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Evaluation of respiratory health of polyester dyeing and printing workers

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ABSTRACT

Objectives: The textile industry contributes significantly to the Indian economy. The wet process in the industry, particularly dyeing and printing, uses several chemicals which are known to be deleterious to respiratory health. This study was undertaken to assess the respiratory health of the workers in the dyeing and printing activity of the industry.

Materials and Methods: A cross-sectional study, with a sample of 209 workers, was conducted in three different dyeing and printing factories. The workers were interviewed using a semi-structured questionnaire adapted from the medical research council (MRC) questionnaire. This was followed by the measurement of the peak expiratory flow rate (PEFR) of each participant.

Results: The present cross-sectional study among polyester dyeing and printing workers revealed that 32.1% of the workers had respiratory morbidity as assessed by respiratory symptoms and/or ≥20% decline in post-shift PEFR values. The comparison of pre-shift and post-shift PEFR values revealed that 12.1% had a≥20% decline in the post-shift PEFR.

Conclusion: The workers working in the printing and dyeing industry are at risk of developing respiratory morbidity which can partly be attributed to reactive chemicals used and partly to poor handling practices of the workers.

Keywords: Textile dyeing, Respiratory health, Reactive dyes, India

INTRODUCTION

Globally, the demand for textile products has seen a rise in the past few decades. The share of textiles, apparel, and handicrafts in India's total exports was 11.4% in 2020–21. India holds a 4% share of the global trade in textiles and apparel.[1] The Indian textile industry is considered to be the second largest employer after agriculture, as it offers employment to over 45 million people directly and another 60 million people indirectly.[2]

The textile industry involves multiple processes. The wet processes, such as pre-treatment, dyeing, printing, and chemical washing, are manual and labour-intensive[3] and make use of enormous amounts of chemicals and solvents from the start till the end. The application of these chemicals is necessary to give a required look to the fabric. They include bleaching agents and chemicals in the form of binders, carriers, dyes, pigments, retardants, coating agents, etc.[4] However, many a time, these chemicals intentionally or unintentionally remain in the final products.

Dyes, particularly reactive dyes, have been linked to occupational asthma, rhinitis, and dermatitis in workers exposed to them.[5-8] An earlier study has shown that more than 15% of workers handling reactive dyes had work-related respiratory or nasal symptoms and considered that the symptoms could be attributed to an irritant response to chemicals used in this industry, including hydrochloric acid vapour and sulphur dioxide, as well as the reactive dyes themselves.[9] Furthermore, reactive dyes have been shown to cause respiratory sensitisation in workers exposed to them, resulting in respiratory symptoms that may be immunoglobulin E-mediated.[10]

Thus, the respiratory system usually manifests in the form of respiratory impairment when exposed to these reactive dyes. Spirometry will reflect this in terms of a reduction in the forced expiratory volume in one second (FEV_1)/forced vital capacity ratio. However, due to limited resources, it may not always be possible to conduct spirometry under field conditions. As an alternative to measuring FEV_1, peak expiratory flow (PEF) is a good way to assess obstructive impairment. According to the research, peak expiratory flow rate (PEFR) measurements have the same sensitivity and specificity as FEV_1 measurements. Moreover, the equipment is portable, easy to handle, and very cost-effective as compared to a spirometer.[11]

Although there are numerous studies on the respiratory hazards due to dust and the effects of dyes on the skin among textile workers, the effect of dyeing and printing chemicals on the respiratory health of such workers is very scarce. Thus, the present study is undertaken to assess the respiratory health of the dyeing and printing workers and understand the factors associated with it.

MATERIALS AND METHODS

The present cross-sectional study was carried out among the textile workers of Mumbai city. Considering a prevalence of 15.5% of occupational morbidities among textile workers,[3] 95% significance level, a relative precision of 5%, and a non-response rate of 20%, the calculated sample size was 242. To fulfil the sample size, a list of all the polyester dyeing and printing factories was obtained, and randomly, three factory settings were selected. The inclusion criteria included all the workers with more than 1 year of work experience in dyeing and printing, whereas the workers working in other departments of the factory were excluded. The list of workers employed in the dyeing and printing units for more than 1 year was obtained from each of the human resources departments of the factories. The technique used for the selection of participants for the study was simple random sampling without replacement using the lottery method. Thus, the selected factories had a total strength of 478 of which proportionately 242 workers were selected for the study. However, 35 workers had incomplete information and were excluded from the final study. Thus, the study results included 209 workers.

The Institutional Ethics Committee (IEC), Kasturba Medical College (KMC), gave the ethical clearance for the study [KMC IEC 38/2016]. After obtaining written informed consent from the selected workers, information on socio-demographic characteristics was collected using an interview technique on a pre-tested pro forma. A pre-tested questionnaire was used to find the respiratory symptoms. This was followed by pre-shift and post-shift PEFR measurements of study participants using a portable PEF meter (Micro Medical Ltd., UK) of the ATS scale with a 60–900 L/min range. Three readings each of pre-shift and post-shift PEFR were done and the highest value was taken for further analysis. The pre- and post-shift PEFR was undertaken to identify the changes in PEFR due to exposure to chemicals used in dyeing and printing such as sulphuric acid and hydrogen peroxide which may cause acute injury to the upper respiratory tract. The time duration between pre- and post-shift PEFR was approximately 12 h.

For the multivariate analysis, the variables were dichotomised. Respiratory morbidity was considered present if a study participant had 2 or more respiratory symptoms and/or ≥20% decline in post-shift PEFR values. Age and duration of exposure were categorised according to median values, whereas educational attainment was dichotomised arbitrarily.

The statistical analyses were carried out using the statistical software package SPSS version 25.0. For the distribution of different variables, descriptive statistics such as proportions and percentages were used. A paired *t*-test was used to compare mean pre-shift and post-shift PEFR values. The difference between proportions was compared using the Chi-square test, whereas the means were compared using the *t*-test and Analysis of Variance. To study the interaction effects of all variables, multiple logistic regression analysis was done.

RESULTS

[Table 1] depicts the demographic characteristics and personal habits of the study population. All the participants were male workers. The mean age of the workers was found to be 31.1 ± 9.2 years. Most of the workers belonged to the age group of 25–35 years (38.3%). Smoking of cigarettes or beedis was seen among 32 (15.3%) workers, whereas 88 (42.1%) workers were consuming tobacco in smokeless form. Overall, alcohol consumption was prevalent among 39.2% of workers, with only 4% consuming alcohol daily.

[Table 2] describes the occupational characteristics of the workers. It can be observed that 127 (60.8%) workers were working in the dyeing process, whereas 82 (39.2%) were working in the printing process. The majority (89.5%) of them worked for 12 or more hours per day for 6 days per

Table 1: Distribution of the participants in accordance with demographic characteristics and personal habits (*n*=209).

Variable	Frequency (%)
Gender	
Male	209 (100)
Age	
<25	66 (31.6)
25–35	80 (38.3)
35–45	46 (22.0)
≥45	17 (8.1)
Smoking habit	
Smoker	32 (15.3)
Non smoker	177 (84.7)
Tobacco chewer	
Yes	88 (42.1)
No	121 (57.9)
Alcohol consumption	
Yes	82 (39.2)
No	127 (60.8)

Total number of participants (*n*)=209

Table 2: Distribution of the participants according to occupational characteristics (*n*=209).

Occupational characteristics	Frequency (%)
Process in which working	
Dyeing	127 (60.8)
Printing	82 (39.2)
Hours/day	
<12	22 (10.5)
≥12	187 (89.5)
Work experience (in years)	
<2	60 (28.7)
3–5	56 (26.8)
6–9	39 (18.7)
≥10	54 (25.8)
Income/month	
<9000	82 (39.2)
9001–10000	49 (23.4)
10001–15000	60 (28.7)
≥15001	18 (8.6)

Total number of participants (*n*)=209

week. With reference to work experience, 54 (24.8%) were working for 10 years or more, whereas 60 (287%) joined the occupation recently (<2 years). Their income range was found to be Rs. 8000–1,00,000, with most of the workers (39.2%) getting Rs. 9000 or less per month. None of the workers were found to be moonlighting.

[Table 3] depicts the presence of respiratory health indicators in the study participants. It can be observed that 143 (68.4%) workers had one or more respiratory symptoms. Breathlessness was the most common symptom in 94 (45%), followed by cough in 83 (39.2%). Other symptoms included wheezing, phlegm production, and chest tightness. Although 31.6% were free from any symptoms, around 43.2% had two or more respiratory symptoms. When pre-shift and post-shift PEFR values were compared, it was found that 103 (49.3%) did not have any decline in post-shift PEFR whereas most (21.1%) had a 1–10% decline. Only 12.1% had a≥20% decline in the post-shift PEFR. The mean pre-shift PEFR was 439.43 ± 104.46 L/min, whereas the mean post-shift PEFR was 438.42 ± 108.43 L/min. This decline in post-shift PEFR was statistically non-significant (t = 0.185, P = 0.85).

Table 3: Distribution of respiratory health indicators of the participants (*n*=209).

Respiratory symptoms	Frequency (%)
Symptomatic	143 (68.4)
Cough	83 (39.2)
Breathlessness	94 (45.0)
Wheezing	25 (12.0)
Chest tightness	51 (24.4)
Phlegm	44 (21.1)
Asymptomatic	66 (31.6)
Number of symptoms	
None	66 (31.6)
One	53 (25.4)
Two	44 (21.1)
More than two	46 (22.1)
Decline in post-shift PEFR (%)	
No decline	103 (49.3)
1–10	44 (21.1)
11–20	35 (16.7)
>20	27 (12.9)

PEFR: Peak expiratory flow rate, Total number of participants (*n*)=209

In the inquiry into knowledge and practise about the safety measures at the workplace, it was observed that only 8.6% were using any kind of facemask or face cover to protect the respiratory system and 11% never read the labels pasted on containers and were thus unaware of the chemicals they were handling. About two-thirds of the participants perceived that the chemical they were handling was harmful to their health.

[Table 4] describes the association between study variables and the risk associated with them. It can be observed that on univariate analysis, age >35 years, not reading the label before use, and alcohol consumption were significantly associated with the presence of respiratory morbidity. However, on multivariate analysis, all the factors were non-significant statistically.

DISCUSSION

The present cross-sectional study among polyester dyeing and printing workers revealed that 32.1% of the workers had respiratory morbidity as assessed by respiratory symptoms and/or ≥20% decline in post-shift PEFR values. A study of textile dyeing workers in Turkey reported respiratory

Table 4: Multivariate analysis for the skin symptoms and study variables.

Variables	Respiratory morbidity		χ^2; *P*-value	Adjusted OR (95% CI)
	Present (*n*=67)	Absent (*n*=142)		
Age				
<35	43 (65.6)	111 (76.9)		1.61 (0.76–3.40)
≥35	24 (34.4)	31 (23.1)	4.59; 0.04*	
Duration of job				
≤5	24 (43.2)	118 (60.7)		1.34 (0.58–3.11)
>5	18 (56.8)	49 (39.3)	0.08; 0.85	
Hours of work				
<12	8 (9.6)	14 (7.7)	0.21; 0.64	0.96 (0.33–2.73)
≥12	59 (90.4)	128 (92.3)		
Education				
Above primary	13 (84.8)	30 (76.1)	0.08; 0.86	1.17 (0.52–2.65)
Up to primary	54 (15.2)	112 (23.9)		
Process				
Printing	30 (44.8)	52 (23.1)	1.27; 0.29	1.37 (0.69–2.69)
Dyeing	37 (55.2)	90 (76.9)		
Wearing face mask				
Yes	6 (93.6)	12 (97.4)	2.05; 0.22	1.03 (0.34–3.12)
No	61 (6.4)	130 (2.6)		
The knowledge that exposure is harmful				
Yes	46 (71.2)	93 (64.9)	0.21; 0.75	0.84 (0.42–1.66)
No	21 (28.8)	49 (35.1)		
Read the label before use				
Yes	64 (88.8)	122 (88.9)	4.29; 0.05*	0.28 (0.07–1.05)
No	3 (11.2)	20 (11.1)		
Cover the lid of the container				
Yes	61 (92.8)	127 (88.0)	0.13; 0.81	1.21 (0.38–3.84)
No	6 (7.2)	15 (12.0)		
Smoking				
No	53 (84.0)	124 (87.2)	2.37; 0.15	1.36 (0.58–3.22)
Yes	14 (16.0)	18 (12.8)		
Chewing tobacco				
No	33 (59.2)	88 (55.6)	0.30; 0.09	1.72 (0.91–3.26)
Yes	34 (40.8)	54 (44.4)		
Alcohol consumption				
No	33 (59.2)	94 (66.2)	5.48; 0.02*	0.57 (0.29–1.09)
Yes	34 (40.8)	48 (33.8)		

*Significant. OR: Odds ratio, CI: Confidence interval

symptoms such as phlegm (36.8%), atopy (34%), wheezing (27.4%), cough (25.5%), and dyspnoea (14.2%). Similarly, in a survey that was conducted at textile plants with dye houses in western Sweden, 6% of workers reported work-related respiratory symptoms.[8]

The study also showed that 12.1% of workers had a significant decline of ≥20% in the post-shift values of PEF as compared to pre-shift values. This suggests that there may be hazardous chemicals or substances at work that cause broncho-constriction and lowering post-shift values. An earlier study among textile-dyeing workers in Iran found that shift changes in spirometric parameters were significantly higher in this workgroup than in the control group.[12]

The univariate analysis showed that respiratory morbidity was associated with increasing age, not reading the label before using chemicals, and alcohol consumption. The increasing age may be associated with the increasing duration of the occupation. This might result in sensitisation to the chemicals present at the workplace, thereby manifesting in terms of the presence of respiratory symptoms or a decline in PEF values. The scouring and washing processes use chemicals such as sulphuric acid, acetic acid, and peroxide whereas the dyeing process uses several reactive dyes that can cause acute injury and inflammation of the upper respiratory tract. The practise of not reading the label of chemicals before use may result in workers being accidentally exposed to hazardous chemicals.

Furthermore, while the law requires employers to make workers aware of hazardous substances they are handling at work, this is rarely done. The association of alcohol with respiratory morbidity may be due to alcohol induced Th2 skewing of the immune response in terms of increased levels of Th2 cytokines and a marked increase in levels of serum total immunoglobulin E.[13,14] In the current study, the respiratory morbidities considered were also due to sensitisation due to the presence of chemicals or reactive dyes. Alcoholic beverages are frequently reported as triggers of skin and airway hypersensitivity reactions. In Asian populations, these reactions are often particularly severe, resulting in alcohol-induced asthma and 'Oriental flushing syndrome'.[15] It is noteworthy here that due to the social stigma attached to a person consuming alcohol, the figures might have been underreported in this study. However, on multivariate analysis, none of the study factors were found to be associated with the occurrence of respiratory morbidity. This may partly be attributed to the reduction in sample size due to the categorisation of variables and partly be due to underreporting of some variables, such as smoking, alcohol consumption, and poor safety measures, due to the inherent weakness of cross-sectional study design.

The study has several limitations. First, due to time constraints, single-point pre-shift and post-shift measurements of PEFR could only be done. Ideally, serial PEFR would have been a better measurement to guide toward the obstructive problem. Second, environmental monitoring could not be done due to the limited resources. It would have highlighted the dose of exposure as well as the type of chemicals. Further, the study is designed as a cross-sectional study, so causal effect and dose response analysis could not be done. This is somewhat taken care of by the surrogate measure of job duration. Further, as the study included only male workers, the generalisation of results to the whole population shall be done with precaution.

CONCLUSION

The workers working in the printing and dyeing industries are at risk of developing respiratory morbidity due to exposure to several chemicals, including reactive dyes. Thus, good handling practices such as using proper tools, using personal protective measures, and closing the lid of the chemical container may help in minimizing the exposure to these chemicals, either through the skin or through the air, and thereby delay the process of sensitization and the manifestation of respiratory symptoms. Similarly, informing the employees through employers, about the harmful nature of the chemicals being handled will make workers more cautious and thereby safeguard their health.

Ethical approval

The author(s) declare that they have taken the ethical approval from the Institutional Ethics Committee (IEC), Kasturba Medical College (KMC), [KMC IEC 38/2016].

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The author(s) confirms that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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