International Journal of Current Research and Review
DOI: http://dx.doi.org/10.31782/IJCRR.2021.131434

Original Research

IJCRR
Section: Healthcare
ISI Impact Factor (2019-20): 1.628
IC Value (2019): 90.81
SJIF (2020) = 7.893

Screening the Effect of Environmental Hazards on Pulmonary Function and Health Risk Biomarkers in Cotton Industry Workers

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ABSTRACT

Introduction: The textile industry is one of the main industries that support the Egyptian economy as it shares with about 10 per cent of the country's exports.[1]Workers in the textile industry are occupationally exposed to many health hazards that invite serious interference

Objectives: Workers in the cotton industry are occupationally exposed to environmental hazards that negatively affect their health. Assessment of environmental exposures and health risk predictors for screening purposes is crucial to maintain a healthier workplace.

Methods: Fifty-two workers in the cotton weaving and spinning section were included in the study. Clinical investigations included pulmonary function tests and measurement of blood pressure after obtaining medical history and socio-demographic data. Serum samples were obtained for biochemical estimation of cortisol, α-amylase and IL-6 using the ELISA technique. Environmental assessments included noise level, presence of fibres, and particulate matter.

Results: Particulate matter did not exceed approved limits where TSP ranged between 1.25 and 1.80 mg/m^3 at four different sites while PM_{10}ranged between 1.65 and 1.95 mg/m^3. Fibres concentration with aspect ratio 3:1 was 0.01 F/CC, long axis fibres range was 9-13 micrometre and short-axis fibres range was 2-7 micrometre. Noise level exceeded the permitted level with a mean of 105.5 dB. Abnormal spirometry was detected in 20% of the sample with the mean value of 3.4 for FEV_1 and 6.6 for the PEF for the whole sample. Cortisol means value (242.3 *ng/ml*) exceeded the upper normal limit as well as that of α-amylase (1001.5 U/L) and IL-6 mean value was 0.075 pg/ml.

Conclusions: Reported respiratory and hearing complaints, abnormal spirometry, increased levels of serum cortisol and α-amylase and reduced level of IL-6 could alarm for serious risk of health deterioration among cotton industry workers that invites continuous checkup for workers' health and monitoring of environmental hazards.

Key Words: Cotton industry workers, Stress, Particulate Matter, Noise, Pulmonary Function Tests

INTRODUCTION

The textile industry is one of the main industries that support the Egyptian economy as it shares with about 10 per cent of the country's exports.[1]Workers in the textile industry are occupationally exposed to many health hazards that invite serious interference.[2]Air pollution with cotton dust –produced while handling cotton- can induce lung diseases, byssinosis, pulmonary fibrosis, and chronic obstructive pulmonary disease.[3] Other respiratory problems due to exposure of workers to particulate matter (PM) include altered pulmonary functions and symptoms of chest tightness.[4]Small particulates can also penetrate the lungs reaching blood-stream carrying toxins to all parts of the body affecting both respiratory and cardiovascular systems.[5,6]

As reported, risks of cardiovascular diseases due to the exposure to fine particles include heart and stroke attacks with the stimulation of inflammatory responses that may interrupt heartbeats and increase the coagulation leading to premature death.[7]Hypertension is also found to be associated with chronic exposure to PM.[8] Besides, particulate matter is suspected to cause endocrine disruption leading to the development of metabolic diseases like obesity and diabetes mellitus that interns increase the risk of cardiovascular disease.[9]

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ISSN: 2231-2196 (Print) **ISSN:** 0975-5241 (Online)

Received: 06.12.2020 **Revised:** 12.02.2021 **Accepted:** 08.04.2021 **Published:** 20.07.2021

Inflammatory responses induced by chronic exposure to PM could explain some of the biological mechanisms underlying their toxic effects. Recent research reveals an increase in circulating levels of interleukin-6 (IL-6), Granulocyte-Macrophage Colony-Stimulating Factor, C-reactive protein, fibrinogen, Tumor Necrosis Factor-α and other inflammatory and pro-inflammatory mediators in response to environmental exposure to PM.[10]According to literature, three hypotheses are proposed to explain pathogenesis induced by PM that involves inflammatory responses.[11]. One suggestion states that activate inflammatory responses directly in the lung followed by spill-over effect leading to systemicinflammation. Others suggest the activation of sensory receptors in the lung through inhalation of a PM that affects the autonomic nervous system and stimulates the sympathetic pathways with subsequent disturbances on the cardiovascular system.A third assumption suggests that ultrafine particles interact directly with target tissues, yet it is still controversial.

Excessive noise in the working environment of textile industry represents another occupational exposure with the threat of loss of hearing.[12]Besides,noise could induce stress with negative health effects including catabolism and intestinal problems, immune suppression, cardiovascular diseases and insulin resistance due to the longer-lasting activation of the hypothalamic-pituitary-adrenal (HPA) axis.[13]

Shift work has also been regarded as one of the most hazardous risk factors in the work environment.[14] It disrupts circadian rhythm affecting health and wellbeing and predisposing to heart problems and other chronic diseases.[15] Moreover, evidence states that stress levels among workers are increased by work pattern and some researchers attribute it to disruption in social and family relationships in consequence to shift work.[16]Cortisol and α-amylase are among the most popular biomarkers of stress. The HPA-axis is dedicated to mediate body responses towards physical and mental stress and regulates the release of cortisol,[17] whileα-amylase increases in blood after pharmacological activation of the adrenergic pathways triggering the sympathetic receptors as a response to physical stress.

Developing countries are greatly in shortage of good knowledge of such kinds of hazards.[18]A serious attention to the health situation of cotton textile workers and underlying environmental hazards are a factual urgency. This could help to identify aspects of health needs as they provide a guide upon setting workplace health programs, identifying key issues impacting the health of working staff, planning workplace health initiatives, and helping to emphasize workers commitment and level of engagement.[19]

Hence, the present work is a screening study for assessment of environmental hazards (particulate matter, fibres, shift work and noise) and health risk predictors including clinical (pulmonary function and blood pressure) and biochemical (cortisol, α-amylase and, IL-6)factors among cotton-weaving and spinning workers.

METHODS

Participants

The study was carried on workers in the weaving and spinning section (open-end spinning process) at the cotton textile factory at Giza governorate. Fifty-two participants–representing the full capacity of the morning shift- were subjected to all of the investigations, and were included in the study. Participants were interviewed where their age, working years (exposure duration) and health complaints (headache, hearing problems, respiratory and cardiac complaints) were recorded. Work is on three shifts per day (8 hr each) where each worker works on the same shift for one week and transfer to the other shift time on the following week on a rotatory basis. Body mass index (BMI) was calculated after weight and height measured for all participants as kilograms per square meter. Both clinical examination and blood sampling for assessment of relevant biomarkers were performed in accordance with ethical considerations and after receiving approval (with number 16/401) from the ethical committee of the National Research Centre (NRC) and consent from all participants.

Blood sampling and Biochemical assessments

Blood samples (5 ml) were obtained from participants using sterile plastic syringes on sterile test tubes and left for 30 min at room temperature to coagulate, then centrifuged at 3000 rpm for 10 minutes. The separated serum was divided into several aliquots and kept frozen at-80°C to be used for biochemical analysis.

Biochemical markers assessed for cotton industry workers at the open end area included cortisol, estimated by ELISA method, kit supplied from Perfect Ease Biotech (Beijing) Co., Ltd. and IL-6, estimated by ELISA method, using the kit supplied from lab science, USA. Serum α-amylase was determined using the colourimetric kit (Biodiagnostic, Egypt).

Clinical examination

1. Blood pressure measurement:

Systolic and diastolic blood pressures(SBP and DBP, respectively) were measured twice using a standard mercury sphygmomanometer for all participants while sitting, then average readings were calculated.

2. Pulmonary function tests:

Determination of Pulmonary Ventilatory Function was done using a portable spirometer Model Smart pft USB. Serial number, name, date of birth, height and weight were recorded as personal data. Upon examination, each individual was asked to breathe normally from 5 to 7 times, then take a deep breath slowly and expire till the end very slowly. Participants were then asked to breathe at a normal rate again 5 to 7 times. Concerning the forced expiratory function, subjects were instructed to breathe normally 5 to 7 times, then to inspire deeply as maximum as possible, then expire forcibly till the end of expiration. They were asked to breathe normally again 5 to 7 times. The test was repeated three times as a minimum for accuracy.

Environmental assessments

1. Measurements of particulate matter:

Total suspended particulates (TSP) and respirable particulates (PM_{10}) were measured by using HAZ-DUST (American instrument) with continuous monitoring for the morning shift work at four different sites; the opening of cotton bales (site 1), weaving sections (open end) (sites 2&3) and humidification room (site 4). The standard limits for TSP and PM_{10} are 10 mg/m^3 and 3 mg/m^3, respectively according to Egyptian environmental law 4/1994.

2. Assessment of the presence of fibres:

According to NIOSH method No 7400,[20] for a period varying between 60-120min. at a flow rate of 5 L/min., air samples were collected on membrane fibres (0.45-micrometer pore size, 25-millimetre diameter) mounted on an open face fibre holder. Samples were then stored after collection in sealed boxes in the upward position and sent for analysis in the air pollution laboratory at NRC. The membrane filters were made transparent by mounting in immersion oil.

The analysis was done for the presence of fibres at a magnification of 400Xusing phase-contrast microscopy (Olympus, Tokyo, Japan). Fibres were considered for counting using Walton Beckett reticule in the eyepiece if they had the dimensions of >5 µm in length and <3 µm in diameter and aspect ratio 3:1.

3. Measurement of sound level:

Environmental noise assessment was done using a portable Sound Level Meter Standard (Model CR 306). Measurements were performed at different sites in the open-end spinning sector then the average was calculated.

Statistical analysis

Statistical analysis for data included descriptive means and standard deviation, frequency distribution, and student t-test for comparing means. The statistical package for social sciences, version 22 for windows (SPSS Inc., USA) was used.

RESULTS

In **Table 1**, the study sample showed a mean age of 39 years with a mean work history of 17 years. SBP, DBP, and HR showed to be within normal and the mean value for BMI exceeded limits of normal body weight. The cortisol mean value (242.3*ng/ml)* exceeded the upper normal limit(normal range: 50-230 *ng/ml*), the mean value for α-amylase was a burst and reached 1001.5 U/L (normal range: 70-340 U/L) and IL-6 mean value for the study population showed to be 0.075 pg/ml proposing immunosuppression.

Hearing and respiratory complaints were mostly addressed with 35% and 33%, respectively followed by headache (25%) and finally cardiac complaints (15%) as shown in **figure 1.**

Table 1: Descriptive data of study variables.

Variable (N)	Mean ± S.D	Minimum	Maximum
Age (52)	39.3±6.9	23	60
Exposure (52)	17.1±5.9	6	29
BMI (44)	26.8±4.2	20	39
SBP (46)	132±19	90	180
DBP (46)	84±12	60	110
HR (47)	76.2±13.6	48	108
Cortisol (ng/ml) (50)	242.3±100.0	35.7	410.90
α-amylase (U/L) (52)	1001.5±242.9	551.6	1479.6
IL-6 (pg /ml)(45)	0.075±0.069	0.00	0.34

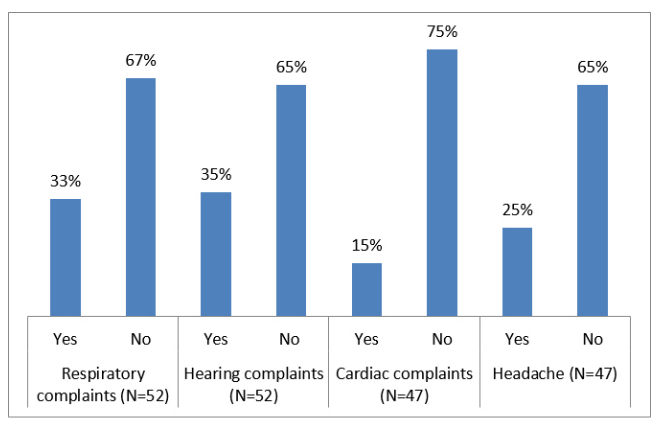

Figure 1: Percentages of different health complaints reported by study sample where 33% declared respiratory complaints, 35% showed hearing complaints, 25% had a headache and only 15% suffered from cardiac problems.

According to Pulmonary function tests, workers with abnormal spirometry functions represented 9 out of 44 workers (20%) who performed the test. Preliminary results are listed in Table 2 as mean, and standard deviation for vital capacity (VC), Forced expiratory volume in the first second (FEV1), Peak expiratory flow (PEF), and Mid expiratory flow (MRF); 25%, 50% and 75%. Compared means of the aforementioned parameters between workers with normal and abnormal spirometry functions are also shown in **Table 2**.

Table 2: Descriptive Statistics and compared means for spirometry indices.

	Spirometer function	Mean	Min/Max.	P value
VC (L)	Normal (35)	4.3±0.6	-	0.059
	Abnormal (9)	3.9±0.6	-	
	Total (44)	4.3±0.6	2.9/5.4	-
FEV_1 (L)	Normal	3.6±0.5**	-	0.008
	Abnormal	2.9±0.9**	-	
	Total (44)	3.4±0.7	1.31/4.6	-
FEV_1/FVC (%)	Normal	89.9±6.2	-	0.12
	Abnormal	79.3±18.1	-	
	Total (44)	87.8±0.5	37.0/100.0	-
FEV_1/VC (%)	Normal	82.8±7.2	-	0.133
	Abnormal	73.1±17.2	-	
	Total (44)	80.8±0.6	36.0/95.0	-
PEF (L/S)	Normal	6.8±1.7	-	0.23
	Abnormal	5.9±2.2	-	
	Total (44)	6.6±1.9	2.1/11.9	-
MEF75 (L/S)	Normal	6.2±1.9	-	0.27
	Abnormal	5.4±2.2	-	
	Total (44)	6.1±2.0	1.2/11.1	-
MEF50 (L/S)	Normal	5.1±1.3*	-	0.02
	Abnormal	3.8±1.6*	-	
	Total (44)	4.81±1.4	0.64/7.7	-
MEF25 (L/S)	Normal	2.7±1.1**	-	0.008
	Abnormal	1.5±0.9**	-	
	Total (44)	2.4±1.2	0.34/5.8	-

* significant difference at p<0.05, ** significant difference at p<0.01

Assessed variables did not show significant differences among workers reporting cardiac, hearing, and respiratory complaints and those who did not report such complaints. Workers suffering from headaches showed a significantly higher level of cortisol and a lower mean of IL-6 at p=0.057 (**Table 3).**

Table 3: Compared means with a standard deviation of study variables between workers with and without health complaints.

	Cardiac complaints		Hearing complaints		Respiratory complaints		Headache	
	Yes	No	Yes	No	Yes	No	Yes	No
Age (52)	41.0±6.5	37.9±6.2	41±8	48±6	41±8	38±6	36±6	39±6
Exposure (52)	17±6	17±6	17±6	17±6	17±6	17±6	15±6	18±6
BMI (44)	26±4	27±4	26±3	28±5	28±5	26±4	26±4	28±4
SBP (46)	136±21	131±19	128±23	133±17	131±23	132±17	123±20	135±18
DBP (46)	88±17	83±10	81±14	86±11	83±11	84±12	80±12	85±12
HR (47)	72±12	77±13	79±13	75±13	80±12	75±14	78±15	76±13
Cortisol (50)	232±127	262±87	238±94	245±105	216±119	253±90	310±53**	236±98**
α-amylase (52)	938±268	1048±232	974±235	1004±265	997±198	1004±265	995±205	1040±252
IL6 (45)	0.055±0.056	0.079±0.072	0.07±0.06	0.08±0.07	0.10±0.07	0.07±0.07	0.05±0.05	0.09±0.07

*significant difference at p<0.05, ** significant difference at p<0.01

Environmental measures included particulate matter at different sites and showed to be within the approved limits as shown in Table4. Fibres concentration (with aspect ratio 3:1) was found to be 0.01 F/CC. the long axis fibres range was 9-13 micrometre and the short-axis fibres range was 2-7 micrometre. Noise levels ranged between 100 dB and 110 dB at different sites with a mean of 105.5 dB that is exceeding the permitted level (90 dB) (Table 4).

Table 4: Measurementsof air born particulates.

	Total Suspended Particulates (TSP)	Respirable Particulates (PM_{10})
Site 1	1.25 mg/m^3	0.90 mg/m^3
Site 2	1.32 mg/m^3	0.820 mg/m^3
Site 3	1.39 mg/m^3	1.650 mg/m^3
Site 4	1.80 mg/m^3	mg/m^3

DISCUSSION

Exposure to Particulate matter is highly associated with the serious risk of a broad variety of deteriorating health conditions. As reported, $PM_{2.5}$ is the fifth-ranking mortality risk factor among air pollutants.[21]Besides, different epidemiological studies ensured the link between PM exposure and cardiopulmonary mortality.[9]Textile workers -in particular- are extensively exposed to PM in the working environment with certain deteriorating effects on their physical health.

Chronic respiratory symptoms have been reported by many recent studies among textile workers. TeferaZele et al.[22] assessment of respiratory symptomsin 306 cotton dust exposed workers in Ethiopia was adapted after the standard American Thoracic Society questionnaire and revealed significant differences from the control group regarding chronic chest tightness, cough, breathlessness and higher cross-shift lung function reduction in spirometry tests. A similar study on 303 male participants working in spinning and weaving sections of 5 different mills in Karachi, Pakistan reported cough, phlegm, and wheezing as respiratory symptoms.[23]In Benin, 656 workers exposed to cotton dust reported cough, dyspnoea, asthma, expectorations, and chronic bronchitis that was significantly higher in frequency compared to the normal non exposed group.

In agreement with the aforementioned studies, in the present work,33% reported the presence of respiratory complaints, and 20% showed abnormal spirometry. Lower means for all the spirometry indices and significant differences concerning FEV1, MEF50 and MEF25 were detected between workers with normal and abnormal pulmonary function tests, suggesting respiratory problems in textile workers to be of the obstructive type.

Fortunately, overall the study population is showing assumedly normal pulmonary function despite the detected problems. Upon comparing mean values of the spirometry indices with those of other exposed groups to cotton dust in similar studies it could be found that the present work reported higher FEV_1 (3.4) than that reported by TeferaZele et al. (2020)[22] in Ethiopia and that stated by Hinson et al. [24] in Benin.

Positive outcomes concerning pulmonary functions could be attributed to the detected particulate matter that didn't exceed the limits permitted by Egyptian environmental law 4/1994 as both parameters showed to be directly associated in a dose-response manner among textile workers.[23]Moreover, workers used to stick to health safety regulations as preventive measures.

On the contrary, the noise level as detected showed to exceed the permissible limit. Such exposure could explain the increased level of cortisol among the study sample above the upper normal limit and ensures the suggested noise-induced stress.[25]In accordance with the present findings Sings et al.[26]proposed the stimulation of the sympathetic nervous system due to exposure to noise above 92 dB. Additionally, in their study Melamed and Bruhis [27]revealed, the effect of chronic exposure to industrial noise above 85 d Bon increased urine cortisol levels. Not only cortisol but also α-amylase has shown to be increased in level in study sample exceeding the upper normal that could indicate workers suffering physiological stress. The level of α-amylase in blood has been suggested by recent research to be responsive to the physiological and not the psychological challenge of the adrenergic system induced by stress.[28]

As for the inflammatory biomarker; IL-6, its mean value lied at the lower normal limit according to references; 0–16.4 pg/mL, 0-20 pg/mL, and 0-31 pg/mL introduced by Khan and Ali[29], Onal *et al.*,[30]and Ng *et al.*,[31] respectively. A critical role has been suggested by endogenous IL-6 in the progress of lung inflammation in experimental research on mice.[32] It has also been shown to be elevated in different human lung diseases involving damage in lung epithelial cells.[33]. Yet the very low detected level among the study sample could indicate immunosuppression.[13]Besides, an inverse proportionality between cortisol and IL-6 -resembling the present case- has been reported in different populations suffering from stress.[34]Lower morning cortisol and increased IL-6, as a pattern, have been frequently observed in association with chronic stress.[35,36] As per the present findings, the case is reversed and could emphasize the concluded state of acute stress expressed by cotton textile workers that could be attributed to excessive, noise, shift work, or both exposures.

The risk of lung cancer is another challenge facing textile workers due to their continuous exposure to cotton fibres yet the issue is still controversial.[37]. Some research studies reported positive associations like Kuzmickiene et al.[38]who detected a slightly elevated incidence of lung cancer in a cohort sample of cotton textile workers in Lithuania. Other studies attributed the lung cancer risk to the exposure to endotoxins that varies with changes in exposure over time. For example, exposure to cotton after its processing reduces endotoxin content and hence increases the risk of lung cancer.[39] Bacterial endotoxins act as protective agents against lung cancer [40]and this could explain the decreased risk of lung cancer among cotton workers as compared to other types of textiles.

CONCLUSIONS

In conclusion, cotton textile workers in the present study showed to be subjected to many health hazards including noise, shift work, and chronic exposure to dust that negatively affected their health. Health consequences were prominent in the reported respiratory and hearing complaints, the abnormal spirometry, increased level of serum cortisol and α-amylase, and reduced level of IL-6.

From future perspectives, continuous checkup for workers health status is crucial for their physiological wellbeing with an emphasis on the importance of management of stress and elimination of sources of excessive noise. Modulation in the shift work pattern could also help reduce health risks for cotton textile workers.

List of abbreviations

BMI: Body mass index

DBP: Diastolic blood pressure

FEV1: Forced expiratory volume in the first second

HPA: Hypothalamic-pituitary-adrenal

HR: Heart rate

IL-6: Interleukin-6

MRF:Mid expiratory flow

NRC: National Research Centre

PDF: Peak expiratory flow

PM: Particulate matter

PM_{10}:Respirable particulates

PM2.5: Fine particulate matter

SBP: Systolicblood pressure

TSP: Total suspended particulates

VC: Vital capacity

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of the National Research Centre with approval number 16/401. The subject participants provided written consents.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This work was supported by the National Research Centre (NRC) [grant numbers 011010180, 2016/2019]. The NRC funded expenses for chemical kits, stationaries and transportation and offered equipment for the different measurements, analyses and examinations as well as incentives for the study team.

Authors' contributions

Prof. Dr. N.M.A. and Dr. M.S.S. were responsible for the conception and design of the study. About acquisition and interpretation of data; Prof. Dr. S.F.H. was responsible for the pulmonary function tests and history collection, Prof. Dr. Y.H.I., Prof. Dr. A.H.A.d, Dr. Y.S. were responsible for the environmental measurements and Dr. Mai SabrySaleh performed all aspects regarding biochemical analyses. Writing the manuscript was done by Dr. M.S.S. and all co-authors contributed to revising the manuscript critically and approved the final version.

ACKNOWLEDGEMENTS

Not applicable.

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