Original article

Assessment of Pulmonary Function and Quality of Life in Salon Workers Exposed to Chemicals: Insights from MMRC and St. George's Questionnaire

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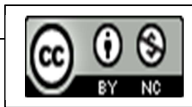
Abstract:

Background: Salon workers frequently come into contact with chemicals and solvents that might damage their respiratory systems.

Objective: The study investigated the impact of occupational chemical exposure on respiratory symptoms among hairdressers in South India, using MMRC and St. George's Respiratory Questionnaire to assess lung function.

Materials and methods: This is a cross-sectional Comparative study that examined the link between chemical exposures and obstructive and restrictive lung disease in salon workers. The research involved 210 salon workers and healthy controls, with a total of 105 participants. The study used various tests, including spirometry, the St George's Respiratory Questionnaire (SGRQ), and the Modified Medical Research Council (mMRC) Dyspnoea Scale, to assess lung health and health impairment in salon workers. The study utilised independent t-tests, one-way ANOVA, and chi-square tests to analyse data, revealing a significant association between chemical exposures and obstructive and restrictive lung disease.

Results: The study revealed that salon employees were exposed to a variety of pollutants, including ammonium thio-glycate, formaldehyde, glyoxylic acid, hydrogen peroxide, and ammonia. Exposure to these substances was linked to poorer health, as demonstrated by lower respiratory function test results and higher scores on the St George Respiratory Questionnaire. Furthermore, researchers discovered a significant correlation between mMRC grade and chemical exposure.

Conclusion: The study highlights the respiratory health issues of salon workers in South India, recommending education, improved ventilation systems, and personal protective equipment for improved productivity.

Keywords: Salon workers, Chemical exposure, Pulmonary function test, St George Respiratory Questionnaire, mMRC grade

Background:

Hairdressing, a profession involving a diverse array of chemical agents and physical stressors, presents a unique occupational health challenge, particularly concerning respiratory health.[1] Hairdressers frequently encounter volatile organic compounds and other hazardous substances through inhalation, which can trigger various adverse health outcomes, including asthma, cardiovascular disease, neurological symptoms, and even. Exposure to these chemicals, coupled with prolonged standing and awkward postures, elevates the risk of musculoskeletal disorders.[2] The hazards inherent in hairdressing necessitate a comprehensive understanding of occupational exposures and their impact on respiratory well-being to implement effective safety measures and protect this workforce.

Employees in hair and nail salons often work long hours in poorly ventilated spaces, which can lead to increased exposure to chemicals at work and a higher risk of respiratory issues. Studies have indicated that the chemical substances found in salons can lead to respiratory problems such as coughing, dyspnoea, and wheezing by irritating and inflaming the respiratory system. Hairdressers, in comparison

to office workers, are more prone to experiencing respiratory symptoms and restrictive lung function impairment.[3]

Hairdressers in Hebron, Palestine, are exposed to chemicals that can increase their risk of developing asthma and other respiratory conditions.[4] A study found that Turkish hairdressers had a 14.6% prevalence of occupational asthma, with atopy and high task intensity identified as the primary risk factors.[5] There was no association found between being a hairdresser and allergic rhinitis, laryngitis, or asthma, but hairdressers are more likely than saleswomen to experience chronic bronchitis. It is essential to implement preventive measures to address the risks associated with working in salons for the purpose of improving the working environment and ensuring personal safety. Regulation and education are necessary to effectively inform employees about the health effects of the chemicals they use on a daily basis.

In the salon profession, hairdressers and nail technicians are regularly exposed to chemicals and solvents that can be harmful to their respiratory systems. Hair straightening and smoothing treatments often contain formaldehyde, a human carcinogen known to cause respiratory issues such as burning sensations, coughing, wheezing, breathing difficulties, and RAS (Reactive Airway Dysfunction Syndrome).[6] Studies have linked long-term formaldehyde exposure to chronic respiratory problems, allergies, and asthma. A study conducted in Cairo, Egypt, found that formaldehyde exposure in salons exceeded the standards set by the National Institute for Occupational Safety and Health and the American Conference of Governmental Industrial Hygienists after just 15 minutes.[7] Cosmetologists working in salons that provide all services face a higher risk of developing health issues due to chemical exposure. Another study looked at the relationship between formaldehyde (FA) and global DNA methylation in salon workers, and it found that FA and global DNA methylation were more correlated in passive samplers.[8] This implies that cancer development may be influenced by occupational exposure to FA.

While studies indicate a heightened risk of respiratory issues among hairdressers, particularly in Western countries, Few studies in India found that 19% of beauty salon workers experienced respiratory morbidity, with a significantly lower mean peak expiratory flow rate than predicted.[9] Hairdressers were found to have a higher risk of impaired lung function and respiratory symptoms compared to the general population.[10] There's a noticeable gap in research focusing on the Indian population. This suggests a need for more studies within the Indian context to understand the specific respiratory risks faced by hairdressers in India. To fill in this gap in knowledge, Our study involved evaluating the potential impact of occupational chemical exposure on the frequency of respiratory symptoms among hairdressers in South India. Furthermore, we examined how this exposure could affect lung function and other respiratory parameters, including the Modified Medical Research Council (mMMRC) and St. George's Respiratory Questionnaire, which are commonly utilized to assess respiratory dysfunction. The assessment aimed to gain insights into the potential health implications associated with working in the hairdressing profession in this region.

MATERIALS AND METHODS

Cross sectional –Comparative study included employees working in hair or beauty salons in the Chengalpattu region of Tamil Nadu state, India, who had been continuously employed for at least a year. A total of 105 salon employees participated in the study after excluding those with a prior history of respiratory issues from other recognized causes. Salons were selected randomly from a list of all the salons in Chennai's urban area that catered to the Chengalpattu district. The Institutional Ethics Committee of the Chettinad Hospital and Research Institute (CHRI), Kelambakkam (IHEC), provided ethical approval for the study under the reference IHEC-II/0466/23. Before initiating the study, written informed consent was obtained from each worker.

Sample Size:

A study by Gupta et al. identified the prevalence of peak expiratory flow rate was reported as 84%. A relative precision of 20% was used to calculate the sample size. Using the single proportion formula:

$$n = \frac{Z^2_{1-\frac{\alpha}{2}}\, p(1-p)}{d^2}$$

22

where n is the initial sample size, Z is 1.96, the corresponding Z-score for the 95% CI, p is the proportion of respiratory symptoms, which is 0.5, and d is the margin of error, which is 0.05. Then; n= 207 $\sim$ 210. 105 subjects in the intervention and 105 subjects in the control group.

Study Procedure

This was a cross-sectional comparative study conducted in the Department of Respiratory Medicine, Chettinad Hospital and Research Institute (CHRI), Kelambakkam, from January 2024 to January 2025. Salons were selected randomly from a list of all the salons in Chennai's urban area that catered to the Chengalpattu district. Data for inclusion. Age group of 18-50 years, male and female subjects, Minimum of two years of exposure in a salon, smokers, Workers who can understand the language of Tamil and/or English. Finally, data were collected from 105 salon workers and the same age-matched 105 healthy controls; a total of 210 subjects were recruited for this study.

Spirometry is a crucial test for salon workers to assess lung health, identifying potential lung diseases or abnormalities. It measures flow, Forced Vital Capacity, and Forced Expiratory Volume in first second, and can be classified as normal, obstructive, restrictive, or mixed.

The St. George's Respiratory Questionnaire (SGRQ) is a self-administered tool used to assess health impairment in individuals with respiratory conditions. It consists of 50 items, divided into two parts: symptom assessment, activity and impact assessment, and social function and psychological disturbance. The SGRQ scale has a range of scores from 0 to 100, with high scores indicating poor quality of life. The questionnaire was read to participants in their native language to avoid bias. The first part assesses symptoms, while the second part measures functional status and daily physical activity disturbances. The impact score covers psychological disturbances and sociological functions. The total score summarizes the disease's impact on the participant's overall health status.

The Modified Medical Research Council (mMRC) Dyspnea Scale is a five-point questionnaire used to assess breathlessness in individuals exposed to airborne chemicals and pollutants. The Modified Medical Research Council (mMRC) Dyspnea Scale is a five-point questionnaire that measures breathlessness severity and its impact on daily activities. It indicates impaired health-related quality of life (HRQoL) and high symptom burden. Higher mMRC scores indicate greater breathlessness, leading to poorer HRQoL across physical function, symptoms, and psychological well-being. The mMRC scale is a useful indicator of overall health-related quality of life.

Statistical Analysis:

The study analyzed data using IBM SPSS Statistics for Windows, comparing mean ± SD between groups. Independent t-tests, one-way ANOVA, and Chi-square tests were used to compare group means and population means. The findings were presented in tables and figures, highlighting the association between chemical exposures and obstructive and restrictive lung disease.

Results:

The study involved both biological as well as social aspects, including detailed interviews and group discussions regarding the salon industry as a whole and occupational health risks due to their profession, in particular. Respiratory and anthropometric measurements were recorded on 105 subjects as a study group and 105 subjects as a control group. All the individuals involved in hairdressing, nailing, hair colouring, bleaching, pedicure, and manicure, which involved chemical exposure activity, were treated as the study group, and healthy volunteers were grouped as the control group. Informed consent was duly taken from all the participants after explaining the significance of the study.

Chemical Exposure Details of Salon Workers

Figure.1 presents the Chemicals in the commonly used hair products among the study subjects were checked and the exposure to the chemicals were analysed. It was found that, majority of the subjects had exposure to hydrogen peroxide (77.1%), followed by glyoxylic acid (66.7%), Formaldehyde (60%), Ammonium Thio-glycate (51.4%), ammonia (41.9%) and other chemicals like silicones, phenyl-de-amine, glycolic acid, parabens, methylene glycol, sulphates and persulfates. Multiple exposure to chemicals were present among the subjects.
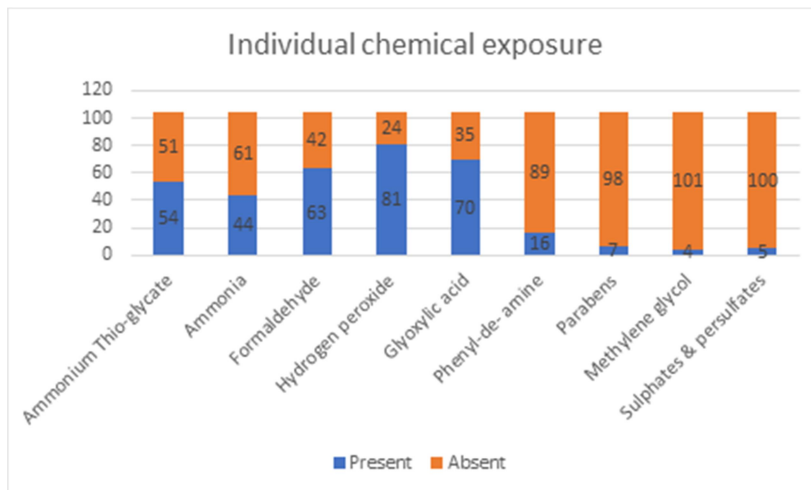
Figure.1: Distribution of subjects based on the chemical exposures (N=105)

Pulmonary Function Tests and PEFR in salon workers

Table 1 shows the pulmonary function test results for the control participants and salon employees. The mean FVC% of the salon employees was 83.69 ± 18.09, which was lower than the mean of the control group (90.99 ± 10.72). Likewise, the mean FEV1% and FEV1/FVC scores of the study group were 77.21 ± 19.35 and 80.53 ± 14.16, respectively, whereas the control group had scores of 86.22 ± 8.95 and 91.96 ± 7.50. The mean PEFR of the research group was 302.05 ± 114.62, with a wide range of 40 to 661, whereas the control group had a mean of 439.48 ± 95.10. In addition, the researchers evaluated FEF; the mean FEF score of the salon employees was 65.92 ± 22.99, while the control group had a mean of 67.71 ± 16.54.

PFT parameters	Study group N (%)		Control group N (%)	
	Mean ± SD	Range	Mean ± SD	Range
FVC %	83.69 ± 18.09	47-123	90.99 ± 10.72	70-145
FEV1%	77.21 ± 19.35	65-83	86.22 ± 8.95	68-127
FEV1/FVC %	80.53 ± 14.16	57-120	91.96 ± 7.50	80-113
PEFR L/min	302.05 ± 114.62	40-611	439.48 ± 95.10	214- 600
FEF 25-75%	55.92 ± 12.99	28- 105	67.71± 16.54	50-154

Table 1: Distribution of subjects based on the pulmonary function tests (n=105 in both groups)

mMRC grading in salon workers

Mean MMRC scores of both groups were compared and analysed using an ANOVA test, and the result obtained is noted in Table 2. A statistically significant association was found between the mean MMRC scores of both groups. The mean score was significantly lower among the control group when compared to the study group.

MMRC grade	Mean ± SD	F	d.f	P value
Study group	1.30 ± 0.101	4.848	209	0.029*
Control group	1.02 ± 0.759			

*p value<0.05 is considered statistically significant.

Table .2: Comparison of MMRC of both groups using ANOVA test (n=105 in both groups)

St. George Respiratory questionnaire scores in salon workers

Table 3. displays the individual and total scores of the St George Respiratory Questionnaire for the control group and salon employees. There was a statistically significant correlation between the groups' St George scores. Both the overall and individual domain ratings for St George were substantially lower than those

of salon employees. This suggests that the respiratory health of the salon employees is worse than that of the control group.

St. George score	Study group N (%)	Control group N (%)	T value	d.f	p value
	Mean ± SD	Mean ± SD			
Symptom	21.85 ± 16.78	2.18 ± 0.74	12.003	208	<0.001*
Activity	38.69 ± 21.53	3.20 ± 0.75	16.879	208	<0.001*
Impact	13.55± 14.03	2.73 ± 0.66	7.895	208	<0.001*
Total	22.67 ± 12.83	2.71 ± 0.43	15.944	208	<0.001*

*p value<0.05 is considered statistically significant
Table 3: Comparison of St. George respiratory questionnaire scores of both groups

Association of exposure to chemicals with St. George respiratory questionnaire score
Table 4 presents the results of the St George Respiratory Questionnaire score and the correlation between chemical exposure in salon workers. The ANOVA test was utilized to investigate the relationship between chemical exposure and the St George Respiratory Questionnaire score. It was found that exposure to ammonia, formaldehyde, H_2O_2, and glyoxylic acid was linked to a notably higher St George score.

Chemical exposure	Study group	Control	F	D.f	P value
Ammonia/formaldehyde /H2O2/glyoxylic acid (n=45)	18.31±11.9	2.69±0.45	77.73154.	90	< .00001**
Ammonia/ H2O2 (n=16)	22.79±7.5	2.72±0.53	114.23412	32	< .00001**
Ammonia/ H2O2/ glyoxylic acid (n=14)	23.58±15.75	2.76±0.56	24.43181	26	.000039**
Ammonia/ formaldehyde (n=09)	25.74±11.1	2.53±0.36	39.39108	18	.000011**
Ammonia/ glyoxylic acid (n=08)	29.8±17.3	2.94±0.4	19.3515	16	.000606**

*p value<0.05 is considered statistically significant
Table 4: Association of exposure to chemicals with St. George respiratory questionnaire score.
Association of chemical exposure with mMRC grade of salon workers
The findings of the link between salon employees' chemical exposure and their mMRC grade are shown in Table 5. An ANOVA test was used to examine the relationship between chemical exposure and mMRC grade. Those exposed to a chemical combination including hydrogen peroxide showed a statistically significant higher mMRC grade.

Chemical exposure	Study group	Control	F	D.f	P value
Ammonia/formaldehyde /H2O2/glyoxylic acid (n=45)	1.25±0.91	0.5±0.41	9.0	90	.009552*
Ammonia/ H2O2 (n=16)	1.9±0.9	0.56±0.5	14.04878	32	.001755*
Ammonia/ H2O2/ glyoxylic acid (n=14)	1.71±1.14	0.57±0.51	11.71831.	28	.002061*
Ammonia/ formaldehyde (n=09)	0.93±0.7	0.6±0.5	2.21519.	18	.147835
Ammonia/ glyoxylic acid (n=08)	1.13±1.0	0.85±0.47	3.00362.	16	.086542.

*p value<0.05 is considered statistically significant

Table 5: Association of exposure to chemicals with mMRC grade.

DISCUSSION
To the best of our knowledge, this is the first study to explore the association of chemical exposure with pulmonary morbidity regarding occupational exposure in hairdressers in South India. Spirometry was performed and the parameters under examination were FVC, FEV1, FEV1/FVC, PEFR, FEF25–75%, **St. George respiratory questionnaire score for airway obstruction** disease-specific health status assessment, and dyspnoea scale by the Modified Medical Research Council (mMRC) in salon workers in Chengelpattu district in Chennai urban location in south India.
The salon workers in our study exposed with different toxic nature chemicals details are explored in Table 8. The most common chemicals were hydrogen peroxide (77.1%), glyoxylic acid (66.7%), Formaldehyde (60%), Ammonium Thio-glycate (51.4%).
Health effect of Hydrogen peroxide exposure in salon workers
As far as we are aware, this is the first study to measure salon employees' exposure to hydrogen peroxide. According to our research, 77.1% of salon employees are exposed to hydrogen peroxide in proportion to the cosmetics used in the salon. A common component of many cosmetic goods, especially hair colours, bleaches, and teeth-whitening solutions, is hydrogen peroxide. The FDA's Voluntary Cosmetic Registration Program (VCRP) study states that hydrogen peroxide can be used in 250 different hair-colouring formulations. It can also be used up to 15% in professional hairdressing products and up to 12.4% in hair dye and colour formulations. It is present in hair products at up to 12% content.
Exposure to 12% hydrogen peroxide can lead to skin irritation, redness, and burns. When handling 12% hydrogen peroxide, it is important to wear gloves and eye protection to prevent any potential harm. The evaporation of a 12% hydrogen peroxide concentration depends on temperature and pressure, and higher concentrations may lead to condensation. Inhaling the vapor of 12% hydrogen peroxide can cause serious harm to the respiratory system, leading to mucous membrane irritation and inflammation. Inhaling concentrated hydrogen peroxide solution, especially above 10%, can result in severe lung irritation, convulsions, shock, coma, and pulmonary edema.
Along with other contributing factors, respiratory morbidity can be linked to the high rates of hydrogen peroxide exposure among salon employees. According to Morio et al., altered alveolar macrophage production of inflammatory mediators and antioxidants is linked to tissue damage caused by hydrogen peroxide inhalation.[11]

26

Rauserova-Lexmaulova and colleagues demonstrated that hydrogen peroxide has a distinct impact on respiratory health. When administered orally to domestic animals, 3% hydrogen peroxide can lead to severe respiratory distress, showing a specific interstitial-to-alveolar pulmonary pattern.[12] Furthermore, a cross-sectional descriptive-analytical study found that the most common health issues among dental clinic employees were dyspnoea (44.4%), cough (33.3%), and nasal burning (22.2%), with 1.3 to 2.83 ppm (0.00013 - 0.000283 %) concentrated hydrogen peroxide inhalation exposure.[13]

Health effect of Glyoxylic acid exposure in salon workers

To the best of our knowledge, this is the first investigation in which the exposure of salon employees to glyoxylic acid has been identified. According to our research, glyoxylic acid is exposed to 66.7% of salon employees in proportion to the cosmetics used in the salon. Glyoxylic acid, a hazardous substance used in hair products, is the second most common hazardous substance encountered by salon employees. It reduces curl and frizz by altering hair's keratin structure and can cause respiratory irritations like shortness of breath and coughing. Some people may experience allergic reactions or sensitisation. Glyoxylic acid is commonly used in cosmetic products, with concentrations ranging from 0.5% to 10%. Heating glyoxylic acid releases formaldehyde, contributing to respiratory morbidity.

Our reports in line with Robert et al., 2024 study, Glyoxylic Acid in hair-straightening products could be absorbed through the skin and metabolized into oxalate by the liver, thereby leading to calcium oxalate nephropathy.[14] However, there is little evidence that glycolic acid, a component of many cosmetic products, may induce acute kidney injury after transcutaneous absorption.

Further evidence: Using inhalation toxicity tests, the study examined the pulmonary toxicity of glycollic acid in rats. Weight loss, pulmonary oedema, inflammation, and necrosis of bronchial epithelia were among the findings, as were elevated levels of lactate dehydrogenase, total protein, polymorphonuclear neutrophils, and inflammatory cytokines in bronchoalveolar lavage fluid. Glycollic acid exposure can be hazardous and dangerous.[15]

Health effect of Formaldehyde exposure in salon workers

Workers who are exposed to formaldehyde in salons may have a variety of health concerns, such as skin responses, irritation of the eyes and respiratory system, and, with chronic exposure, the possibility of developing cancer.[16] According to our research, the third most common chemical exposure among salon employees is formaldehyde (60%). High levels of formaldehyde exposure might cause respiratory problems. Our results are in line with research conducted in Kumasi, West Africa, on salon employees, which discovered that significant quantities of formaldehyde may be present in the cosmetics used in beauty salons. To ascertain the amounts of formaldehyde and related health hazards, samples of the indoor air from sixty salons were taken. According to Asare-Donkor et al., hairdressers who work in salons that offer all services are more vulnerable.[16]

Our study has also shown that high formaldehyde exposure can cause respiratory health problems. Our results are comparable to research that found salon employees who were exposed to formaldehyde-containing hair straighteners on a regular basis acquired new-onset asthma. According to other reports, there is a significant chance of acquiring asthma in salon settings when formaldehyde is used for hair straightening.[17] Furthermore, the study looked into the occupational exposure to formaldehyde among hairstylists in Cairo, Egypt, who used hair-straightening products. The quantities of formaldehyde exposure after 15 minutes were found to be higher than the National Institute for Occupational Safety and Health limits. All of the chosen genotoxicity biomarkers have shown a significant increase in exposed workers and a positive association with the length of exposure, according to the study's findings on the relationship between genotoxicity biomarkers and working years.[18]

Health effect of Ammonium Thio-glycate exposure in salon workers

According to our research, ammonium exposure ranks fourth among chemicals that salon employees encounter (51.4%). Ammonium exposure in salons can cause a number of health problems for employees, mostly affecting the respiratory and skin systems. Coughing, wheezing, burning sensations, and irritation of the eyes, nose, and throat are common issues. More serious respiratory conditions such as bronchitis, pulmonary oedema, and even asthma can result from prolonged or high-level exposure. According to our research, according to a study conducted in 50 hair salons in Portugal, skin and respiratory tract disorders

are associated with occupational exposure to NH_3. The most common occupational complaints were eye irritation and hand dermatitis.[19] Additionally, ammonia exposure was linked to occupational dangers. 38.7% of workers in Elbrega, Libya, reported having irritations in their mouths, throats, eyes, and noses as a result of ammonia exposure, according to cross-sectional research.[20] Moreover, according to a case-control study, a cough and shortness of breath were reported by 33% of hairdressers who had been exposed to bleach chemicals. According to a survey of hairdressers, 90% of respiratory illnesses and 27% of hand dermatoses are attributed to ammonium persulfate salt. The lifetime prevalence of allergic rhinitis, asthma, and hand dermatoses is reported as 16.9%, 4.5%, and 16.9%, respectively.[21]

Quality of respiratory health of the salon workers

Many salon employees suffer from respiratory problems as a result of exposure to different chemicals and unsuitable working conditions. These problems might be anything from minor irritants to more severe ailments like asthma. It is essential to regularly evaluate respiratory health in order to spot possible issues early and take preventative action. We used the following instruments in our study to evaluate salon employees' respiratory health.

1. **St. George Respiratory Questionnaire**
2. **mMMRC grading for dyspnoea**
3. **Pulmonary Function Tests and PEFR**

Pulmonary Function Tests and PEFR in Salon Workers:

Due to their frequent exposure to a variety of chemicals and allergens, the respiratory health of salon employees can be evaluated with the use of pulmonary function tests (PFTs) and peak expiratory flow rate (PEFR) measurements. In particular, worse lung function than the general population may be experienced by hairdressers, according to studies; lower values for PEFR and other PFTs, such as FVC and FEV1, are frequently recorded. This implies that a deleterious effect on lung health may be caused by occupational exposure in salons. Consistency with a study conducted on salon employees in Sikkim, North India's Gangtok district, is observed in our results, which identified a significant decrease in all metrics among hairdressers.[10] Moreover, the pulmonary functions of fifty-two hairdressers between the ages of twenty-five and forty-five were evaluated in a study conducted in Bidar, North India, and contrasted with a control group. It was found that the indices of forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), FEV1/FVC, maximum mid-expiratory flow rate (MMEF), and peak expiratory flow rate (PEFR) were significantly lower among hairdressers than in the general office-going population. This decline in pulmonary function can be identified by spirometry before it has a substantial negative impact on health.[22] Additionally, a 2019 study conducted in Azamgarh, Uttar Pradesh, India, by Hasan and Srivastava revealed that noticeably worse lung functions were experienced by hairdressers compared to those of the control group. More respiratory symptoms and lower PFT values are experienced by hairdressers due to their exposure to chemicals in hair products, colours, and cleaning agents. These negative consequences can be worsened by smoking, and the degradation of lung function is aggravated by longer workdays.

Distribution of subjects based on FEF value

One important sign of minor airway blockage is forced expiratory flow, more especially the forced expiratory flow between 25% and 75% of the forced vital capacity (FEF25-75). This section of the forced vital capacity reflects small airways, which are more likely to collapse during exhalation because they have less cartilage support. A decrease in FEF25–75 indicates that there may be a minor airway blockage since airflow is restricted in these narrower passageways.

With mean FEF values of 55.92% for salon workers and 76.71 for control subjects, we discovered that 56.2% of study participants and 34.3% of control participants had small airway obstruction, according to FEF values. Salon employees' lower FEF values suggest a little airway blockage. Our results are comparable to a study conducted in a leather factory in Chennai that discovered that the exposed group's average FEF was 65.4, indicating a little airway obstruction and a considerable decrease. The Indian leather industry is vulnerable to respiratory issues as a result of formaldehyde, aniline, and resin exposure.[23]

Association of chemical exposures with the respiratory health of the salon workers

Every day, salon employees come into contact with a wide range of chemicals from products such as hair colours, styling solutions, acrylic nail polish, and chemical relaxers, which can cause or worsen respiratory conditions.

ANOVA was used in our study to determine the relationship between salon employees' PFT and PEFR values and their exposure to a combination of chemicals in hair products. We discovered a strong correlation between the pulmonary function measures FVC, FEV1, FEV1/FVC, and PEFR and exposure to ammonia, formaldehyde, hydrogen peroxide, and glyoxylic acid. On the other hand, exposure to hydrogen peroxide has a strong correlation with EFE-25-75.

Exposure to different chemical combinations resulted in a significant decrease in the FEV1, FEV1/FVC, and PEFR values. Specifically, the Forced Vital Capacity (FVC) values were significantly decreased by the combination of ammonia, H2O2, and glyoxylic acid. These results clearly show that an obstructive pattern of lung illness is frequently caused by chemical exposure in salon settings. EFE-25-75 readings significantly decreased for workers exposed to a combination of substances, including hydrogen peroxide. This shows that exposure to hydrogen peroxide may play a role in the development of a restrictive pattern of lung illness. Our results are consistent with those of Evtyugina et al. and Acharya et al., who found a strong correlation between the common chemicals found in salon products and the obstructive pattern of pulmonary morbidity. Depending on the concentration, pressure, and environment in the salon, as well as the air conditioning and ventilation systems, salon products containing specific chemicals may produce aerosol particles.[24,25] In particular, when heated, several salon products, including hair straightening or smoothing treatments, may create formaldehyde aerosol, which is a vaporised version of formaldehyde or chemicals that release formaldehyde into the air. According to certain studies, formaldehyde is present in many fullness salon items.

Products like Brazilian Blowout Acai Professional Smoothing Hair Solution, which contains both hydrated and non-hydrated forms of formaldehyde together with methylene glycol, are used by hairstylists. The product exceeds the exposure limitations set by the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA), according to a pilot study. Hair straightening products with a third-party guarantee of less than 1 mg/mL are advised to maintain airborne formaldehyde exposure.

St. George Respiratory Questionnaire for Assessing Respiratory Illness in Salon Workers

One useful tool for measuring the many aspects of respiratory health, such as symptom frequency, activity limits, and general quality of life, is the St George Respiratory Questionnaire. The thoroughness of this questionnaire enables a sophisticated awareness of the respiratory issues salon employees face, enabling focused interventions and preventative actions. Questionnaire surveys can reveal that a significant percentage of workers experience work-related respiratory or nasal issues. It is imperative to meet and maintain high standards of safety, health, and hygiene in salons to protect both workers and clients. Questionnaires can be used to assess the hazards faced by workers.

A comprehensive grasp of the particular respiratory dangers that are common in salon employment is essential for using the St George Respiratory Questionnaire in this setting. Three domains are used to quantify health impairment: symptoms, activity, and impacts. Better health is indicated by lower scores.

As far as we are aware, this is the first study to use the St George's Respiratory Questionnaire (SGRQ) to assess respiratory illness in salon employees. The mean total score for salon workers on the St George respiratory questionnaire was 22.67 ± 12.83, which is significantly higher than the mean score for the control group (2.71 ± 0.43), according to our study. Salon employees' St George respiratory questionnaire scores increased as a result of mesenchymal inflammation in the respiratory system brought on by long-term chemical exposure. Formaldehyde, one of the chemicals frequently encountered in salons, can cause inflammation via a number of pathways, such as oxidative stress, immunological activation, and airway remodelling. Increased blood levels of inflammatory markers, including C-reactive protein (CRP) and interleukin-6 (IL-6), can be a sign of this inflammation.

According to a study conducted in northern Seoul, Korea, salon professionals' health may suffer from prolonged exposure to carbonyl compounds and volatile organic compounds (VOCs) found in cosmetic goods. According to the study, acetone, benzaldehyde, and toluene concentrations were greater among salon professionals who had negative health impacts. According to the study, the best way to lower both carcinogenic and non-cancer hazards is to use personal protective equipment.[26]

mMRC grading for Assessing dyspnoea in Salon Workers

Dyspnoea during everyday activities can have its level evaluated by people using the Modified Medical Research Council (mMRC) scale, a straightforward questionnaire. Dyspnoea is graded by people on this self-assessment measure using a scale of 0 to 4; higher scores are denoted by higher levels of symptoms. A higher mMRC score was suggested to indicate a higher symptom burden and a lower health-related quality of life (HRQoL), indicating that the mMRC scale may be used to screen and identify patients with more serious illnesses. This measure can help assess the effects of dyspnoea on salon employees and comprehend how exposure to chemicals impacts their respiratory health by causing dyspnoea. As far as we are aware, this is the first study in which the respiratory illnesses of salon employees are graded using the Modified Medical Research Council (mMRC) scale. The majority of mMRC scale grades in our study were grade-1 (30.5%), grade-2 (26.7%), and grade-3 (15.2%). It is shown that dyspnoea is one of the common symptoms of chemical exposure for salon workers. The exposure of beauty salon staff to respirable particulate matter (PM) was evaluated in our study, by Vinnikov et al., 2023, a study conducted in Almaty, Kazakhstan. Twelve salons provided 122 samples for the study, which used CAT and mMRC to evaluate lifestyle, respiratory symptoms, and health-related quality of life (HRQL). The scores of both HRQL (mMRC) domains in salon personnel were significantly higher compared to the general population. [27] Poorer HRQoL is linked to higher mMRC scores, which indicate more dyspnoea. Dyspnoea, or breathlessness, can result from exposure to a variety of chemicals and physical elements in the salon setting. Breathing problems may result from these exposures because the respiratory system may be irritated or sensitised. Chemical aerosols are produced by a variety of salon operations. When inhaled, these microscopic particles can irritate the airways and perhaps result in asthma or other respiratory problems. Respiratory issues in hairdressers have been connected to ammonium persulfate, a prevalent chemical in bleaching solutions. Higher mMRC scores, which are linked to lower HRQoL, are correlated with breathlessness. Dyspnoea, or breathlessness, may be experienced by salon workers as a result of exposure to several chemicals and physical elements in the salon setting.

Association of exposure to chemicals with St. George respiratory questionnaire score in salon workers

To understand the potential long-term health impacts of their profession, it is crucial to assess the respiratory health of salon workers who are subjected to various chemicals. By maintaining sanitary conditions in healthcare facilities, environmental service providers, for instance, play a vital role in preventing the spread of infections, highlighting the importance of protecting employees from occupational hazards. Salon staff, who may be subjected to various chemicals, could also experience respiratory issues, potentially elevating their SGRQ scores and reflecting a diminished quality of life regarding health.

To our knowledge, this represents the inaugural study to identify a link between chemical exposure and the St George respiratory questionnaire scores of salon employees. Employing an independent T-test, we analysed the connection between salon workers' exposure to a mixture of chemicals found in hair products and their results on the St George respiratory questionnaire.

Our findings revealed a significant correlation between the St George respiratory questionnaire and exposure to ammonia, formaldehyde, hydrogen peroxide, and glyoxylic acid. Furthermore, Kumar et al. highlighted the role of environmental contaminants that influence hormones in contributing to respiratory issues and other non-communicable diseases. It is crucial to recognise that salon employees are often subjected to various endocrine-disrupting chemicals, which can exacerbate respiratory conditions.[28] A study conducted in Romania indicated that exposure to dust and chemicals increases the likelihood of developing chronic respiratory ailments. The lung function and quality of life of 40 patients

were assessed through spirometry and the St George's Respiratory Questionnaire, underscoring the necessity for more sensitive assessment methods.[29]

Association of chemical exposure with m mMRC grade of salon workers

Hair dyes, straightening products, and various cosmetics are among the numerous chemicals that salon workers are often exposed to. This exposure can lead to adverse health effects, particularly respiratory issues, as indicated by the modified Medical Research Council (mMRC) scale. Many studies emphasise the detrimental impact of workplace chemical exposure on health. For instance, the findings of Morakinyo et al., who examined the health implications of exposure to both biological and chemical elements of inhalable and respirable particulate matter, support the notion that salon employees may be vulnerable to respiratory ailments.[30] Sexton's (2012) cumulative risk assessment framework is particularly relevant as it underscores the importance of evaluating the combined health effects of various environmental stressors, including the diverse chemical exposures faced by salon workers.[31] Understanding these relationships is essential for identifying the health risks associated with specific mMRC grades. mMRC grades 1 and 2 indicate mild to moderate dyspnoea. Grade 1 refers to experiencing shortness of breath when hurrying or walking up a slight incline, while grade 2 involves walking more slowly than others or needing to pause for breath during normal activities. These scores are crucial, as they reflect the impact of dyspnoea on daily functioning and can guide treatment decisions. To our knowledge, this is the first research to establish a connection between chemical exposure and the mMRC grades of salon workers. Our study employed an independent t-test to analyse the relationship between the mMRC grades of salon employees and their exposure to a mixture of chemicals found in hair products. We found a significant correlation between mMRC grades and exposure to ammonia, formaldehyde, hydrogen peroxide, and glyoxylic acid.

Conclusion:

In conclusion, this assessment has highlighted significant concerns regarding the respiratory health of salon workers in South India, illuminating the often-overlooked ramifications of occupational exposure to harmful chemicals within the salon environment. The clear correlation between chemical exposure and respiratory symptoms emphasizes a critical need for intervention. To mitigate these health risks, it is imperative to prioritize educational initiatives aimed at raising awareness among salon workers about potential hazards and the importance of adhering to safety protocols. Furthermore, advocating for improved ventilation systems and the consistent use of personal protective equipment can serve as fundamental strategies to safeguard the respiratory well-being of these workers. The findings of this study not only call for the attention of health authorities and policymakers but also stress the necessity for the establishment of robust health and safety regulations tailored to the salon industry. By fostering a safer work environment, we can enhance the quality of life and productivity of salon workers, ultimately contributing to a healthier community overall.

References:

1. Franić Z, Ljubojević Hadžavdić S, Babić Ž, Macan J. Incidence and prevalence of occupational contact dermatitis in hairdressing apprentices: A 3-year prospective cohort study. *Contact Dermatitis*. 2023;89(3):153-160. doi:10.1111/cod 14355
2. Soares CO, Pereira BF, Pereira Gomes MV, Marcondes LP, de Campos Gomes F, de Melo-Neto JS. Preventive factors against work-related musculoskeletal disorders: narrative review. Rev Bras Med Trab. 2020;17(3):415-430. doi: 10.5327/Z1679443520190360.
3. Tesfaye AH, Engdaw GT, Desye B, Abere G. Occupational respiratory morbidity and associated factors among hairdressers in Ethiopia: a cross-sectional study. BMJ Open. 2023;13(6):e074299.. doi:10.1136/bmjopen-2023-074299
4. Heibati B, Jaakkola MS, Lajunen TK, Ducatman A, Bamshad Z, Eslamizad S, et al. Occupational exposures and respiratory symptoms and lung function among hairdressers in Iran: a cross-sectional study. *Int Arch* Occup Environ Health. 2021;94(5):877-887. doi:10.1007/s00420-020-01645-z
5. Akpinar-Elci M, Cimrin AH, Elci OC. Prevalence and risk factors of occupational asthma among hairdressers in Turkey. J Occup Environ Med. 2002;44(6):585-590. doi:10.1097/00043764-200206000-00023

PMR P ISSN: 0975-0533, E ISSN: 0976-0164

6. hat AA, Afzal M, Goyal A, Gupta G, Thapa R, Almalki WH, et al. The impact of formaldehyde exposure on lung inflammatory disorders: Insights into asthma, bronchitis, and pulmonary fibrosis. Chem Biol Interact. 2024;394:111002. doi:10.1016/j.cbi.2024.111002

7. Aglan MA, Mansour GN. Hair straightening products and the risk of occupational formaldehyde exposure in hairstylists. Drug Chem Toxicol. 2020;43(5):488-495. doi:10.1080/01480545.2018.1508215

8. Barbosa E, Dos Santos ALA, Peteffi GP, Schneider A, Müller D, Rovaris D, et al. Increase of global DNA methylation patterns in beauty salon workers exposed to low levels of formaldehyde. Environ Sci Pollut Res Int. 2019;26(2):1304-1314. doi:10.1007/s11356-018-3674-7

9. Tomar S, Tiwari RR, Verma G. Occupational respiratory morbidity among hair and beauty salon workers in Udupi taluk, Karnataka, India. Am J Ind Med. 2020;63(10):902-906. doi:10.1002/ajim.23171

10. Gupta K, Thapa B, Gupta S, Sharma S. Lung Function Tests in Hairdressers of Gangtok: A Cross-Sectional Study. Indian J Occup Environ Med. 2022;26(2):91-94. doi:10.4103/ijoem.ijoem_264_21

11. Morio LA, Hooper KA, Brittingham J, Li TH, Gordon RE, Turpin BJ, et al. Tissue injury following inhalation of fine particulate matter and hydrogen peroxide is associated with altered production of inflammatory mediators and antioxidants by alveolar macrophages. Toxicol Appl Pharmacol. 2001;177(3):188-199. doi:10.1006/taap.2001.9316

12. Rauserova-Lexmaulova L, Agudelo C, Prokesova B. Acute Respiratory Failure after Administration of Hydrogen Peroxide as an Emetic in a Cat. Case Rep Vet Med. 2019;2019:7242631. doi:10.1155/2019/7242631.

13. Hesam G, Shekarloo M V, Atamaleki A, Jalali M, Hajipour-Verdom B, & Moradpour Z, et al. Health risk assessment of inhalation exposure to dry fogging of hydrogen peroxide in a dental clinic during the COVID-19 pandemic. Environmental Science and Pollution Research, 2022;29(50), 75338–75343. https://doi.org/10.1007/s11356-022-21174-1

14. Robert T, Tang E, Kervadec J, Desmons A, Hautem JY, Zaworski J, et al. Hair-straightening cosmetics containing glyoxylic acid induce crystalline nephropathy. Kidney Int. 2024;106(6):1117-1123. doi:10.1016/j.kint.2024.07.032

15. Lim SK, Kim H, Yoo J, Kim W, Shim I, Yoon BI, et al. Acute Toxicity in the Rat Lung Induced by Intratracheal Instillation of Glycolic Acid. In Vivo. 2022;36(4):1710-1717. doi:10.21873/invivo.12883

16. sare-Donkor NK, Kusi Appiah J, Torve V, Voegborlo RB, Adimado AA. Formaldehyde Exposure and Its Potential Health Risk in Some Beauty Salons in Kumasi Metropolis. *J Toxicol*. 2020;2020:8875167. doi:10.1155/2020/8875167

17. Asare-Donkor NK, Kusi Appiah J, Torve V, Voegborlo RB, Adimado AA. Formaldehyde Exposure and Its Potential Health Risk in Some Beauty Salons in Kumasi Metropolis. *J Toxicol*. 2020;2020:8875167. doi:10.1155/2020/8875167

18. Dahlgren JG, Talbott PJ. Asthma from hair straightening treatment containing formaldehyde: Two cases and a review of the literature. Toxicol Ind Health. 2018;34(4):262-269. doi:10.1177/0748233717750982

19. Mendes A, Madureira J, Neves P, Carvalhais C, Laffon B, Teixeira JP. Chemical exposure and occupational symptoms among Portuguese hairdressers. J Toxicol Environ Health A. 2011;74(15-16):993-1000. doi:10.1080/15287394.2011.582027

20. Mohamed H, Alfutmani A, Omar K, bokhatwa O, Alreshy A. Irritation Effects of Ammonia Gas on Workers in Ammonia Factory at Elberga Petroleum Company During 2017. Sch J Appl Sci Res. 2018;1(5): 54-58

21. Leino T, Tammilehto L, Luukkonen R, Nordman H. Self reported respiratory symptoms and diseases among hairdressers. Occup Environ Med. 1997;54(6):452-455. doi:10.1136/oem.54.6.452

22. Ns, M., & Banner, R. R. Pulmonary function tests in hairdressers. Indian J Clin Anat Physiol. 2017. 4(3), 353–355. https://www.ijcap.org/article-details/4767

23. Sruthi Priyadarsini S, Chandrasekar Chokalingam, Balamurugan Shanthalingam, Manikandan Nagesh, & Manoj Ramanathan. Early diagnosis of small airway disease in asymptomatic polishing sector workers of a leather factory. Asian J Med Sci [Internet]. 2024 ;15(8):136-9. Available from: https://ajmsjournal.info/index.php/AJMS/article/view/570

24. Evtyugina M, Vicente E D, Vicente A M, Nunes T, Lucarelli F, Calzolai G, et al. Air quality and particulate matter speciation in a beauty salon and surrounding outdoor environment: Exploratory study. Atmos. Pollut. Res. 2021;12(11), 101174. https://doi.org/10.1016/j.apr.2021.101174

25. Acharya SR, Moon DH, & Shin YC. Assessment of VOCs, PM10, and formaldehyde exposure in the hair salons of South Korea. Environ. Health Sustain. Dev.2020. https://doi.org/10.18502/jehsd.v5i4.4958

26. Choi YH, Kim HJ, Sohn JR, Seo JH. Occupational exposure to VOCs and carbonyl compounds in beauty salons and health risks associated with it in South Korea. Ecotoxicol Environ Saf. 2023;256:114873. doi:10.1016/j.ecoenv.2023.114873

27. Vinnikov D, Romanova Z, Raushanova A, Beisbekova A, Vitale E, Bimuratova G, et al. Exposure to Respirable Particulate Matter and Its Association with Respiratory Outcomes in Beauty Salon Personnel. *Int J Environ Res Public Health*. 2023;20(3):2429. doi:10.3390/ijerph20032429

28. Kumar M, Sarma DK, Shubham S, Kumawat M, Verma V, Prakash A, et al. Environmental Endocrine-Disrupting Chemical Exposure: Role in Non-Communicable Diseases. *Front Public Health*. 2020;8:553850. doi:10.3389/fpubh.2020.553850

29. Otelea M R, Arghir O C, Zugravu C, Naghi E, Antoniu S, & Rascu A. Lung Function and Quality of Life in Workers with Chemical and Dust Exposure. Revista De Chimie. 2018; *69*(2), 346–349. https://doi.org/10.37358/rc.18.2.6104

30. Morakinyo OM, Mokgobu MI, Mukhola MS, Hunter RP. Health Outcomes of Exposure to Biological and Chemical Components of Inhalable and Respirable Particulate Matter. Int J Environ Res Public Health. 2016;13(6):592. doi:10.3390/ijerph13060592

31. Sexton, K. Cumulative Risk Assessment: An Overview of Methodological Approaches for Evaluating Combined Health Effects from Exposure to Multiple Environmental Stressors. Int J Environ Res Public Health,2012; *9*(2), 370–390. https://doi.org/10.3390/ijerph9020370