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Evaluation of Formaldehyde as a Potential Cause of Olfactory Dysfunction in Hairdressers

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Abstract

Objective: The aim of this study was to compare the olfactory function between hairdressers exposed to formaldehyde and unexposed controls, as exposure to toxic agents is a potential cause of olfactory disorders in humans. Hairdressing professionals frequently encounter formaldehyde, a component found in hair products that are known to have various toxic effects on the human body, including alterations in the sense of smell. **Methods:** A total of 32 hairdressing volunteers exposed to formaldehyde and 32 non-exposed volunteers matched for age, sex, education and smoking status underwent the University of Pennsylvania Smell Identification Test (UPSIT®). **Results:** The findings demonstrated a decrease in UPSIT® olfactory test scores and a higher degree of olfactory loss among hairdressers exposed to formaldehyde (mean UPSIT® scores: 30.6 vs 35.1, $p < 0.01$) compared to the unexposed controls. **Conclusion:** Occupational exposure of hairdressers to formaldehyde is associated with diminished olfactory function. Education approach and promotion of personal protective equipment usage should be encouraged.

Keywords

Formaldehyde, Olfaction Disorders, Occupational Medicine, Toxicology

1. Introduction

The sense of smell holds significant importance in the lives of human beings. The loss of olfactory function directly impacts individuals' health and quality of life, interfering with food perception, the detection of potential life-threatening situations such as smoke or spoiled food, personal hygiene, social relationships,

and can even lead to social isolation and depression [1] [2]. Various mechanisms can contribute to olfactory dysfunction, including exposure to toxic agents, which, although accounting for only 1% - 5% of cases, warrants attention, particularly among populations occupationally exposed to these agents, given the crucial role of this sense in human well-being [3] [4].

Among exposed populations and those more susceptible to olfactory damage, hairdressers in beauty salons are prominent. They frequently encounter various chemical compounds present in hair products during the execution of different procedures [5]. One of the primary xenobiotic associated with these professionals' daily activities is formaldehyde, primarily used in the popular hair straightening technique known as the "progressive brush". Formaldehyde is a colorless, volatic and flammable gas with a pungent odor at room temperature. Exposure to this gas is linked to various toxic effects on the body, including upper respiratory tract irritation, allergic skin sensitivity, neurotoxicity, mutagenicity, and carcinogenicity, some of which have already been reported in hairdressing professionals [6] [7]. Animal studies have demonstrated that inhalation of formaldehyde can affect olfactory function by disrupting neurotransmission [8] and altering the morphology of the olfactory bulb in long-term exposures [9]. However, the impact of long-term formaldehyde exposure on the olfactory function of hairdressers remains unknown. Therefore, this study aims to investigate the relationship between this exposure and the development of olfactory loss in this professional group. The objective of this research is to compare the olfactory test results between a group of professional hairdressers exposed to formaldehyde and a matched control group without exposure. Additionally, we aim to explore potential factors associated with hairdresser exposure that are highly correlated with olfactory impairments.

2. Methods

This is a cross-sectional observational study that recruited professional hairdressers who regularly used formaldehyde in their work routine during the period from October 2020 to October 2021. These volunteers were actively recruited and invited to participate via telephone or the internet. Control subjects, who were not exposed to formaldehyde, were also recruited and matched for sex, age, education, and smoking status. Their data were obtained from medical records and pre-existing data sheets [10]. Individuals with upper airway infections on the day of data collection, a history of post-infectious or post-traumatic olfactory loss, Parkinson's disease, Alzheimer's disease, epilepsy, schizophrenia, severe memory loss, or diagnosed with chronic rhinosinusitis were excluded from the study. For chronic rhinosinusitis, the presence of a major criterion (yellowish rhinorrhea and nasal obstruction) and a minor criterion (olfactory loss and headache) for more than 12 weeks or two major criteria were also investigated for diagnosis [11].

To measure the olfactory function, the University of Pennsylvania Smell Iden-

tification Test (UPSIT®) was utilized, which has been validated for the Brazilian population [10]. This test represents a quantitative method to assess human olfactory function with high test-retest reliability, being the gold standard test for olfactory assessment [12]. The UPSIT consists of four booklets of 10 pages, with each page containing a different odor. The odorous stimuli are encapsulated in plastic microcapsules located in a brown strip at the bottom of each page. The examiner instructs the individual being tested to scratch the strip with a pencil, releasing the odor. Subsequently, the examinee selects the most appropriate multiple-choice answer to describe the smelled odor. Based on the responses, a score is obtained, allowing for the classification of the individual's olfactory function as normosmia, hyposmia (mild, moderate, or severe), or anosmia [12]. A questionnaire was administered to hairdressing volunteers to assess the intensity of their formaldehyde exposure and obtain demographic information. The questionnaire included details on weekly working hours, the number of weekly applications of formaldehyde-containing products, duration of formaldehyde exposure in years, utilization of personal protective equipment, and the use of other chemical products.

Statistical analysis was conducted using STATA software (version 13; Stata Corp., Texas, USA). The Shapiro-Wilk test was employed to examine the data distribution. For demographic data, the Student's T test was used to compare age means, while the Chi-square test was utilized to compare gender, education level, and smoking status among the groups under study. The Chi-square test was also employed to compare the degrees of olfactory function between the two groups. To compare the mean olfactory test scores between the groups, the Mann-Whitney test was employed due to the non-normal distribution of the data. Pearson's and Spearman's correlation tests were used to examine the correlation between hairdressers' olfactory test scores and other factors associated with formaldehyde exposure investigated during the interviews. A statistical significance level of 5% was adopted.

3. Results

Sixty-four volunteers were enrolled in the study, consisting of 32 hairdressers exposed to formaldehyde and 32 unexposed controls. The demographic characteristics of both groups are presented in **Table 1**. Hairdressers exposed to formaldehyde exhibited an average UPSIT® score of 30.6 (range: 20 - 36, SD: 3.9), whereas the unexposed controls had an average score of 35.1 (range: 28 - 40, SD: 2.5). These results indicate a statistically significant difference in the mean olfactory test outcomes between the two groups ($p < 0.01$), as illustrated in **Figure 1**.

In addition to evaluating the average UPSIT score, we examined the extent of olfactory loss, ranging from normal smell (normosmia) to varying degrees of hyposmia (mild, moderate, and severe). Among the hairdressers, 26 (81.3%) individuals demonstrated some level of olfactory loss in the UPSIT, while only 8

(25%) volunteers in the control group exhibited such loss. This discrepancy was statistically significant ($p < 0.01$), as show in Figure 2.

Regarding the independent factors evaluated in the interview with hairdressers, the average working day was 46.6 hours (SD: 11.1) per week and the average time of exposure to formaldehyde was 9.3 years (SD: 3.6). The average frequency of exposure was 3.6 weekly applications of products with formaldehyde. Fifteen hairdressers (46.7%) also used products with glyoxylic acid, a versatile organic compound, finds application in various industries including pharmaceuticals, cosmetics, and textiles [13]. None of these factors, however, correlated significantly with the result of the olfactory test in this group (Table 2).

Table 1. Comparison of demographic data between hairdressers exposed to formaldehyde and unexposed controls.

	Hairdressers (n = 32)	Controls (n = 32)	p valor
Age, mean (±SD)	39.6 (±1.9)	39.9 (±1.9)	0.9
Sex, n (%)			1
Female	21 (65.6)	21 (65.6)	
Male	11 (34.4)	11 (34.4)	
Education level, n (%)			0.17
Incomplete high school	7 (21.9)	3 (9.4)	
Complete high school	25 (78.1)	29 (90.6)	
Smoking, n (%)			0.17
smoker	7 (21.9)	3 (9.4)	
non-smoker	25 (78.1)	29 (90.6)	

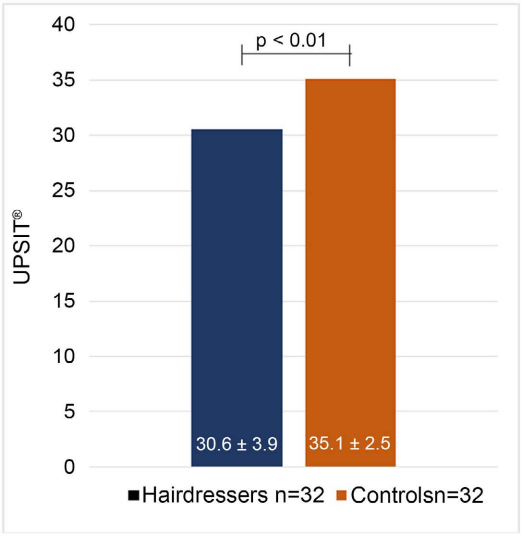

Figure 1. Comparison of UPSIT® scores between hairdressers exposed to formaldehyde and age, education, smoking status and sex-matched controls. UPSIT®: University of Pennsylvania Smell Identification Test.

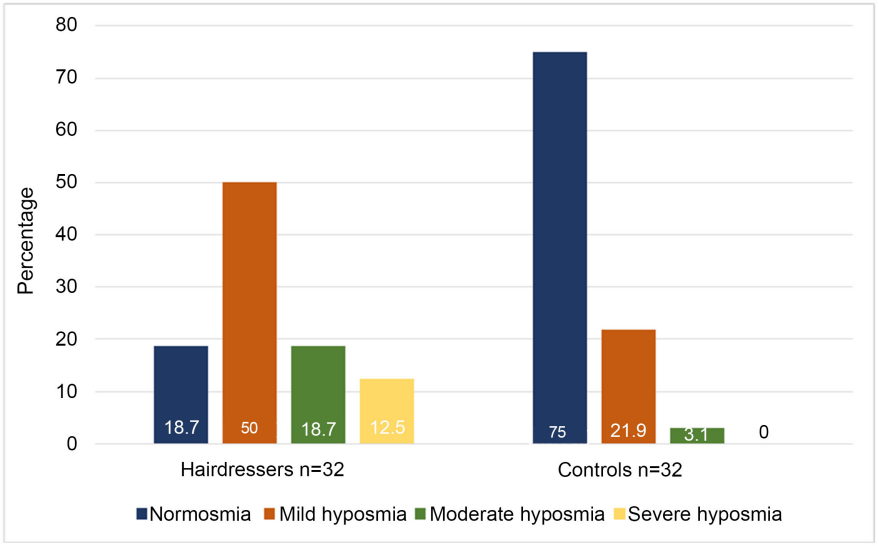

Figure 2. Categories of olfactory loss in hairdressers exposed to formaldehyde and in non-exposed matched controls (p = 0.01).

Table 2. Pearson and Spearman correlation coefficients between independent variables and olfactory test results in hairdressers exposed to formaldehyde.

	r	p value
Weekly workday	0.0373	0.8507
Exposure time (years)	0.1770	0.3973
Weekly frequency of exposure to formaldehyde	−0.1197	0.5519
Weekly frequency of exposure to glyoxylic acid	0.0842	0.6642

r: Pearson correlation.

4. Discussion

The findings of this study indicate a clear relationship between occupational exposure of hairdressers to formaldehyde and a reduction in olfactory function. However, it is noteworthy that this reduction in olfactory function does not appear to be correlated with the duration and frequency of exposure to the chemical, the use of personal protective equipment, or exposure to other chemical agents. This discrepancy in the results may be attributed to the data collection method, which solely relied on self-reports provided by the volunteers.

In the general population, the prevalence of olfactory dysfunction is estimated to be around 5%, with a higher occurrence among older individuals. The data regarding olfactory dysfunction caused by occupational exposure are still inconclusive. However, when it comes to the effects of chemicals and pharmaceuticals, the incidence of olfactory dysfunction ranges from 0.5% to 5% of all cases [14]. Occupational exposure to chemicals, especially those that are irritants, corrosive to mucous membranes, or detrimental to olfactory nerves, has been associated with the development of olfactory dysfunction. Moreover, the severity of this dysfunction tends to increase with longer durations of exposure to these agents

[14] [15]. The impact of formaldehyde on olfactory function in humans was first described by Spealman (1954), who linked the use of deodorants containing formaldehyde in passenger planes to impaired sense of smell [16]. Consistent with our findings, Kilburn *et al.* (1985) reported a reduced olfactory function in 32% of women exposed to formaldehyde for 1 to 3 hours during their work with histological preparations [17]. However, we were unable to find any existing literature specifically addressing olfactory loss due to formaldehyde exposure in professional hairdressers.

One of the strengths of this article is the inclusion of a control group that was matched for important factors such as sex, age, education, and smoking status strengthens the study's ability to draw accurate conclusions about the effects of formaldehyde exposure and the use of a validated olfactory test. The limitations are the relatively small sample size and the cross-sectional study design, which means it can only establish associations and cannot determine causality between formaldehyde exposure and olfactory function, despite very probable considering our results.

These results highlight the need for further research in this area to elucidate the specific factors contributing to olfactory dysfunction among hairdressers exposed to formaldehyde. It is essential to investigate the underlying mechanisms and potential interactions with other chemicals commonly used by these professionals that may contribute to the development of olfactory impairments. Future studies employing more comprehensive and objective measurement techniques would provide valuable insights into this issue.

5. Conclusion

In this study, we have established a correlation between hairdressers' occupational exposure to formaldehyde and a decline in olfactory function. Our findings underscore the significance of understanding the impact of formaldehyde on the sense of smell in this profession.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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