** *April 13, 2022*

INTRODUCTION

The American College of Chest Physicians defines work-related asthma (WRA) as asthma caused or worsened by allergen or irritant agents inhaled at work. Work-related asthma is subdivided into occupational asthma (OA) and work-exacerbated asthma (WEA).[1] The difference between OA and WEA is that OA defines newly started asthma in a previously non-asthmatic person, whereas work-aggravated asthma defines asthma worsening in an asthmatic person but both are due to occupational exposures.[2] The cases with OA constitute 10%-25% of all asthma cases.[3] Professional cleaning is one of the occupations with a risk of OA. Moreover, professional cleaning workers in developed countries have more asthma symptoms than those in the general population.[4] Workforce-based studies are used to evaluate the variety of exposures in occupations with different duties and materials used.[5]

Cleaning workers are exposed to indoor allergens and dust besides irritant and sensitizing chemicals. Asthma triggering or worsening may be the result of an irritant-related mechanism or a specific sensitization. The main sensitizers in cleaning products are disinfectants, quaternary ammonia compounds, amine compounds, and scents. The most potent airway irritants in cleaning products that can also be found in mixed forms are bleach (sodium hypochlorite), hydrochloric acid, and alkali substances (ammonia and sodium hydroxide).[5]

In this cross-sectional study, we aimed to determine the prevalence of WRA, its relationship to allergic symptoms, and possible triggering exposures among hospital cleaning workers.

MATERIAL AND METHODS

Study Population

The study population included professional cleaning workers at a university hospital located in Turkey. The study protocol was approved by the non-interventional clinical research ethics board of Hacettepe University (decision no. GO 17/937-16). All cleaning workers of the hospital were invited to the Occupational Diseases Department between

Corresponding author: Seval Müzeyyen Ecin, e-mail: seval44ecin@gmail.com

Copyright@Author(s) - Available online at TurkThoracJ.com. Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

May and July 2018. After obtaining informed consent from all participants, 5 fellows of occupational diseases' sub-specialty collected data via a questionnaire, spirometry, and serial peak expiratory flow (PEF) measurements, if suggested.

Questionnaire

Data were collected via a questionnaire completed by the interviewer. The questionnaire was adapted from The European Community Respiratory Health Survey II Occupational Modules and Screening Questionnaire.[6] Questions related to demographic characteristics, smoking status, pulmonary symptoms, personal and family history of asthma, personal history of rhinitis, occupational history, exposure to cleaning products at home, and hobbies with a risk of asthma (i.e., gluing, painting, wood carving, painting, hairdressing, welding, construction, farming, and bakery) were asked.

- Asthma-related medical history was determined from the responses to the following questionnaire data:
- **Asthma diagnosed by a physician:** "Have you been diagnosed with asthma before you started your current occupation?" If the answer was affirmative, the duration of asthma was asked.
- **History of respiratory symptoms in the last 12 months:** History of cough, chest tightness, nocturnal symptoms, asthma attack history, and medical therapy for asthma were asked.

Occupational history: Division of the hospital in which the participant worked, duration of work hours per day, and workdays per week, and previous occupations with a risk for asthma (i.e., cleaning, gluing, painting, wood carving, painting, hairdressing, welding, construction, and farming, bakery) were asked via open-ended questions.

Participants who reported using cleaning products were asked if they used 6 common types of cleaning products (detergent, polisher, limescale remover, ammonia, bleach, and any other products). Detergent/cleaning product exposure assessment was determined from the answers to the questionnaire and workplace observations. Products were reported by participants to determine the main ingredients of concern (quaternary ammonium (QACs), chloramines/ bleach). Quaternary ammonium and other compounds are grouped under detergent. The use of a personal protective mask at work was also asked. Regular usage of a mask (usage at any time during cleaning or whenever exposure to products) at work was defined as the time of exposure to cleaning products.

Work-related asthma symptoms: Yes/no questions were used to determine if asthma symptoms (wheeze and/or shortness of breath) worsened at work and were relieved on days away from work or on holidays.

Pulmonary Function Test: Medwelt SP10 Portable Spirometry device was used for spirometric measurements with single-use antibacterial filtered mouthpieces. Pulmonary function tests (PFTs) were performed and evaluated according to American Thoracic Society/European Respiratory Society standards with European Respiratory Society/European Coal and Steel Community 1993 reference values.[7] The spirometric maneuver was repeated at least 3 times, and the test results with the highest values were recorded. The volume difference between measurements should be a maximum of 3% or 0.05 L.[8] The collected PFT data included forced expiratory volume (FVC), forced expiratory volume in 1 second (FEV1), percentages according to predicted values (FVC, FEV1), and FEV1/FVC ratio. Bronchodilator reversibility by administering salbutamol was also measured if the percentages of FEV1 was <80% of expected and/or the FEV1/FVC ratio was 0.70. Reversibility criterion was determined as an increase in FEV1 of at least 200 mL in volume and 12% measured 15-20 minutes after the inhalation of 400 µg salbutamol.[7]

Serial PEF Measurements

Serial PEF measurements were planned if at least one of the following criteria were met:

- a medical diagnosis of asthma (asthma diagnosed by a physician or a history of asthma medication prescription within the last 12 months),
- respiratory symptoms of cough and/or chest tightness within the last 12 months,
- asthma attack history within the last 12 months,
- positive bronchodilator reversibility,
- FEV1 < 80% predicted and/or FEV1/FVC ratio between 0.7 and 0.8 after bronchodilator inhalation despite negative bronchodilator reversibility.

Daily PEF variability percentages were calculated according to the following formula in the Global Initiative for Asthma guideline[9]:

PEF variability = 100 × (maximum PEF – minimum PEF)/(½ (maximum PEF + minimum PEF))

Each participant was provided with an e-Mini Wright Digital PEF meter to record PEF values digitally along with both verbal and written instructions. Participants with asthma symptoms and or diagnosis of asthma were asked to measure their PEF values via PEF meters 4 times daily (at the beginning, middle, end of the workday, and after work) for 3 weeks and to continue the measurements over the weekends at similar hours. PEF measurement data were digitally obtained. We calculated the PEF variability values for those participants who measured their PEF 4 times per day, for at least 6 workdays and non-workday. Criteria for acceptable PEF results were the presence of at least 75% of the total measurements. Mean daily peak flow variability in workdays above 20% or higher and/or relatively more frequent variability on workdays than non-work days was used to confirm work-related asthma.[10]

We analyzed PEF measurements with the Occupational Asthma System program (OASYS) version of February 2020. This system was initially developed by Gannon et al[11] and Burge et al. and has been reported to have a sensitivity of 76% and specificity of 94% for identifying work-related changes in peak flow (once suspicion of OA has been raised) confirmed by independent objective tests. The OASYS currently has a scoring system (work effect index (WEI)), which uses a discriminant analysis and scores "complexes," composed of either a work–rest–work period or a rest–work–rest period.[11]

Occupational Asthma System score requires a minimum of 4 readings per day, 3 consecutive workdays in any work period, and ~3 weeks' worth of readings (3 complexes, a feature of OASYS).[12] Less data lead to reduced sensitivity and specificity. The ABC score has recently been shown to have a sensitivity of 69% and specificity of 100% when the cut-off score is 15 L/min/h for OA diagnosis.[13] The OASYS uses the discriminant analysis to score the record between 1 and 4 using a cut-off of 2.5. Scores above this have a 94% specificity for OA and a 75% sensitivity when using independent diagnosis methods.[11]

Determination of Asthma, WRA, and Asthma Excluding WRA

Cleaners who reported wheezing within the last 12 months or a history of physician-diagnosed asthma or asthma medication prescribed within the last 12 months were grouped as asthma. Among those asthma cases, cleaners who had asthma with increased symptoms at the workplace were grouped as WRA, and those who did not have asthma symptoms in the workplace were grouped as asthma excluding WRA (non-work-related asthma, NWRA).

Statistical Analysis

Data were analyzed using IBM Statistical Package for the Social Sciences Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics of continuous variables with normal distributions were given as means ± standard deviation, whereas those without normal distributions were provided as medians and minimum–maximum range. Independent samples *t*-test and chi-square tests were used to compare 2 continuous variables and 2 independent categorical variables, respectively. Multinomial logistic regression analysis was conducted for WRA and NWRA, with forward selection criteria of entry and removal of 0.05 and 0.10, respectively. This modeling approach was used since these 2 outcomes were related, and we aimed to compare the association of potential risk factors between WRA and NWRA. Age, gender, work-related and domestic exposures, hobbies, and smoking status were introduced to the model as the potential risk factors. Odds ratios and 95% CIs were calculated as the estimates of relative risk. *P*-values below .05 were considered statistically significant.

RESULTS

Of 366 hospital cleaning staff, 78 (21.3%) could not be reached and 11 (3%) did not agree to participate. Data were collected from 278 (75.7%) cleaners. Nearly two-thirds of the participants were men (63.3%); the ages ranged between 20 and 59 years, and 41.4% were in their fourth decade (40-49 years).

Previous work history was reported by 70.9% of participants, and 70.5% had previous occupations as cleaning workers and in occupations related to asthma risk, including cleaning and other occupations including jobs with exposure to glues or chemicals, carpentry, painting, hairdressing, welding, farming, construction, bakery.

Except for 1 participant with facial paralysis, PFTs of 277 participants were evaluated. Airway obstruction (FEV1/FVC < 0.8) was detected in 47 (17.0%) participants. Of those, 7 had bronchodilator reversibility, 28 had fixed airway obstruction, and 12 could not repeat the test after bronchodilator application due to failure to cooperate.

Of the 40 cleaners (14.4%) with asthma diagnosis and/or medication use and/or wheezing in the last 12 months, 17 (6.1%) reported asthma symptoms in the workplace. Among these WRA cases, 13 (4.7%) cleaners were grouped as OA and 4 (1.4%) cleaners (asthma worsening in an asthmatic person at work) were grouped WEA. The comparison of WRA with NWRA and no asthma groups is shown in Table 1.

In the multinomial logistic regression, no asthma group was defined as the reference group. Age, gender, work-related and domestic exposures, hobbies, and smoking status were introduced to the model as the potential risk factors (Table 2). Work-related asthma was significantly associated with the female gender (OR: 3.2, 95% CI: 1.0-10.3, p: 0.004). The NWRA was significantly associated with female gender (OR: 3.0, 95% CI: 1.1-8.4, p: 0.03), family history of asthma (OR: 5.1, 95% CI: 2.0-13.2, p: 0.001) and limescale remover use at work (OR: 0.21, 95% CI: 0.97-1.36, p: 0.04).

Serial PEF testing was offered to 26 cleaners. One cleaner did not agree to use PEFmeter devices. Seven had acceptable PEF readings. WRA was confirmed in 4 of those 7 cleaners. Changes in serial PEF testing were depicted in Table 3.

Since the cleaners measured PEF records 2 to 4 times per day, we used the OASYS cut-off score of 2.5. Two cleaners' scores were 2.80 and 3.00, which were consistent with OA. The OASYS plots of PEF in these 2 workers were shown in Figure 1.

DISCUSSION

We investigated WRA in hospital cleaning staff, who constitute a risk group with occupational exposure to chemicals via inhalation or skin contact, causing urticaria and dermatitis. We found that the prevalence of WRA was 6.1%, and the risk for WRA increased with the female gender. Our findings suggested that NWRA was significantly associated with a family history of asthma. A negative association between limescale remover use at work and NWRA was observed. The serial PEF measurements were planned, but only 7 (28.0%) of the 25 cleaning workers who were suggested serial PEF measurements could complete the measurements. Measurements of 2 cleaning workers were consistent with OA.

In our study, WRA among cleaning workers was 6.1%. The prevalence of WRA was within this range of within the range of previous studies in cleaning workers (3.3-12%).[14,15] The mean age and mean duration of working among the cleaners were 38.9 years and 10.3 years, respectively. Our study population was younger than that reported by Lipińska-Ojrzanowska et al.[15] who reported the mean age as 46 years and the duration of work as 6.3 years in the hospital cleaning staff.

The proportion of current smoking in cleaners was higher than that of the general Turkish population (50.0%, and 27.1%, respectively).[16] After collecting the information, we

Table 1. The Characteristics of Cleaning Workers According to the Classification of the Asthma Status.

Characteristic	No Asthma (n = 238)	WRA (n = 17)	NWRA (n = 23)	*P* (WRA vs. No Asthma)	*P* (NWRA vs. No Asthma)
Age (years), mean ± SD	38.6 ± 8.1	39.2 ± 7.5	41.5 ± 7.9	.76	.11
Female gender, n (%)	77 (32.4)	12 (70.6)	13 (56.5)	.003	.02
BMI (kg/m^2)* , mean ± SD	26.7 ± 4.2	28.3 ± 6.6	25.8 ± 4.2	.34	.33
Ever smoking, n (%)	145 (60.9)	11 (64.7)	14 (60.9)	.76	.1
Rhinitis, n (%)	50 (21.0)	12 (70.6)	8 (34.8)	<.001	.13
Family history of asthma, n (%)	60 (25.2)	9 (52.9)	15 (65.2)	.02	<.001
Usage of cleaning products at home, n (%)	114 (47.9)	13 (76.5)	13 (56.5)	.02	.43
Work hours per week, mean ± SD	47.3 ± 2.3	47.2 ± 2.7	47.4 ± 1.8	.81	.87
Total duration of work (years) , mean ± SD	10.4 ± 5.2	9.1 ± 4.5	10.9 ± 5.3	.32	.6
Allergic symptom at work**, n (%)	20 (8.4)	7 (41.2)	5 (21.7)	.001	.54
Regular usage of mask at work, n (%)	21 (8.8)	1 (5.9)	2 (8.7)	1	1
Cleaning products used at work, n (%)	231 (97.1)	16 (94.1)	23 (100.0)	.40	1
Detergent	228 (95.8)	16 (94.1)	23 (100.0)	.54	.69
Polishes	149 (62.6)	12 (70.6)	13 (56.5)	.51	.57
Limescale remover	70 (29.4)	7 (41.2)	2 (8.7)	.31	.34
Ammonia	122 (51.3)	10 (58.8)	15 (62.5)	.55	.2
Bleach	209 (87.8)	15 (88.2)	23 (100.0)	1	.88
Hobbies with asthma risk***, n (%)	15 (6.3)	2 (11.8)	2(11.8)	.39	.68
Previous work history of cleaning, n (%)	37 (15.5)	3 (17.6)	3 (13.0)	.74	1
Previous work history of jobs related to asthma***, n (%)	86 (36.1)	1 (5.9)	9 (39.1)	.01	.78

BMI, body mass index; SD, standart deviation; WRA, work-related asthma; NWRA, Asthma excluding WRA.
*Height and weight measurements were performed in 274 subjects; **Sensation of swelling in the throat and dyspnea and/or itching and wheals in the skin; ***Gluing, painting, wood carving, painting, hairdressing, welding, construction, farming, bakery, etc. Cleaning was excluded.

informed and warned cleaners about the harmful effects of smoking and cessation recommended them to attend smoking cessation clinics.

Most of the participants reported that they worked 8 hours per day (95%) and 6 days per week (86.3%) with a mean of 47.3 ± 2.3 working hours per week, which was similar to a previous study from Turkey (mean working hours per day and per week of 8.0 ± 0.1 and 43.3 ± 9.5, respectively) and above the legal limits of 45 hours a week.[17,18]

We found that the female gender increased the risk of WRA by almost 3.2-fold (95% CI, 1.0-10.3). Similarly, Li et al[19] found that cleaning agent exposures had a significantly larger proportion of females, and several other studies also showed increased WRA risk with the female gender.[20-22]

Table 2. Risk Factors Associated with WRA and NWRA Adjusted in the Multinomial Logistic Regression Analysis Model

Characteristic	WRA OR (95% CI)	*P*	NWRA OR (95% CI)	*P*
Female gender	3.2 (1.0-10.3)	.04	3.0 (1.1-8.4)	.03
Age ≥ 40 versus 20-39 years	0.79 (0.27-2.35)	.66	0.98 (0.38-2.5)	.95
Limescale remover use at work	1.7 (0.5-5.2)	.30	0.21 (0.04-0.97)	.04
Family history of asthma	2.8 (0.99-7.9)	.05	5.1 (2.0-13.2)	.001
Previous work history of jobs related to asthma*	0.16 (0.02-1.36)	.09	1.9 (0.71-5.5)	.19

OR, odds ratio; WRA, work-related asthma; NWRA, asthma excluding WRA.
*Gluing, painting, wood carving, painting, hairdressing, welding, construction, farming, bakery, etc. Cleaning was excluded.

Table 3. Characteristics, PFT, and Serial PEF Measurements of Cleaning Workers Whose Serial Measurements Met the Pre-defined Criteria for Inclusion in Variability Analysis

					Cleaning products used at work							PFT		PEF Variability									
														Work Days					Non-Working Days				
	Age	Gender	WRA	Aggravation of Symptoms at Work	Detergent	Polishes	Limescale Remover	Ammonia	Bleach	Use of Cleaning Products at Home	OASYS Score*	FEV1/FVC	FEV1, % of Expected	Median %	Mean	Percentiles 25	50	75	Median %	Mean	Percentiles 25	50	75
Worker 1	35	M	+	+	+	+	−	−	+	−	2.08	0.69	65	20.3	2.4	−8.6	−1.1	15.5	18.7	−23.3	−33.8	−23.3	−12.8
Worker 2	48	M	+	+	+	+	+	+	+	−	2.80	0.81	90	29.6	−1.1	−19.7	−1.5	14.5	39.6	5.6	−8	11.8	12.9
Worker 3	53	M	−	+	+	−	−	+	+	−	1.29	0.76	78	10.6	−3.1	−8.3	−3.8	3.2	5.0	1.6	−1.8	0.1	6.4
Worker 4	47	F	−	+	+	+	−	−	+	+	1.20	0.85	87	16.1	−0.4	−14.5	−4.3	11.4	24.3	10.6	−8.2	10.7	29.4
Worker 5	40	M	−	+	+	+	+	−	+	+	1.38	0.85	89	17.6	1.2	−3.6	3.5	8	19.5	5.1	−6.6	2.5	19.4
Worker 6	42	F	+	+	+	−	+	−	+	+	3.00	0.93	71	13.7	4.8	−3	3.3	11.2	13.7	−15.4	−52.3	2.5	16.5
Worker 7	45	M	+	+	+	+	+	+	+	−	1.00	0.81	69	13.9	3.0	−1.7	3.6	7.5	22.0	−4.4	−28.7	−3.9	13.1

FEV1, forced expiratory volume in 1 second; FVC, forced expiratory volume; PFT, pulmonary function tests; PEF, peak expiratory flow; WRA, work-related asthma; OASYS, Occupational Asthma System.
*The OASYS scores of workers 2 and 6 were consistent with occupational asthma (score cut-off, >2.5).

A family history of asthma is a risk factor for asthma.[9] That could indicate atopic status. We found a significant relationship between family history and NWRA.

Several suspected agents in cleaning have been identified, including glutaraldehyde, quaternary ammonium compounds (QATs), formaldehyde, bleach, chloramines, detergents, limescale remover, and fragrances.[23] In our study, the most frequently used cleaning products were reported as bleach, detergent, limescale remover, and most participants used more than one cleaning product so that causative agents could not be determined with certainty. Limescale remover use at work was negatively associated with NWRA (odds ratio: 0.21, 95% CI: 0.04-0.97). Vizcaya et al[24] in a study of female cleaning workers found an association of upper respiratory tract symptoms with exposure to bleach, glass cleaner, detergents, limescale remover, and air fresheners, which was stronger among women with atopy. Limescale remover exposure at work could be triggering asthma symptoms, and asthmatic workers could be more likely to avoid this exposure.

Studies have shown that the results of asthma studies on the effects of occupational exposures on morbidity and mortality could be masked due to workers with respiratory symptoms changing or quitting their jobs.[25,26] Although the associations were not statistically significant in the model, previous work history of asthma-triggering jobs other than cleaning was less common in WRA than NWRA, which indicated a possible health selection bias, that is cleaning workers who worked in asthma-triggering jobs were mostly not admitting for cleaning work.

One of the limitations of our study is the lack of a specific bronchoprovocation test. One alternative for cases that cannot undergo the specific bronchoprovocation test is serial PEF measurements on workdays and non-workdays for at least 4 weeks as 2 weeks for workdays and 2 weeks non-workday.[27] In our study, we used serial PEF measurements to find daily mean PEF variability of 20.6 and 20.38 for work days and non-work days, respectively. Chiry et al[28] reported values of 23.2 ± 11.6 and 11.8 ±7.3, respectively. Similar values between workdays and non-workdays in the present study may be the result of the continued exposure to cleaning products at home, inappropriate measurements of PEF, the shorter follow-up period for days away from work compared to those for workdays, or other unexplained reasons. One study reported that two-thirds of patients for which PEF follow-up was suggested had completed PEF recordings, whereas another study reported that 55% of workers had appropriate PEF recordings.[29,30] In our study, 7 of 24 participants (29.1%) had PEF records meeting the pre-defined criteria for analysis. The value of PEF follow-up in the diagnosis of OA is related to patient compliance and awareness of the importance of the follow-up in addition to the cessation of medical therapy for asthma. Self et al[31] showed that patients did not use PEF meter properly so clinicians should regularly follow patients' PEF devices, detect errors, and ensure their correct use. Quirce et al[32] reported that PEF follow-up might be unreliable due to the unobserved nature of in-home measurements. Additionally, relatively long follow-up periods (3 weeks), the unwillingness of participants to carry a PEF meter between home and work, varying workload, and

participant education levels may affect the adequacy of PEF meter follow-measurement. Fear of losing the current job as a result of job insecurity and frequent change of job among our study participants may be a potential reason for the low proportion of completed PEF data in our study.

To our knowledge, our one center study is the first to investigate the frequency of WRA among Turkish hospital cleaning staff. The strength of our study also includes a high percentage (75%) of the population who agreed to participate. A relatively small number of workers with a sufficient number of PEF measurements according to pre-defined criteria were the major limitation. Lack of previous occupational health records, including medical evaluation for fitness to work, precluded the distinction between OA and work-aggravated asthma.

In summary, we detected work-related asthma symptoms and PFT abnormalities in hospital cleaning workers. Our findings suggest that cleaning workers with a medical history of asthma may require close attention to the risk of WRA. Also, prior working history in a job with a risk for WRA and limescale remover usage could be a health selection factor, which signifies a healthy worker effect. Mask usage among cleaners was uncommon. Therefore, in a workplace with asthma-triggering features (e.g., use of different types of cleaning products), hospitals should be evaluated for ventilation, and required engineering measures and personal protective measures, including mask usage, should be taken. Cleaning workers should be informed about the hazardous health effects of cleaning products, mixture toxicity, and protective measures.

Ethics Committee Approval: This study was approved by non-interventional clinical research Ethics committee of Hacettepe University (Approval No: GO 17/937-16).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – S.M.E., A.S., A.K., A.N.Y., A.U.D.; Design – S.M.E., A.S., A.K., A.N.Y., A.U.D.; Supervision – S.M.E., A.S., A.U.D.; Data Collection and/or Processing – S.M.E., A.S., S.P.Ç., A.K., Ö.K.K.; Analysis and/or Interpretation – S.M.E., A.S., A.U.D.; Literature Search – S.M.E., A.S., A.U.D..; Writing Manuscript – S.M.E.; Critical Review – S.M.E., A.U.D.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: This study was supported by the Hacettepe University Scientific Research Projects Coordination Unit (Project Number: THD-2018-16714).

REFERENCES

1. Tarlo SM, Balmes J, Balkissoon R, et al. Diagnosis and management of work-related Asthma: American College of Chest Physicians Consensus Statement. *Chest*. 2008;134(3):1S-41S. [CrossRef]
2. Henneberger PK, Redlich CA, Callahan DB, et al. An official American Thoracic Society statement: work-exacerbated asthma. *Am J Respir Crit Care Med*. 2011;184(3):368-378.
3. Dykewicz MS. Occupational asthma: current concepts in pathogenesis, diagnosis, and management. *J Allergy Clin Immunol*. 2009;123(3):519- 529. [CrossRef]
4. Zock JP, Vizcaya D, Le Moual N. Update on Asthma and cleaners. *Curr Opin Allergy Clin Immunol*. 2010;10(2):114-120. [CrossRef]
5. Malo JL, Chan-Yeung M. Agents causing occupational asthma. *J Allergy Clin Immunol*. 2009;123(3):545-550. [CrossRef]
6. European Community Respiratory Health Survey II Steering Committee. The European Community respiratory health survey II. *Eur Respir J*. 2002;20(5):1071-1079. [CrossRef]
7. Laszlo G. Standardisation of lung function testing: helpful guidance from the ATS/ERS task force. *Thorax*. 2006;61(9):744-746. [CrossRef]
8. Ulubay G, Köktürk N, Dilektaşlı-Görek A, et al. Turkish Thoracic Society national spirometry and laboratory standarts. *Tuberculosis and Thorax*. 2017;64(2):2. (in Turkish). [CrossRef]
9. Global Initiative for Asthma. Global strategy for asthma management and prevention; 2019. Available at: http://www.ginasthma.org.
10. Liss GM, Tarlo SM. Peak expiratory flow rates in possible occupational asthma. *Chest*. 1991;100(1):63-69. [CrossRef]
11. Gannon PF, Newton DT, Belcher J, Pantin CF, Burge PS. Development of OASYS-2: a system for the analysis of serial measurements of peak expiratory flow in workers with suspected occupational asthma. *Thorax*. 1996;51(5):484-489. [CrossRef]
12. Anees W, Gannon PF, Huggins V, Pantin CFA, Burge PS. Effect of peak expiratory flow data quantity on diagnostic sensitivity and specificity in occupational asthma. *Eur Respir J*. 2004;23(5):730-734. [CrossRef]
13. Moore VC, Jaakkola MS, Burge CBSG, et al. A new diagnostic score for occupational asthma; the area between the curves (ABC score) of peak expiratory flow on days at and away from work. *Chest*. 2009;135(2):307-314. [CrossRef]
14. Arif AA, Delclos GL, Whitehead LW, Tortolero SR, Lee ES. Occupational exposures associated with work-related asthma and work-related wheezing among US workers. *Am J Ind Med*. 2003;44(4):368-376. [CrossRef]
15. Lipińska-Ojrzanowska A, Wiszniewska M, Świerczyńska-Machura D, et al. Work-related respiratory symptoms among health centres cleaners: a cross-sectional study. *Int J Occup Med Environ Health*. 2014;27(3):460-466. [CrossRef]
16. World Health Organization. *WHO Report on the Global Tobacco Epidemic. Enforcing Bans on Tobacco Advertising, Promotion and Sponsorship*. Luxembourg: World Health Organization; 2013.
17. İlhan MN, Kurtcebe ZÖ, Durukan E, Koşar L. The sociodemographic characteristics and working conditions of the cleaning workers and the prevalence of occupational accidents and diseases. *Fırat Univ Sağlık Bilimleri Derg*. 2006;20(6):433-439 (in Turkish).
18. Ministry of Labour and Social Security. The law number 4857 (in Turkish). Available at: https://www.mevzuat.gov.tr/MevzuatMetin/1.5.4857.pdf.
19. Li RWH, Lipszyc JC, Prasad S, Tarlo SM. Work-related asthma from cleaning agents versus other agents. *Occup Med (Lond)*. 2018;68(9):587-592. [CrossRef]
20. Obadia M, Liss GM, Lou W, Purdham J, Tarlo SM. Relationships between asthma and work exposures among non-domestic cleaners in Ontario. *Am J Ind Med*. 2009;52(9):716-723. [CrossRef]
21. Radon K, Gerhardinger U, Schulze A, et al. Occupation and adult onset of rhinitis in the general population. *Occup Environ Med*. 2008;65(1):38-43. [CrossRef]

22. Lipinska-Ojrzanowska AA, Wiszniewska M, Walusiak-Skorupa JM. Work-related asthma among professional cleaning women. *Arch Environ Occup Health*. 2017;72(1):53-60. [CrossRef]
23. Dumas O, Le Moual N. Do chronic workplace irritant exposures cause asthma? *Curr Opin Allergy Clin Immunol*. 2016;16(2):75-85. [CrossRef]
24. Vizcaya D, Mirabelli MC, Gimeno D, et al. Cleaning products and short-term respiratory effects among female cleaners with asthma. *Occup Environ Med*. 2015;72(11):757-763. [CrossRef]
25. Kroenke CH, Spiegelman D, Manson J, Schernhammer ES, Colditz GA, Kawachi I. Work characteristics and incidence of type 2 diabetes in women. *Am J Epidemiol*. 2007;165(2):175-183. [CrossRef]
26. Li CY, Sung FC. A review of the healthy worker effect in occupational epidemiology. *Occup Med (Lond)*. 1999;49(4):225-229. [CrossRef]
27. Palange P, Simonds AK. *ERS Handbook of Respiratory Medicine*. 2nd ed. Sheffield, United Kingdom: European Respiratory Society; 2013.
28. Chiry S, Cartier A, Malo JL, Tarlo SM, Lemière C. Comparison of peak expiratory flow variability between workers with work-exacerbated asthma and occupational asthma. *Chest*. 2007;132(2):483-488. [CrossRef]
29. Draper A. Occupational asthma. *J Asthma*. 2002;39(1):1-10. [CrossRef]
30. Arbak P. Mesleki Astım ve Bissinosis. *Klin Gelişim*. 2010;23(4): 23-28 (in Turkish).
31. Self TH, George CM, Wallace JL, Patterson SJ, Finch CK. Incorrect use of peak flow meters: are you observing your patients? *J Asthma*. 2014;51(6):566-572. [CrossRef]
32. Quirce S, Contreras G, DyBuncio A, Chan-Yeung M. Peak expiratory flow monitoring is not a reliable method for establishing the diagnosis of occupational asthma. *Am J Respir Crit Care Med*. 1995;152(3):1100-1102. [CrossRef]