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Respiratory Health Risks in Hairdressing: A Cross-sectional Study of Occupational Subgroups

Mahsa Choroom Kheirabadi[1], Elahe Hesari[2], Mansoureh Shariat[1], and Mohammad Gharagozlou[1]

[1] Division of Allergy and Clinical Immunology, Department of Pediatrics, Pediatrics Center of Excellence, Children's Medical Center Hospital, Tehran University of Medical Sciences, Tehran, Iran
[2] Department of Pediatrics, Pediatrics Center of Excellence, Children's Medical Center Hospital, Tehran University of Medical Sciences, Tehran, Iran

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ABSTRACT

Occupational exposure in hairdressing is associated with significant respiratory health risks, including impaired lung function and respiratory symptoms. This study aimed to evaluate and compare respiratory symptoms and pulmonary function across subgroups of hairdressers categorized by their specific exposure profiles.

A cross-sectional analysis was conducted involving 152 female hairdressers in Tehran, Iran, who were stratified into four subgroups: (1) individuals with direct exposure to hair dyes, dechlorinating agents, and keratinizing substances; (2) individuals exposed to varnish, acetone, and nail implant materials; (3) individuals exposed to adhesives for hair and eyelash extensions; and (4) individuals with minimal or no direct chemical exposure. Respiratory and nasal symptoms were assessed using the European Community Respiratory Health Survey (ECRHS) III questionnaire. spirometry measurements, including forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC ratio, and forced expiratory flow at 25–75% of FVC (FEF25–75), were performed to evaluate pulmonary function.

Overall, 42.1% of participants reported respiratory symptoms, with subgroup 1 exhibiting the highest prevalence. Cough (64.3%), wheezing (35.7%), and dyspnea (64.3%) were the most commonly reported symptoms, while 22.4% reported nasal symptoms. Subgroup 1 demonstrated significantly lower pulmonary function indices and a higher prevalence of obstructive lung patterns (40.5%). Bronchodilator responsiveness indicative of asthma was observed in 34.2% of participants.

In conclusion, direct occupational exposure to hairdressing chemicals, particularly hair dyes and bleaching agents, is associated with substantial respiratory impairment. Implementation of regular health surveillance, personal protective equipment, and enhanced workplace ventilation is strongly recommended.

Keywords: Asthma; Hairdressers; Lung function tests; Occupational exposure; Respiratory tract diseases

Corresponding Author: Mohammad Gharagozlou, MD;
Division of Allergy and Clinical Immunology, Department of Pediatrics, Pediatrics Center of Excellence, Children's Medical Center, Tehran University of Medical Sciences, Tehran, Iran. Tel: (+98 21) 6692 9234, Fax: (+98 21) 9663 0024, Email: gharagoz@tums.ac.ir

INTRODUCTION

Long-term occupational exposure to irritants and allergens is a significant risk factor for the development of work-related respiratory diseases, including occupational asthma, chronic obstructive pulmonary disease (COPD), and, in some instances, respiratory tract cancers.[1,2]

Work-related asthma, which encompasses asthma caused directly by occupational exposures and asthma exacerbated by workplace conditions, is among the most common occupational respiratory diseases. It should be considered in all adults presenting with asthma, particularly those with recent-onset or difficult-to-control symptoms.[3] Hairdressing is the fourth most common occupation associated with occupational asthma across genders and the second most common occupation among women, accounting for 6.8% of reported cases.[4] The estimated incidence of occupational asthma among hairdressers is up to 3.7 cases per 10,000 individuals annually.[5]

Hairdressers and nail technicians are regularly exposed to a wide range of substances through both inhalation and skin contact. These include acetone, toluene, ammonia, hydrogen peroxide, and persulfate salts, which are known to cause respiratory and skin symptoms through irritant or hypersensitivity mechanisms.[6-8] Among these, bleaching agents, particularly persulfate salts, are considered the primary contributors to respiratory symptoms in hairdressers.[6,9-12] Although persulfates are generally classified as IgE-mediated sensitizers, research, including animal studies, suggests that non-IgE-mediated allergic reactions are also significant contributors.[1,13,14]

Certain small molecules present in hairdressing materials act as potent haptens, capable of inducing allergic contact dermatitis.[12] Moreover, studies indicate that primary skin contact with low molecular weight asthmagens, such as ammonium persulfate and potassium persulfate, can lead to systemic sensitization. This sensitization increases the likelihood of asthma development upon subsequent respiratory exposure.[15]

Several risk factors have been associated with the occurrence of work-related respiratory diseases. These include smoking, genetic predisposition, and prolonged occupational exposure to irritants and allergens.[16-19] Numerous studies have demonstrated that hairdressers exposed to high concentrations of irritants and allergens in poorly ventilated salons experience significantly more respiratory symptoms and exhibit lower lung function indices compared to the general population.[1,2,4,20-24]

Despite the recognition of work-related asthma as a significant occupational health issue, occupational rhinitis has received comparatively less attention. Studies investigating its prevalence in hairdressers are limited. The reported prevalence of occupational rhinitis in hairdressers is approximately 1.7%, placing them among the top 13 occupational groups at risk for this condition.[2,4,5,8,14] Importantly, epidemiological studies have established that rhinitis is associated with an increased risk of developing asthma.[25-27] Moreover, pre-existing rhinitis prior to occupational exposure has been identified as an independent risk factor for IgE sensitization to high molecular weight allergens.[28-29]

Diagnostic methods for work-related asthma remain limited, primarily due to the lack of access to standardized commercial products for skin prick testing, specific bronchial and nasal challenges, and the measurement of serum-specific IgE against suspected substances. Consequently, the diagnosis of work-related asthma often relies on patient history, noting the exacerbation of respiratory symptoms at work and their improvement during periods away from the workplace, combined with spirometry.[12]

The primary treatment approach for work-related respiratory diseases involves eliminating contact with the causative agent in the workplace. However, when avoidance is not feasible, reducing exposure levels is recommended, although this strategy is less effective in controlling symptoms.[30,31] Epidemiological studies suggest that infectious and chronic diseases can be effectively controlled through surveillance and preventive programs. Despite this, the implementation of such programs for occupational diseases remains rare, despite their substantial social and economic impact.

In Iran, most studies on work-related respiratory diseases have focused on bakers and other high-risk occupational groups.[32-35] Research on hairdressers is scarce, with only three studies conducted using questionnaires and spirometry.[7,36,37] Notably, none of these studies included bronchodilator challenge testing, which could result in underdiagnosis of asthma cases.

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Hairdressing appears to be one of the most common professions among women in Iran, with its popularity attributed to relatively high-income potential. As such, the prevalence of occupational asthma in this group underscores the need for more comprehensive investigations, including follow-up studies. While most hairdressers work in shared salon spaces, their specific tasks determine the extent of their exposure to harmful chemicals, which may explain variations in the prevalence of work-related respiratory diseases among subgroups. This study aimed to evaluate the prevalence of upper and lower respiratory symptoms and compare spirometry parameters across four defined occupational subgroups of female hairdressers based on their chemical exposure profiles. This is the first study among Iranian hairdressers to incorporate bronchodilator responsiveness testing alongside exposure-specific subgrouping, thus allowing more accurate identification of undiagnosed asthma across occupational roles.

MATERIALS AND METHODS

Study Design and Population

A cross-sectional study was conducted from January to May 2024 in Tehran, Iran. Participants were recruited from 27 beauty salons. To minimize selection bias, beauty salons were randomly selected across diverse geographical districts in Tehran using a simple random sampling technique stratified by salon density and socioeconomic area. A total of 152 female hairdressers aged 18 to 65 years were included in the study. The eligibility criteria required at least one year of work experience in hairdressing. Exclusion criteria included a history of chronic heart or lung diseases (other than asthma), recent respiratory infections, and refusal to participate in spirometry tests or bronchodilator challenges.

Subgroup Classification

Participants were divided into four subgroups based on their occupational tasks and primary exposure to irritants and allergens:

1. **Subgroup 1**: Hairdressers working with permanent hair dyes, bleaching agents, and keratinizing substances.
2. **Subgroup 2**: Technicians handling varnish, acetone, and nail implant materials.
3. **Subgroup 3**: Workers exposed to glues for hair and eyelash extensions.
4. **Subgroup 4**: Individuals with minimal or no direct exposure to hazardous chemicals, including haircutters, secretaries, models and photographers.

Data Collection

Data were collected using the ECRHS III questionnaire, a validated tool for assessing respiratory and nasal symptoms, asthma diagnosis, and occupational exposures.[24,38] Information on age, height, weight, body mass index (BMI), smoking status, and the use of protective equipment was also recorded.

Spirometry and Bronchodilator Responsiveness Testing

Spirometry was conducted on-site in the hair salons using the Spirolab IV portable spirometer (Medical International Research [MIR], Rome, Italy). Tests were performed during off-peak hours and under standardized conditions as per American Thoracic Society guidelines. This approach was chosen to ensure maximum participation and reduce the risk of data loss associated with laboratory-based testing. spirometry indices measured included:

- **Forced Vital Capacity (FVC)**: Total volume of air exhaled after a deep breath.
- **Forced Expiratory Volume in 1 Second (FEV1)**: Volume of air expelled in the first second of forced exhalation.
- **FEV1/FVC Ratio**: The proportion of air expelled in the first second relative to total exhalation.
- **Forced Expiratory Flow at 25–75% of FVC (FEF25-75)**: Average airflow during the middle portion of forced exhalation.

Testing was conducted at baseline and repeated 15 minutes after administering 200 µg of salbutamol to assess bronchodilator responsiveness. Although many guidelines recommend a ≥12% and ≥200 mL increase in FEV1 for bronchodilator responsiveness, we employed a ≥10% and ≥200 mL criterion to enhance sensitivity in this high-risk occupational population, consistent with 2021 European Respiratory Society (ERS) and the American Thoracic Society (ATS) interpretive strategies for routine lung function tests.[39,40]

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Statistical Analysis

Data were analyzed using SPSS software version 25.0. Quantitative variables were reported as mean ± standard deviation (SD), and categorical variables as percentages. Chi-square tests and fisher exact test were used for categorical variables, while analysis of variance (ANOVA) and linear regression were applied for continuous variables. In invariable model, variables with *p* values less than 0.2 were included in the multivariable model, which employed a backward selection approach. In multivariable model a *p* value<0.05 was considered to be statistically significant.

RESULTS

The study included 152 participants, who were distributed across the four occupational subgroups as follows: 27.6% (*n*=42) in subgroup 1 (direct contact with hair dyes, bleaching agents, and keratinizing substances), 27.6% (*n*=42) in subgroup 2 (contact with varnish, acetone, and nail implant materials), 20.4% (*n*=31) in subgroup 3 (contact with glues for hair and eyelash extensions), and 24.2% (*n*=37) in subgroup 4 (minimal or no direct contact with hazardous chemicals).

The subgroups were comparable in terms of height, weight, and smoking status; however, statistically significant differences were observed in age, BMI, working hours per week, years of employment, and use of protective equipment (*p*<0.05). These differences are presented in Table 1.

Of the 152 participants, 42.1% (*n*=64) reported at least one respiratory symptom, with subgroup 1 having the highest prevalence of symptoms (Table 2). Analysis revealed that lower respiratory symptoms, including cough, phlegm, wheezing, shortness of breath, and chest tightness, were significantly more prevalent in subgroup 1 compared to the other subgroups (*p*< 0.001, Table 2).

In terms of nasal symptoms, 22.4% (*n*=34) of participants reported at least one symptom. There were no significant differences between subgroups for rhinorrhea (*p*=0.075) and nasal blockage (*p*=0.546); however, nasal itching was significantly more prevalent in subgroup 2 (*p*=0.025, Table 2).

Table 1. Characteristics of four hairdressing subgroups

Variable	Subgroup 1 *n*(%)=42(27.6)	Subgroup 2 *n*(%)=42(27.6)	Subgroup 3 *n*(%)=31(20.4)	Subgroup 4 *n*(%)=37(24.2)	*p*
Age (year), mean±SD	41.4 ±11.9	31.8±7.6	33.2±9.5	40.6±9.2	<0.001
Height (cm), mean±SD	164.1±4.5	164.5±5.7	165.3±4.8	162.7±5.8	0.211
Weight (kg), mean±SD	65.6±10	61.8±10	65.7±11.7	68.5±12.1	0.064
BMI (kg/m2), mean±SD	24.3±3.5	22.8±3.5	24±4.1	25.8±4.1	0.009
Working hours per week, mean±SD	32±5.7	38.8±6.9	36.3±5.7	39.8±8	<0.001
Years of employment, mean±SD	10.1±6.7	5.6±3.8	6.6±4.6	9±6	0.001
Smoking status					
Current smoker, *n* (%)	16 (38.1)	13(31)	12(38.7)	12(32.4)	
Ex-smoker, *n* (%)	1 (2.4)	3(7.1)	2(6.5)	6(16.2)	0.532
Never smoker, *n* (%)	25(59.5)	26(69.1)	17(54.8)	19(51.4)	
Use of protective equipment in the workplace, *n* (%)	9 (21.4)	23(54.8)	3(9.7)	7(18.9)	<0.001

Subgroup 1 hairdressers who work directly with all kinds of hair dyes, bleaching and keratinizing agents
Subgroup 2 hairdressers who deal with all kinds of varnish, acetone and nail implant materials
Subgroup 3 hairdressers who are in contact with all kinds of glues for hair and eyelash extensions
Subgroup 4 people who are not directly in contact with any of the mentioned materials, but are present in the beauty salon, which includes hairdressers who only do haircut, cashiers, models, photographers, etc. BMI: body mass index; M: mean; SD: standard deviation
Statistically significant at *p* value<0.05

Table 2. Respiratory and nasal symptoms in four hairdressing subgroups

Symptoms *n* (%)	**Subgroup1 *n*=42**	**Subgroup2 *n*=42**	**Subgroup3 *n*=31**	**Subgroup4 *n*=37**	***p***
Cough	27(64.3)	11(26.2)	8(25.8)	7(18.9)	<0.001
Phlegm	10(23.8)	0	0	2(5.4)	<0.001
Wheezing	15(35.7)	2(4.8)	1(3.2)	1(2.7)	<0.001
Shortness of breath	27(64.3)	9(21.4)	4(12.9)	4(10.8)	<0.001
Chest tightness	16(38.1)	3(7.1)	1(3.2)	2(5.4)	<0.001
Rhinorrhea*	7(16.7)	11(26.2)	2(6.5)	3(8.1)	0.075
Nasal blockage*	1(2.4)	4(9.5)	1(3.2)	2(5.4)	0.546
Nasal itching*	6(14.3)	11(26.2)	1(3.2)	3(8.1)	0.025

*Other than common cold
A patient may have two or more respiratory symptoms
Statistically significant at *p* value<0.05

Among the participants, 11.8% (*n*=18) had a pre-diagnosed history of asthma, the majority of whom were in subgroup 1 (*n*=11). A positive bronchodilator challenge, defined as an increase in FEV1 of ≥10% and ≥200 mL post-bronchodilator, was observed in 34.2% (*n*=52) of participants. This group was subsequently diagnosed with asthma based on the presence of compatible symptoms (Fig.1). Subgroup 1 had the highest proportion of bronchodilator-responsive individuals (Table 3).

In terms of lung function patterns, 74.3% (*n*=113) exhibited normal lung function, 22.3% (*n*=34) demonstrated an obstructive pattern, 1.3% (*n*=2) exhibited a restrictive pattern and 1.9% (*n*=3) exhibited a mixed obstructive-restrictive pattern.

Statistical analysis of spirometry indices revealed the following (Table 3):

1. FVC: No significant difference was observed between the subgroups (*p*=0.141).
2. FEV1: Significant differences were found between the subgroups (*p*=0.013). Subgroups 1 and 2 exhibited the lowest FEV1 values, while subgroups 3 and 4 showed the highest values.
3. FEV1/FVC Ratio: Subgroup 1 exhibited significantly lower values compared to other subgroups (*p*=0.005).
4. FEF25-75: Significant differences were also observed for this parameter, with subgroup 1 showing the lowest values and subgroups 3 and 4 exhibiting the highest (*p*=0.015).

Linear regression analysis further confirmed the significant differences in lung function parameters (Table 4):

- FVC: Subgroup 1 exhibited significantly reduced FVC values compared to subgroup 4 (β:-8.5, 95% CI:-16, -1.0, *p*=0.026).
- FEV1: Subgroup 1 demonstrated markedly reduced FEV1 values compared to subgroup 4 (β: -17.1, 95% CI: -25.5, -8.8, *p*<0.001).
- FEV1/FVC Ratio: A significant reduction in FEV1/FVC was observed in subgroup 1 compared to subgroup 4 (β: -5.2, 95% CI: -11.0, -0.5, *p*=0.004).
- FEF25-75: Subgroup 1 also exhibited significantly lower FEF25-75 values compared to subgroup 4 (β:-16.3, 95% CI: -27.6, -5.0, *p*=0.005).

The analysis also revealed the following (Table 4):

1. Age: Age was included as a covariate in the multivariable regression model to account for its potential confounding effect on lung function. The adjusted analysis revealed subgroup 1 still had significantly lower FEV1, FEV1/FVC, and FEF25-75 values compared to subgroup 4.
2. Smoking Status: Current and ex-smokers exhibited significantly reduced FEV1, FEV1/FVC, and FEF25-75 values compared to never smokers.

Other Variables: No statistically significant differences were observed in lung function parameters with respect to height, weight, BMI, working hours per week, or years of employment.

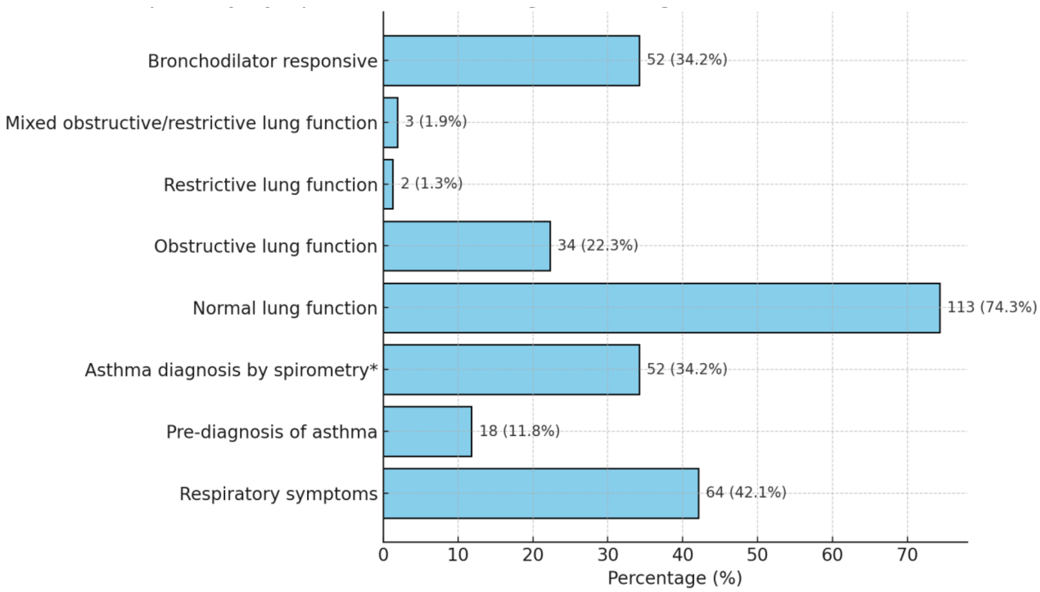

Figure 1. Respiratory and Lung Function Data in Participants. *Based on normal FVC (≥80%), reduced FEV1 (<80%), reduced FEV1/FVC (<0.7) and bronchodilator responsiveness (pre and post bronchodilator challenge FEV1 change ≥10% and ≥200 ml)

Table 3. Lung Function Patterns and Parameters in Hairdressing Subgroups

Lung Function Parameter / Pattern	Subgroup1 *n*=42	Subgroup2 *n*=42	Subgroup3 *n*=31	Subgroup4 *n*=37	*p*
Normal pattern (%)	21(50)	30(71.4)	28(90.3)	34(91.9)	0<0.001
Obstructive pattern (%)	17(40.5)	11(26.2)	3(9.7)	3(8.1)	0<0.001
Restrictive pattern (%)	1(2.4)	1(2.4)	0	0	0<0.001
Mixed obstructive/ restrictive pattern (%)	3(7.1)	0	0	0	0<0.001
Bronchodilator responsive (%)	28(66.7)	12(28.6)	6(19.4)	6(16.2)	0<0.001
FVC(L), mean±SD	105.2±16.5	105.8±16.9	101.2±13.2	110.8±19.6	0.141
FEV1(L), mean±SD	89.6±19.7	95±17.9	97±16.9	103.1±17.2	0.013
FEV1/FVC%, mean±SD	73.8±15.5	79.2±11	83.2±7.7	80.7±8.85	0.005
FEF25-75(L/sec), mean±SD	70.6±29.3	76.7±20.6	86.5±24.6	84.8±18.8	0.015

Normal pattern FVC normal (≥80%), FEV1 normal (≥80%), FEV1/FVC normal (≥0.7)
Obstructive pattern FVC normal (≥80%), FEV1 reduced (<80%), FEV1/FVC reduced (<0.7)
Restrictive pattern FVC reduced (<80%), FEV1 normal or reduced (≥80% OR<80%), FEV1/FVC normal or increased (≥0.7)
Mixed obstructive/restrictive pattern FVC reduced (<80%), FEV1 reduced (<80%), FEV1/FVC reduced (<0.7)
Bronchodilator responsive pre and post bronchodilator FEV1 change ≥10% and ≥200 ml
FVC: forced vital capacity; FEV1: forced expiratory volume in 1 second; FEF25-75: forced expiratory flow over the middle half of the FVC
Statistically significant at *p* value<0.05

Table 4. Factors effecting on lung function parameters in participants*

Variable (base line)	FVC (L)			FEV1(L)			FEV1/FVC (%)			FEF25-75 (L/sec)		
	β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*
Subgroups (Subgroup4)												
- Subgroup1	-8.5	-16, -1.0	**0.026**	-17.1	-25.5,8.8	**<0.001**	-5.2	-11.0,0.5	**0.004**	-16.3	-27.6, -5.0	**0.005**
- Subgroup2	-3.0	-10.5,4.4	0.423	-2.4	-10.4,5.6	0.552	-0.07	-5.6,5.5	0.980	-2.8	-13.7, 8.0	0.602
- Subgroup3	-6.2	-14.3,1.8	0.129	1.1	-7.4,9.8	0.786	4.2	-1.8,10.2	0.168	6.9	-4.7,18.6	0.240
Age	0.2	-0.04, 0.4	**0.029**	0.6	0.2,1.06	**0.001**	0.14	-0.1,0.4	0.288	0.8	0.3,1.3	**0.002**
Height	1.4	-1.4, 4.3	0.320	-0.6	-3.5,2.1	0.644	-1.7	-3.6,0.2	0.088	-2.4	-6.3,1.4	0.217
Weight	-2.5	-6.1,1.1	0.180	0.2	-3.4,3.8	0.909	1.8	-0.6,4.3	0.144	2.8	-2.1,7.7	0.260
BMI	6.6	-3.2, 16.4	0.185	-1.03	-10.7,8.7	0.833	-5.0	-11.7,1.7	0.142	-8.1	-21,3,5.0	0.223
Working hours per week	-0.05	-0.4, 0.3	0.775	-0.11	-0.5,0.3	0.588	0.07	-0.2,0.3	0.616	-0.01	-0.5,0.5	0.951
Years of employment	-0.003	-0.4, 0.4	0.990	-0.36	-1.0,0.2	0.251	-0.09	-0.5,0.3	0.678	-0.3	-1.2,0.4	0.387
Smoking status (**Never smoker)**												
- Current smoker	1.3	-4.4, 7.2	0.644	-5.8	-11.6, -0.02	**0.049**	-6.2	-10.2, -2.2	**0.002**	-10.1	-18.0, -2.3	**0.011**
- Ex-smoker	-4.7	-15.1, 5.6	0.365	-15.4	-26.0,-4.9	**0.004**	-9.4	-16.6, -2.1	**0.012**	-20.1	-34.3, -5.9	**0.006**

*Linear regression

FVC: forced vital capacity; FEV1: forced expiratory volume in 1 second; FEF25-75: forced expiratory flow over the middle half of the FVC; BMI: body mass index; CI: confidence interval

Statistically significant results are shown in bold

DISCUSSION

The findings of this study underscore the significant respiratory risks faced by hairdressers, particularly those in subgroup 1, who handle permanent hair dyes, bleaching agents, and keratinizing substances. These workers reported the highest prevalence of respiratory symptoms and exhibited the most pronounced impairments in lung function. The data confirm that occupational exposures in hairdressing, as in other professions involving frequent contact with chemical irritants and allergens, substantially contribute to work-related respiratory conditions.

We acknowledge that environmental pollution in Tehran, a city known for its high levels of air pollution, could potentially act as a confounding factor in respiratory health outcomes. However, since all participants were from the same urban environment, the effects of outdoor air pollution are likely to be consistent across all subgroups, thereby minimizing its potential as a significant confounder in our analysis.

The high prevalence of cough, wheezing, shortness of breath, and chest tightness in subgroup 1 is consistent with the literature, which identifies hair dyes and bleaching agents as major contributors to occupational asthma.[6,9] Ammonium and potassium persulfates, widely used in bleaching powders, are potent sensitizers that can induce asthma through both IgE-mediated and non-IgE-mediated mechanisms.[6,13,14] Studies in France and Turkey have similarly identified persulfates as the leading cause of occupational asthma among hairdressers.[6,21]

In subgroup 2, exposure to acetone and varnish appears to account for the higher prevalence of nasal symptoms, such as nasal itching. Volatile organic compounds (VOCs) like acetone are well-documented irritants that can lead to rhinitis and nasal hyperreactivity.[12,14] Similar findings were reported in studies of hairdressing apprentices, where nasal symptoms were more frequent among those exposed to VOCs.[5,17]

Subgroup 3, which involves the use of glues for hair and eyelash extensions, exhibited relatively lower respiratory and nasal symptoms. However, the long-term impact of adhesive fumes on respiratory health requires further investigation. Glues used in salons often contain formaldehyde and other sensitizing agents, which are recognized as potential asthma triggers.[18,22]

The low prevalence of symptoms in subgroup 4, which includes hairdressers with minimal or no direct exposure to irritants, aligns with expectations. This group serves as an internal control, illustrating the protective effect of reduced exposure. These findings emphasize the need for exposure-specific interventions to mitigate risks.

The significant differences in lung function indices (FEV1, FEV1/FVC, and FEF25-75) between subgroups further highlight the health impact of occupational exposures. Subgroup 1 exhibited the most severe impairments, consistent with the literature linking exposure to bleaching powders and dyes to reduced lung function.[6,7] Previous studies in Spain and India reported similar reductions in FEV1 and FEV1/FVC among hairdressers compared to non-exposed controls.[20,23]

Interestingly, FVC values did not differ significantly across subgroups, suggesting that restrictive patterns were less prevalent. This finding contrasts with earlier research in Iran, where restrictive patterns were observed among hairdressers.[7,37] The discrepancy may reflect differences in exposure intensity or variations in study populations.

Bronchodilator responsiveness, observed in 34.2% of participants, underscores the prevalence of undiagnosed asthma in this population. Most cases were identified in subgroup 1, reinforcing the role of irritant exposures in asthma pathogenesis. The use of bronchodilator challenge in this study represents a methodological strength, as it enables more accurate diagnosis compared to studies relying solely on questionnaires and baseline spirometry.[7,23,36,37]

The findings of this study align with international research demonstrating elevated respiratory risks in hairdressers. A study in Italy identified ammonium persulfate as the primary cause of occupational asthma in hairdressers, which is consistent with the high prevalence of symptoms in subgroup 1.[14] Similarly, research in Turkey and Palestine reported significant lung function impairments and high asthma prevalence among hairdressers exposed to chemical irritants.[21,22]

In Iran, three previous studies have examined respiratory risks in hairdressers. Heibati et al reported a higher prevalence of respiratory symptoms and restrictive lung function patterns among hairdressers in Shiraz, while a study in Bandar Abbas found obstructive patterns in waxing workers.[7,36] A study in Mashhad observed significant reductions in lung function indices

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and a high prevalence of work-related respiratory symptoms, which is consistent with the findings of the current study.[37] Notably, none of these studies performed bronchodilator testing, which limits their ability to diagnose asthma accurately.

The pathophysiology of respiratory disorders in hairdressers involves both irritant and allergic mechanisms. Persulfates, commonly used in bleaching agents, are potent haptens that can induce systemic sensitization and airway inflammation.[12,14,15] It has been shown that primary skin contact with these chemicals has been shown to result in subsequent respiratory sensitization in animal models.[15] Ammonia and hydrogen peroxide, frequently used in hair dyes, are irritants that can cause airway hyperresponsiveness through non-specific inflammatory pathways.[6,7]

Exposure to VOCs, such as acetone and toluene, is associated with oxidative stress and epithelial damage, which contribute to nasal and lower respiratory symptoms.[17,18] Chronic exposure to these substances may result in airway remodeling, leading to persistent lung function impairments.

The prevalence of nasal symptoms, particularly in subgroup 2, highlights the importance of addressing occupational rhinitis. Rhinitis often precedes asthma and is considered a risk factor for sensitization to high-molecular-weight allergens.[14,15] Studies have shown that rhinitis increases the likelihood of developing asthma, which emphasizes underscoring the need for early intervention.[25-27]

The findings of this study have important implications for occupational health policies in the hairdressing industry. Several measures can mitigate the risks identified in this study:

1. **Protective Equipment**: The use of masks and gloves should be mandatory for all workers handling hazardous substances. Subgroup-specific protective measures, such as fume extractors for nail technicians, may further reduce exposure.
2. **Ventilation**: Improved salon ventilation is critical to minimizing airborne concentrations of irritants and allergens. The use of local exhaust ventilation systems near workstations should be prioritized.
3. **Health Monitoring**: Regular spirometry and bronchodilator testing should be implemented as part of occupational health programs. Baseline lung function assessments can identify susceptible individuals before they enter the profession.
4. **Training and Education**: Workers should receive training on safe handling practices for chemical substances. Awareness campaigns highlighting the health risks associated with exposure may encourage adherence to protective measures.

Limitations and Future Directions

While this study provides valuable insights, it has several limitations:

- The exclusion criteria did not account for heavy smoking or seasonal allergic rhinitis, both of which may influence respiratory symptoms and lung function. Although smoking status was included in multivariate models, the lack of exclusion may introduce residual confounding.
- The lack of an external control group of non-exposed individuals limits the ability to compare respiratory symptoms between hairdressers and individuals outside the profession, hindering the differentiation between occupational and environmental causes (e.g., urban air pollution) of respiratory symptoms and impaired lung function.
- The study did not assess previous occupational exposures outside the hairdressing profession, which may have influenced baseline respiratory function and symptom presentation.
- Some overlap in occupational tasks among hairdressers may exist (e.g., one worker performing multiple services), which could blur subgroup distinctions. We attempted to minimize this by classifying participants based on their predominant tasks and materials used over the previous 12 months.

Future studies should employ longitudinal designs to evaluate the long-term impact of exposures and incorporate objective allergen-specific diagnostic tests, such as skin prick or inhalation challenges. Additionally, the potential health risks to salon clients and children accompanying hairdressers should be investigated. The small, poorly ventilated spaces typical of many salons may expose these populations to harmful concentrations of irritants and allergens.

This study emphasizes the respiratory risks associated with chemical exposure in hairdressing, particularly for those working with hair dyes, bleaching agents, and keratinizing substances. Regular lung function assessments are essential to identify individuals with pre-existing impairments and monitor for declines over time. Hairdressers with progressive lung function

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deterioration should be informed about the need to take appropriate measures or consider medical consultation.

Mandatory use of personal protective equipment, improved salon ventilation, reduced exposure duration, and elimination of smoking can mitigate risks. Raising awareness through education and promoting safer workplace practices are essential. Protecting hairdressers and salon patrons requires systematic health monitoring and the adoption of safer alternatives to hazardous chemicals. Implementing these measures will help minimize occupational health risks and support long-term well-being in the hairdressing profession.

STATEMENT OF ETHICS

The study was approved by the Research Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.CHMC.REC.1403.011). All Participants provided written informed consent, and confidentiality was ensured throughout the study.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

AI ASSISTANCE DISCLOSURE

Not applicable.

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