e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2025; 17(1); 151-163

Original Research Article

Effect of Inhaled Chemical Exposure during Hospital Laboratory Work on Pulmonary Functions of Healthy Working Women

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Received: 25-10-2024 / Revised: 23-11-2024 / Accepted: 26-12-2024

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Conflict of interest: Nil

Abstract:

Aim: This study aims to check the pulmonary functions of healthy working women exposed to inhaled chemicals in hospital laboratories and to compare that with the non-exposed healthy women.

Materials and Methods: The study was carried out in 50 healthy working women in the age group of 20-40 years who are working in hospital chemical laboratories and in other 50 healthy working women of same age group who are working in the administrative section. Volunteers were selected on basis of inclusion criteria. The volunteers were chosen in both case as well as control group in order to minimize the confounding factors and make the study reproducible. Informed written consent was obtained from all the volunteers before testing. Volunteers were explained in detail about the test procedure and a diagram was shown for the better understanding of the tests.

Result: In females exposed to laboratory chemicals as compared to the unexposed, all parameters were significantly reduced. FVC, FEV1 & FVC/FEV1 were significantly reduced in exposed as compared to unexposed indicating that the lung volume, flow and resistive properties of the bronchopulmonary tree were affected. The difference was also significant for static lung function tests as TV, IRV and SVC in exposed females and indicated that lung volume was affected along with lung elasticity and mobility. Significantly decreased PEFR and FEF 25-75 in the exposed group indicated that upper as well as small airways might be affected due to exposure to lab chemicals. Lung age was more than chronological age in both the groups but the gap was huge for exposed females. The difference in lung age in exposed and non-exposed females was highly significant and pointed towards the decreased function. No single chemical was found to lead to the cause rather it was the cumulative effect of multiple chemicals and reagents used in the laboratory. We found out that inhaled chemical exposure during hospital laboratory work resulted in detrimental effects on static lung volumes as well as flow rates amongst the exposed group.

Conclusion: This study concluded that risk factors for respiratory dysfunction significantly increase in females who are exposed to laboratory chemicals. Thus, there is a need for regular pulmonary function testing and taking preventive measures to avoid chemical exposure in laboratory workers.

Keywords: Pulmonary Dysfunction, Laboratory Chemicals, Pulmonary Function Tests.

Introduction

Optimal well-being depends on essentials like fresh air, clean water, sunlight, hygiene, and adequate rest. Any deficiency in these, particularly access to pure, pollutant-free air, can lead to health issues, highlighting its vital role in sustaining life.

Pure air contains normal amounts of oxygen, carbon dioxide, carbon monoxide, inert ozone, formaldehyde, sulfur dioxide, nitrogen dioxide, ammonia, particulates and water vapour all of which the body is well equipped to handle.[1] Polluted air is a major contributor to disease and debility, with modern environments exposing us to levels of pollutants far beyond our natural adaptations.

The gaseous air pollutants of primary concern in urban settings include nitrogen dioxide, and carbon monoxide; these are emitted directly into the air from fossil fuels such as fuel oil, gasoline, and natural gas that are burned in power plants, automobiles, and other combustion sources [2].

Along with these gases, the external industrial environment contains sulfur dioxide, which is extraordinarily poisonous. [3]

People who are exposed to indoor air pollution, or who are exposed to various inhaled chemicals at their work station are also predisposed to various forms of diseases. Review of literature shows that residing near polluted sites may be contributing to bad reproductive outcome especially congenital anomalies and low birth weight. [4] Workers exposed to solvents used for dry cleaning show the signs of visual neurotoxicity [5] Gasoline exposure induces multisystem pathology by causing bio activation, reactive metabolites and oxidative stress which poses a serious health hazard to humanity particularly in developing countries. [6]

Study has shown that health care workers are prone to chemical hazards along with other occupational hazards at their work stations. [7] Nursing interns are highly prone to physical hazards followed by chemical and biological hazards. [8] Cleaners working in the hospitals are also exposed to same types of hazards as health care workers. [9] There has been ample evidence that shows formalin which is the chemical most commonly used for embalming is toxic, allergenic and carcinogenic. [10,11] Many times chemical exposure occurs primarily by inhalation and is handled by the respiratory system, which may be the first to be prone for pathological changes if exposure is more than its handling capacity.

Important predictor of both respiratory disease and overall health are lung function or pulmonary function tests. [12] Cessation of lung growth occurs at around twenty years of age and plateau in lung functions followed by gradual age-related decline occurs, if no measures are taken to improve it. [13] Two common patterns of lung function impairment, obstruction and restriction are generally seen which have a different effect on morbidity and mortality [14]. Obstructive disease is a major and growing cause of morbidity, disability and death worldwide whereas restrictive disease is a predictor of all-cause mortality even in the absence factors for lung function impairment, particularly in relation to our immediate surroundings. [15] Pulmonary function is a long-term predictor for overall survival rates in both genders and associated with increased mortality and morbidity [16,17,18].

Government tertiary healthcare centers often have chemical laboratories with a majority of female staff, yet research on their chemical exposure remains limited. Studies on occupational exposures often lack gender-specific analysis or sufficient female participants, leaving a gap in understanding how these exposures uniquely affect women. More focused research is needed to address this issue in hospital settings. These are the few key findings we came across when we searched at our level best for research work about the effect of chemical exposure on employees of hospital setup.

Aims and Objectives

Aim: This study aims to check the pulmonary functions of healthy working women exposed to inhaled chemicals in hospital laboratories and to compare that with the non-exposed healthy women.

Objectives:

1. Evaluate the respiratory function tests of healthy working women exposed to inhaled chemicals in hospital laboratories of a tertiary heath care centre.
2. Evaluate the respiratory function tests of the healthy women, not exposed to hospital laboratory chemicals.
3. Compare respiratory function tests of exposed and non-exposed women.

Materials and Methods

Study protocol was approved by Institutional Ethics Committee and was in accordance to Helsinki Declaration for studies on humans.

The study was carried out in 50 healthy working women in the age group of 20-40 years who are working in hospital chemical laboratories and in other 50 healthy working women of same age group who are working in the administrative section.

Volunteers were selected on basis of inclusion criteria.

The volunteers were chosen in both case as well as control group in order to minimize the confounding factors and make the study reproducible.

Informed written consent was obtained from all the volunteers prior to testing. Volunteers were explained in detail about the test procedure and a diagram was shown for the better understanding of the tests.

Inclusion Criteria for Group I (Exposed):

1. Apparently healthy, non-obese, females falling into age group of 20-40 years.
2. Working in a hospital laboratory for minimum 6 hours per day and 6 days a week since at least 3 years.
3. Absence of physical disabilities or illness that would restrict normal activities.

Exclusion Criteria for Group I (Exposed):

1. Subjects with chronic systemic diseases [19] like Hypertension, Ischemic Heart Disease, Diabetes Mellitus.
2. Subjects with history of smoking, chronic cough, recurrent respiratory tract infection,

personal history of asthma, chronic obstructive lung disease
3. Neuromuscular abnormalities including Kyphoscoliosis
4. Any surgical procedure within 8 month (typical tissue healing time for soft tissue injury and any minor nerve repair is ranging between 3-5 months, so to be more sure we kept that window at 8 months.) [19]
5. Pregnancy
6. Subjects on long-term drug therapy.

Inclusion criteria for Group II (Non exposed):

1. Apparently healthy, non-obese, females falling into age group of 20-40 years.
2. Working as staff in administrative section for minimum 6 hours per day and 6 days a week since at least 3 years.
3. Absence of physical disabilities or illness that would restrict normal activities.

Exclusion criteria for Group II (Non exposed):

1. Subjects with chronic systemic diseases like Hypertension, Ischemic Heart Disease, Diabetes Mellitus [19]
2. Subjects with history of smoking, chronic cough, recurrent respiratory tract infection, personal history of asthma, chronic obstructive lung disease
3. Neuromuscular abnormalities including Kyphoscoliosis
4. Any abdominal/thoracic surgical procedure within 8 month (typical tissue healing time for soft tissue injury and any minor nerve repair is ranging between 3-5 months, so to be more sure we kept that window at 8 months.) [19]
5. Pregnancy
6. Subjects on drug therapy whose side effects are not known, eg. Ayurvedic medicines taken for weight reduction.

Procedure:

1. Informed consent: All subjects were informed about the test and a written consent was obtained.

2. History and general examination: A thorough history was collected from all the participants including personal history such as name, age, sex, ethnicity, address, habit of smoking and medical history including history of any respiratory, cardiac diseases and other chronic diseases. Proper general and systemic examination was taken for each and every participant to rule out any abnormalities.

3. Anthropometry: Body height, body weight, waist circumference, hip circumference measured according to current anthropometric methodology. The following index was also be calculated:

Waist to hip ratio (WHR): All anthropometric measurements were obtained with the subjects wearing lightweight clothes without shoes. It was recorded in the morning two hours after light breakfast with empty bladder. Weighing machine was used to measure standing weight. Weight was measured to the nearest 0.1 kg. Height was recorded using a stadiometer/ measuring tape with the subject standing erect with heels together with back as straight as possible with the head positioned so that the top of the external auditory meatus is at level with the inferior margin of the bony orbit [Frankfurt's plane].

Waist to hip ratio (WHR) [20]

Table 1: WHR groups

Group Name	Category	WHR
I	Normal	<0.85
II	At Risk	>0.85

The subjects with normal weight as per the age & normal WHR (Non obese) were taken as study subjects.

4. Spirometry: The spirometry tests were conducted using an electronic PC based spirometry machine (RMS HELIOS) in the well-ventilated laboratory. All subjects underwent spirometry tests, in sitting position, using techniques recommended by the American Thoracic Society (ATS) [21] .

The subjects were asked to take maximum deep inspiration and then blow out with maximum effort into the mouthpiece of spirometer wearing a nose clip. This test was repeated 3 times, and the best value was be obtained and taken as final reading.

The parameters that were measured by spirometry were:

1. Vital capacity (VC) in litres
2. Tidal volume (TV) in litres
3. Inspiratory reserve volume (IRV) in litres
4. Forced vital capacity (FVC) in litres
5. Peak expiratory flow rate (PEFR) in litres/sec
6. Forced expiratory volume in 1 s (FEV1) in litres and
7. Forced midexpiratory flow (FEF25%–75%) in litres/sec.
8. Lung age in years
9. Ratio of FEV1 to FVC (FEV1 /FVC, expressed as a percentage)

Pulmonary function tests:

Pulmonary function tests were performed on PC based spirometer (RMS HELIOS). The spirometer calibration was done regularly to ensure accuracy. Equipment requirements, performance criteria,

validation, quality control, calibration of instrument, participant preparation and measurement maneuvers were all in accordance with American Thoracic Society statement of standardization of spirometry [12, 22, 23, 24]

Sterile mouthpieces, single time use; were used.

Participants were instructed-

1. Not to have any heavy meal 2 hours before the test.
2. Not to perform vigorous exercise before 30 minutes of tests
3. To loosen tight clothing and waist belt
4. To seal the lips around the mouthpiece
5. To close nostrils with thumb and index finger during recording.

Name, age, sex, date of birth, height, weight and race of the participants were entered in computer. BMI was recorded. Based on National Health and Nutrition Examination Survey (NHANES) III reference equations predicted values of lung volumes and capacities were automatically calculated in the spirometer. Tests were performed in the afternoon as flow rates are more in this period [25, 26]. Participants were first explained about the test procedures and demonstrated the correct techniques of FVC and SVC maneuvers. Each participant was given two trials to get familiarized with the instrument and allay anxiety. According to the norms given by American Thoracic Society three satisfactory efforts were recorded for each participant and the highest measurements among three technically acceptable and reproducible manoeuvres were expressed at body temperature and pressure saturated with water vapour [12,19,20,21]. These results were entered in the Microsoft office EXCEL for further analysis. Participants were coaxed to give maximum efforts for all 3 tests. FVC, SVC manoeuvres were recorded as follows –

1. Forced Vital Capacity (FVC) :

Participants were seated upright, looking straight ahead, and instructed to hold the mouthpiece tightly to prevent air leaks. The instrument's zero flow was confirmed, and the "start" test command was initiated on the computer. To avoid air leakage through the nostrils, the nose was pinched or secured with a nose clip during the recording. Participants began with normal breathing through the mouth, followed by maximum inspiration and forced expiration until no more air could be exhaled, all while maintaining an upright posture [19]. This process generated flow-volume curves. Once completed, the nose clip was removed, allowing participants to resume nasal breathing. The computerized spirometer confirmed the "end of test" criteria, and the absolute values of FVC, FEV1, and FEF max were recorded.

2. Slow Vital Capacity (SVC):

Participants were seated upright, looking straight ahead, and instructed to hold the mouthpiece tightly to prevent air leaks. After confirming zero flow on the instrument, the "start" test was initiated on the computer. To prevent air leakage through the nostrils, the nose was pinched or secured with a nose clip during the recording. The maneuver was performed in a relaxed manner, except near end-inspiration and end-expiration [19]. Participants began with normal mouth breathing, during which four tidal breaths were recorded, followed by maximum inspiration and slow, prolonged expiration. Once completed, the nose clip was removed, allowing participants to resume nasal breathing. The computerized spirometer confirmed the "end of test" criteria, and the absolute value of IC was recorded.

Statistical Analysis

Data were entered in Microsoft Office Excel and analyzed using the Statistical Package for Social Sciences (SPSS) version 16. Data is expressed as Mean ± Standard deviation.

Parameters measured by Spirometry from the two groups and demographic data was compared using Students Unpaired ‘t’ test.

Data of FEV1 to FVC ratio (expressed as percentage) from two groups was compared using Mann Whitney U Test.

P value of < 0.05 was considered as significant.

Results

Group I – exposed women

Group II- non exposed women

Table 2:

Demographic Data	Group I (Mean + SD) (n = 50)	Group II (Mean + SD) (n = 50)	p value
Age (years)	31.44	29.48	0.0829
Weight (kg)	59.3	60.86	0.1348
Height (cms)	157.44	157.76	0.1058
Waist Circumference	78.6	80.36	0.2414
Hip Circumference	103.66	105.7	0.2589
Waist Hip Ratio	0.75	0.75	0.934

***Analysis of demographic data does not show any statistically significant difference**

Table 3:

Parameter	Group I	GROUP II	p Value
Vital Capacity (Ltrs)	1.94±0.42	2.53±0.6	*p=0.0119
Tidal Volume (Ltrs)	0.77±0.32	1.61±0.2	*p=0.0014
Inspiratory Reserve Volume(Ltrs)	0.45±0.2	1.46±0.31	*p=0.0036
PEFR(ltrs/sec)	3.1±1.07	6.64±1.48	*p=0.0287
FEV1(ltrs)	1.85±0.49	2.14±0.34	*p=0.0113
FVC(ltrs)	2.24±0.6	2.45±0.41	*p=0.0488
FEF (25-75%) (ltrs/sec)	1.53±0.5	2.55±0.69	*p=0.0264
Lung Age(yrs)	43.72±12.61	31.48±6.45	*p<0.0001

*** P value < 0.05 is significant**

Table 4:

Parameter	Group I	Group II	P Value
FEV1/FVC	0.83±0.11	0.88±0.06	*p=0.0499

*** P value < 0.05 is significant**

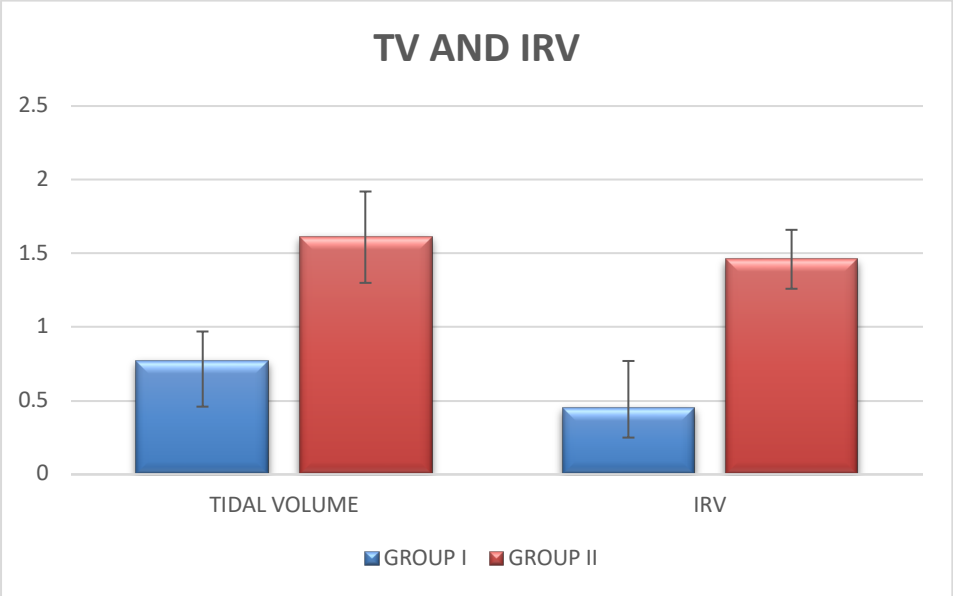

Figure 1: comparison of tidal volume and inspiratory reserve volume

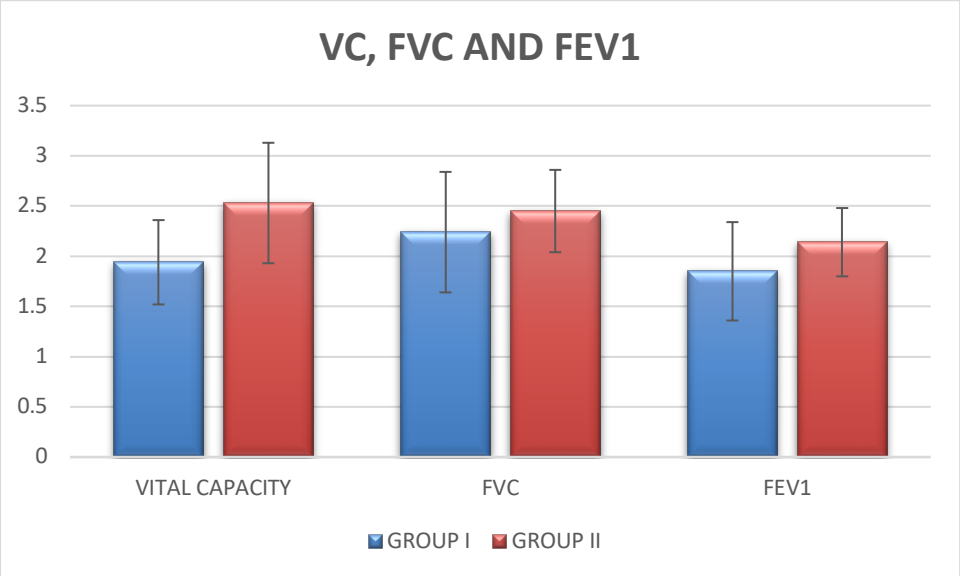

Figure 2: Comparison of vital capacity, forced vital capacity and forced expiratory volume in 1st second

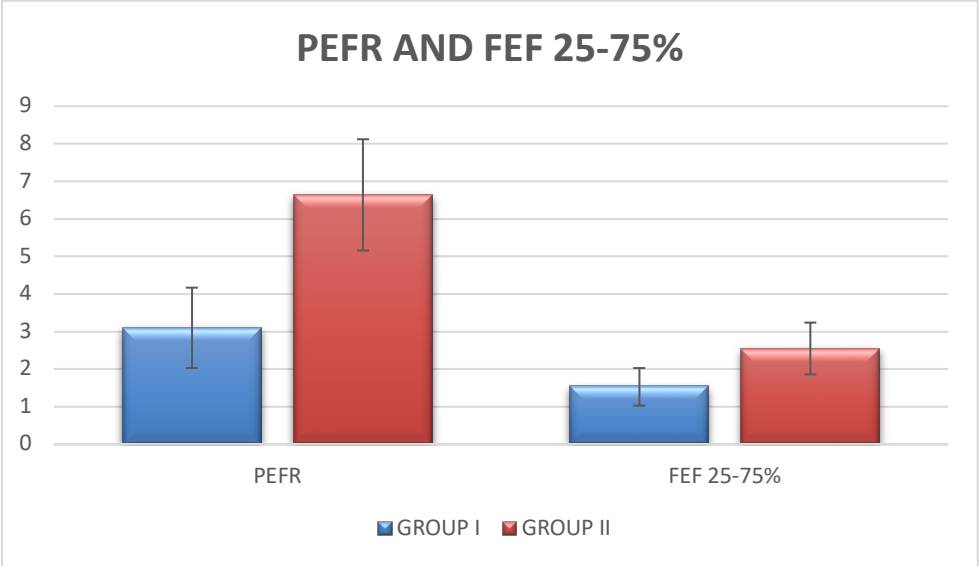

Figure 3: comparison of peak expiratory flow rate and forced expiratory flow (25-75%)

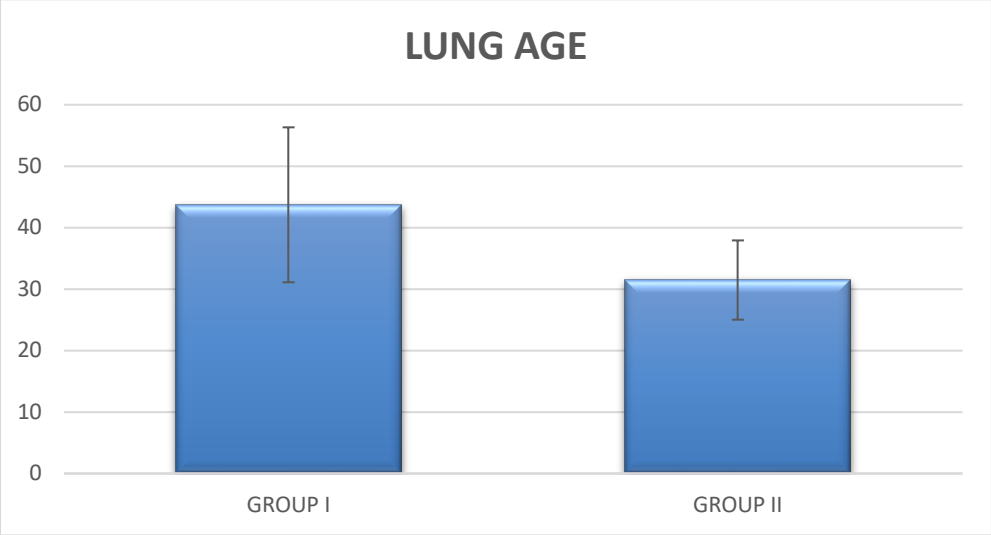

Figure 4: comparison of lung age

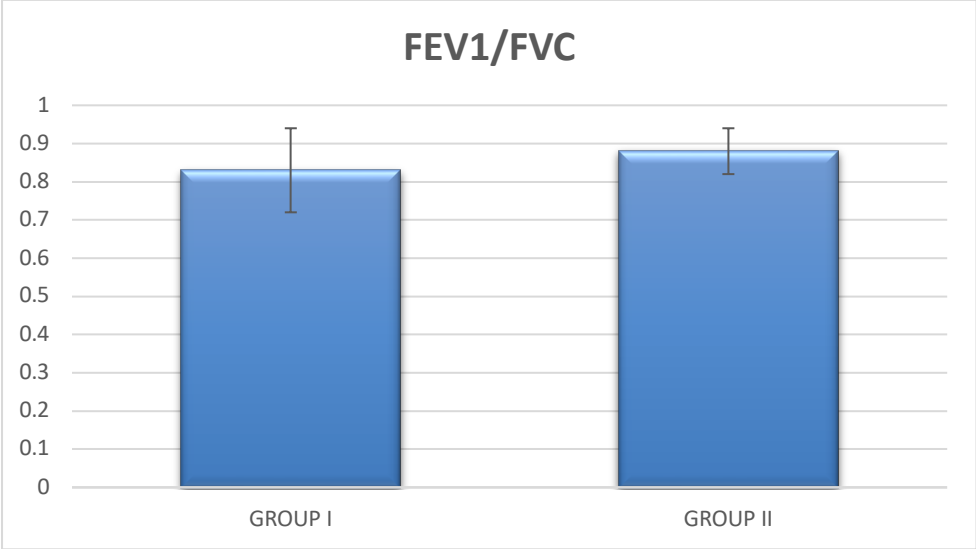

Figure 5: comparison of FEV1/FVC

Discussion

Air pollution and respiratory dysfunction are recognized as important causes of morbidity and mortality [27]. In developing countries like India, industrialization and urbanization created more opportunities for employment in urban areas leading to increased urban population. This situation leads to increased work load on tertiary health care centres and their laboratories which already receives considerable load of referrals from lower health care centres. Few of the main challenges confronting public hospitals are deficient infrastructure, deficient manpower and unmanageable patient load. [28] This fact forces lab technician to work in a small areas and increased their exposure to considerable chemical environment of laboratories where they have to work in day and night.

Study population considered in our study was from hematology, microbiology, biochemistry, surgical pathology and histology laboratory. Some of the chemicals and reagents used in these laboratories include acetic acid, antiserums, buffers, chloride, diluents, ethanol, sodium hypochloride, nitric oxide, sulfuric acid, and many reagents such as hematology, immunofixationphoresis, phenobarbital, phenytoin, ammonium etc. This is as per the list we got from these laboratories. Working technicians exposed to these chemicals via skin, sometimes accidental ingestion but through respiratory system all the times during their work schedule. They have to work many times beyond their schedule to clear the work load.

Formaldehyde and xylene are common hazards in histology and pathology laboratories. [29] Chemicals like formalin, glutaraldehyde, ammonia, chlorine which cannot be considered as an ideal chemical, causes respiratory dysfunction amongst students / support staff / laboratory technicians in anatomy dissection halls, testing laboratories, operation theatres etc. [30] According to the Global Initiative for Chronic Obstructive Lung Diseases, chronic obstructive pulmonary disease (COPD) is a common, treatable, and preventable illness marked by ongoing respiratory symptoms and restricted airflow brought on by abnormalities of the airways and/or alveoli, which are typically brought on by prolonged exposure to harmful particles or gases. [31] Occupational exposures - including chemical agents and fumes, are under-appreciated risk factors for COPD. [32] Chronic obstructive pulmonary disease is easily detected in its preclinical phase, using office spirometry and improvements in spirometry software have made it much easier to obtain good quality spirometry test sessions, thereby reducing the misclassification rate. [33,34,35] A joint document sponsored by two international pulmonary medicine organizations, both the American Thoracic Society (ATS) and the European Respiratory Society (ERS), as well as the Global initiative for chronic obstructive lung disease guidelines indicate that spirometry is necessary for the diagnosis of COPD. The ATS/ERS standards advocate performing spirometry in all persons with a history of exposure to environmental pollutants. [36] Spirometry is a noninvasive, readily available, most reproducible and objective measurement of airflow limitation but in spite of its good sensitivity, peak expiratory flow measurement alone cannot be reliably used as the only diagnostic test because of its weak specificity [37]

It is thus evident that modern computer spirometry is a simple, easy and convenient method of evaluating respiratory disorder in young adult who are exposed to the environmental hazards. We found negligible studies about the effect of laboratory chemicals on respiratory system. So the present study was undertaken with main question in mind, what alterations take place in respiratory system of young adult upon exposure to laboratory chemicals with the help of modern spirometry. Most of the technicians working in these labs are females between the ages of 20 to 40 yrs, so they were taken as study population. Though the pattern of abnormality in pulmonary function tests indicates the type of problem, no single test can evaluate all aspects of pulmonary function. [35] Hence multiple parameters of pulmonary function tests were selected for the study.

In the present study Mean + SD for FVC was observed to be 2.24±0.6 liters in group I and 2.45±0.41 liters in group II. Values were less in exposed group and the difference was statistically significant (p value = 0.0488). FVC is maximum volume of air which can be exhaled during a forced (FVC) maneuver. FVC serve little purpose as an independent measure of pulmonary function, they can be of much value when considered in conjunction with the result of other tests. FVC is an indirect measure of the flow and resistive properties of the lungs. [38] FVC normally equals to the Slow Vital Capacity(SVC) and it is also the measure of the lung volume. Statistically significant difference for FVC was observed in the present study probably suggests that lung volumes and other properties of the lungs were influenced by exposure to lab chemicals.

Mean + SD for forced expiratory volume in first second (FEV1) was observed to be 1.85±0.49 liters in group I and 2.14±0.34 liters in group II. Values were less in exposed group and the difference was statistically significant (p = 0.0113). The volume of air exhaled in the first second of maximal expiration following a complete inhalation is known as FEV1. FEV1 is highly diagnostic of

obstructive disease. Determinants of FEV1 are factors determining flow, such as lung recoil and airways resistance upstream of a flow limiting collapse point. [38] Statistically significant difference was observed in the present study probably suggest that airway status of bronchopulmonary tree was affected by exposure to lab chemicals.

Mean + SD for FEV1/FVC was observed to be 0.83±0.11 in group I and 0.88±0.06 in group II. Values were less in exposed group and the difference was statistically significant (p=0.0499). FEV1/FVC indicates what percentage of the total FVC was expelled from lungs during the first second of forced exhalation. It gives an idea about overall resistance to air movement from the lungs and expiratory power for forceful expiration. FVC, FEV1 and FEV1/FVC% decide whether the disorder is obstructive or restrictive. FEV1/FVC < 70 % where FEV1 is reduced more than FVC signifies an obstructive defect and FEV1/FVC > 70% where FVC is reduced more than FEV1 is seen in restrictive defects. [39,40] Although in present study, mean FEV1/FVC % was above 70% in both the groups, but the exposed group had statistically significant lesser values. This result probably suggests that airway status of bronchopulmonary tree was affected by exposure to lab chemicals.

Mean + SD for SVC was observed to be 1.94±0.42 liters in group I and 2.53±0.6 liters in group II. Values were less in exposed group and the difference was statistically significant (p=0.0119). Test eliminates the bronchoconstriction that usually accompanies a strong forced expiratory effort as in FVC manoeuvre and help to decide whether the low FVC is due to obstructive or restrictive process. [41] In the present study difference between group I and group II for VC was statistically significant. So the study suggests that lung volumes and airways were influenced by exposure to lab chemicals.

Mean + SD for tidal volume (TV) was observed to be 0.77±0.32 liters in group I and 1.61±0.2 liters in group II. Values were less in exposed group and the difference was statistically significant (p=0.0114). This is the volume of air that moves in and out of lung during inspiration or expiration of normal respiratory cycle. Mean + SD for Inspiratory reserve volume (IRV) was observed to be 0.45±0.2 liters in group I and 1.46±0.31 liters in group II. Values were less in exposed group and the difference was statistically significant (p=0.0036). This is the volume of air that can be maximally inspired after a normal inspiration.

IRV and TV are calculated from SVC test maneuver. These are static lung volumes measured by method in which the velocity of the gas plays no role and indicates status of lung size and capacity. Values of IRV along with other reserve values reflect the balance between lung and chest wall elasticity, respiratory muscle strength, and thoracic mobility. [42] Significantly decreased TV and IRV in exposed group indicate that lung elasticity and mobility might get affected by exposure to lab chemicals. However these findings may require further evaluation.

Mean + SD for PEFR was observed to be 3.1±1.07 liters per second in group I and 6.64±1.48 liters per second in group II. Values were less in exposed group and the difference was statistically significant (p=0.0287). PEFR is dependent on the upper airway condition and the expiratory efforts made during forceful expiration. PEFR reflects mainly the caliber of the bronchi and larger bronchioles, which are subjected to reflex bronchoconstriction. [43]

Mean + SD for FEF 25-75 was observed to be 1.53±0.5 liters per second in group I and 2.55±0.69 liters per second in group II. Values were less in exposed group and the difference was statistically significant (p=0.0264). The flow rate over the middle half of FVC is represented by FEF 25–75, which is an effort-independent flow rate.

Specifically FEF25-75 has been recommended to identify small airway diseases. [44] Small airways contribute to about 20% of airway resistance. Considerable degree of small airway disease may go unnoticed if values of FEV1 % and MVV are normal. [45] Several study in the recent and past have shown that small airways obstruction plays an important role in asthma and abnormalities of small airways function precede the abnormalities of the large airways function. [46] In present study PEFR and FEF25-75 were significantly decreased in subjects exposed to lab chemicals suggesting that upper as well as small airways might be affected due to exposure to lab chemicals.

Thus positive relationship between inhaled chemical exposure and decreased pulmonary function was supported by our data. The results of our study were in concordance with the results of other studies which had shown effect of chemicals on respiratory system.

Banoo Hajra et al. demonstrated that medical students exposed to the toxic substance formalin during anatomy dissection experienced a reduction in lung functioning and occupational hazards. [47]

A.A. Mohammad pour and M. Maleki showed the decreased pulmonary function tests in males as well as female students after short exposure to formaldehyde in veterinary anatomy dissection. [48] P. Uthiravelu et al. found mixed disordered that is obstructive as well as restrictive in formalin exposed subjects who were exposed to chemical

since five or more years. They have also shown a negative correlation between pulmonary function with degree and duration of exposure to formalin. [49] Masoud Neghab et al. showed that occupational exposure to low level of ammonia is associated with decreased lung's functional capacity and effect was chronic irreversible and acute reversible in nature. [50] Rahman MH et al. got the association between high level of ammonia exposure and prevalence of respiratory symptoms in the urea factory. They also got the acute decline in lung functions in those subjects. [51]

Ali BA et al. showed a significant reduction in pulmonary function in workers chronically exposed high levels of ammonia. These findings were suggestive of combined restrictive / obstructive ventilatory defect. [52]

Boskabady MH et al. got reduced pulmonary function tests values among lifeguards who were exposed to chlorine. Their study also showed the higher frequencies of work related respiratory symptoms and allergic symptoms particularly during their work period. [53]

Clark KA et al. studied the effect of accidental inhalation of chlorine gas using pulmonary function tests and got significant reductions in lung function immediately after the accident. They also got significant decline in FEV1 in some of the affected as a long term effect of accident. [54]

Yoon HI et al. showed significantly lower values of FEV1, FEV1/FVC and FEF 25-75% in the elderly subjects who were exposed to volatile organic compounds such as toluene and xylene [55]

Waters A et al. noticed significant cross-shift reductions in FVC and FEV1 in health care personnel exposed to glutaraldehyde at their work place. Even dose response relationship was not seen for the results noted. [56] Gary W. Hoyle and Erik R. Svendsen stated in their study that, accidental exposure to chlorine causes acute lung injury in which symptoms are ranging from dyspnea to pulmonary oedema. Persistence of these symptoms was observed in some cases after recovery from chlorine injury. [29]

The lung age concept was initially developed by Morris and Temple to express spirometry results in an easily understandable manner in order to encourage patients to change their smoking behavior. [57] Lung age/Chronological age index was also used as an indicator of clinical improvement or severity in asthma patients. [58] In the present study Mean + SD for lung age was observed to be 43.72±12.61 years in group I and 31.48±6.45 years in group II.

Values were more in exposed group and the difference was statistically significant ($p < 0.001$). On the contrary mean chronological age of exposed group was 31.44 years and non-exposed group was 29.48 years. This was the unexpected finding in our study as lung age was more in both the groups than their chronological age. But the gap between chronological age and lung age in exposed was huge than non-exposed group indicating decreased lung function in exposed group. All the participants of our study were healthy and free from respiratory diseases. Keeping all other factors same in both the groups; it appears that inhaled chemical exposure during hospital laboratory work results in detrimental effects on static lung volumes as well as flow rates amongst exposed group. Decreased pulmonary functions can lead to increase of infections [59], increase in respiratory symptoms [60], acute exacerbations of COPD [61], onset of asthma, more hospitalizations and increased respiratory mortality. [62]

In our study, the results are not pertaining to a single chemical in any particular laboratory setting. Results were cumulative effect of multiple chemicals and reagents used in medical laboratories. Possible explanation for causes of these results was difficult to explain. Regular inhaled chemical exposure for prolonged periods causes bronchial irritation and brochoconstriction of respiratory tracts [63]. During practice of forced breathing, lungs and chest were inflated and deflated to the fullest possible extent and muscles work to their maximum capacity. [64] Lung inflation near to total lung capacity is a major physiological stimulus for the release of lung surfactant and prostaglandins into alveolar space, which increases lung compliance and decreases bronchiolar smooth muscle tone, respectively [65].

These physiological functions of respiratory system might be getting hampered in lower volumes and flow rates which we observed in exposed population. Chemicals such as toluene and xylene exacerbating oxidative stress and exert a harmful effect on pulmonary function. [55] Animal studies have proven that glutaraldehyde, a low molecular weight agent, may induce an immunologic response or cause a direct injury with low grade chronic airway injury. [66, 67] Chlorine inhalation causes acute lung injury and persistent small airway disease in animal model [68] all these studies had shown that chemical exposure causes reduced volume causing decreased physiological function of respiratory system, bronchial irritation, immunological response, oxidative stress and lung injury resulting in decreased lung function.

Although there aren't many occupational chemical injuries, case studies have shown that these injuries can result in death or lasting impairments. Participation of public health department and training workers about preventive measures can minimize occupational chemical injuries. [69] The present study suggests that effect of different

individual laboratory chemicals on respiratory functions should be studied. Our study also highlights the need of preventive care if required by individual laboratory worker and policy maker. Study also highlights the need for performing pulmonary function tests of laboratory technicians before giving them employment and during their service at suitable intervals. This would be useful in early detection of any underlying respiratory dysfunction, its treatment and prevention of complications arising later in life. All these effects and highlighted needs are not only applicable to females but also applicable to male who are exposed to lab chemicals.

Limitations of this study are small sample size and confounding factors such as genetic makeup, cost of living index of the participants. We got more lung age values than chronological age in both the groups and this was may be due to effect of pollution or other confounding factors. Outdoor and indoor pollution, use of air-conditioned environment and dietary factors may be also playing role as confounding factors which we have not considered.

Conclusion

Parameters considered for comparison were TV, IRV, SVC, FVC, FEV 1, Ratio of FVC/FEV 1, PEFR, FEF 25-75 and Lung age. All the parameters were significantly decreased in females exposed to laboratory chemicals. Significant difference for FVC, FEV 1 and highly significant difference for ratio of FVC/FEV 1 between exposed and non-exposed indicated that lung volume, flow and resistive properties of bronchopulmonary tree were affected in exposed females.

Difference was also significant for static lung function tests as TV, IRV and SVC in studied groups and indicated that lung volume was affected along with lung elasticity and mobility in exposed females. But these were the findings which will require further evaluation.

Significantly decreased PEFR and FEF 25-75 in exposed group indicated that upper as well as small airways might be affected due to exposure to lab chemicals. Lung age was more than chronological age in both the groups but gap was huge for exposed females. Difference for lung age in exposed and non-exposed females was highly significant and pointed towards the decreased function.

Results were not pertaining to a single chemical in any particular laboratory setting. Results were cumulative effect of multiple chemicals and reagents used in medical laboratories. Results indicated that inhaled chemical exposure during hospital laboratory work resulted in detrimental effects on static lung volumes as well as flow rates amongst exposed group.

It was very difficult to describe the causes of these finding but bronchial irritation, bronchoconstriction of respiratory tracts occurs to regular inhaled chemical exposure for prolonged periods. (63) Studies in animals showed that chemical injury causes immunological response or lung/airway injury. (66, 67, 68)

Finding indicates towards risk factors for respiratory dysfunction in future such as asthma and could be detected early in adulthood. Study also suggested the need for regular pulmonary function testing and taking preventing measures to avoid chemical exposure in laboratory workers. This would be useful in early detection of any underlying respiratory dysfunction, its treatment and prevention of complications arising later in life.

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