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Respiratory Status of Darkroom Technicians Working in Various Radiology Departments in Harare, Zimbabwe.

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Abstract

X-ray film processing chemicals have side effects such as respiratory problems and the people handling such chemicals as part of their work may be affected. This study had the following aims: to assess the respiratory status; to measure the prevalence of respiratory symptoms amongst darkroom technicians; to establish whether their respiratory symptoms were work related or not and investigate the relationship between respiratory symptoms and factors such as work characteristics and high exposure job-tasks. A non-experimental, descriptive cross sectional study, including darkroom technicians working at 9 radiology departments in Harare was done. Data was collected by use of a questionnaire, data collection sheet and spirometry tests and analysed using SPSS version 22. More than 35% of the subjects who participated in this study were affected by film-processing chemicals as confirmed by the presentation of work-related respiratory symptoms among subjects. The prevalence of work-related respiratory symptoms, based on questionnaire responses, was 57.1% when calculated for the whole group of participants. Basing on the spirometry tests result, the prevalence of respiratory diseases was 41.2% for the whole group and 23.5% for “never smokers” only. The spirometry tests results reflected that most of the affected subjects were suffering from restrictive as compared to obstructive lung conditions. Respiratory symptoms such as nasal congestion, chest pains and shortness of breath were significantly correlated to work characteristics such as clogged floor drains and processor leakages.

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Symptoms such as sore throat and chest pains were also correlated to high exposure job tasks such as cleaning chemical spillage and unblocking a blocked processor drain. This study concludes that the prevalence of respiratory diseases and symptoms among darkroom technicians in Harare is high enough to be worth noting and therefore recommends that solutions be sought.

Keywords: respiratory status; darkroom disease; spirometry test; respiratory disease symptoms.

1. Introduction

The use of developer and fixer chemical containing such ingredients as glutaraldehyde and acetic acid respectively that are used to convert the latent image to a visible image in conventional x-ray image processing has been associated with side effects especially on those that work in the x-ray darkroom. [1, 2, 3] Glutaraldehyde, a constituent of the developer, has been reported as capable of inducing occupational asthma in users and causing nasal and pharyngeal irritation, and sore throat. [4, 5]. Acetic acid, a constituent of the fixer, may cause a runny nose, sore throat, cough or chronic bronchitis in cases of long-term exposure [6] while sulphur dioxide, a by-product of the sulphites found in both the developer and fixer, has been discovered to cause a persistent cough. Chronic exposure to sulphur dioxide may also result in bronchospasms [3].

Darkroom disease which has been defined as a term which describes a number of health conditions and symptoms in radiographers and darkroom technicians that are as a result of handling film-processing chemicals. [7]. Such symptoms include sore throat, nasal discharge, catarrh, shortness of breath, chest tightness, dermatitis, severe headaches, fatigue and tinnitus [8]. Several studies have reported such symptoms in professionals exposed to those chemicals. [9, 10]. Even though there are preventative measures put in place to reduce exposure to fumes from these chemicals, Teschke and colleagues reported the presence of darkroom disease symptoms in subjects even though concentrations of contaminants were below the occupational exposure limits [11].

Despite the advances in technology, most radiology centres in Harare are still employing the use of developer and fixer chemicals for x-ray image processing. Respiratory effects associated with handling and using film-processing chemicals among radiographers have been assessed in other countries like The United Kingdom and Canada. [10, 12]. B ethnic differences and differences in living and working conditions, made it necessary to conduct such studies amongst Zimbabwean radiographers and darkroom technicians. The presence of darkroom disease among darkroom technicians in Harare, as noted by such factors as respiratory problems has been reported before [13]. However, the presence and extent of the respiratory problems was not confirmed through pulmonary function tests.

This article reports on a study that sought to assess the respiratory status, prevalence of respiratory symptoms amongst darkroom technicians and whether their respiratory symptoms were work related. The relationship between respiratory symptoms and such factors as work characteristics and high exposure job-tasks is also reported. The study focused on only darkroom technicians because in this set-up, they handle film-processing chemicals to a greater extent than radiographers.

2. Methods and Materials.

2.1 *Participants*

This was a non-experimental research design with the study being a descriptive, cross-sectional and quantitative study. The study population consisted of darkroom technicians working in the radiology departments at three central hospitals and six private radiology centres. The population of darkroom technicians in Harare is small; hence they were all enrolled in the study.

2.2 *Data Collection*

A total of 23 self-administered, hand distributed questionnaires, each with 36 closed questions set to collect information on such factors as participant demographics, health and smoking history, respiratory symptoms and level of contamination and exposure were used to collect data. A darkroom checklist for processor and darkroom characteristics was also used. A MicroGP spirometer, which is a compact, battery operated, fully portable, digital spirometer, was used to measure the volume of air that can be breathed in or out and also the speed with which the air is blown out in order to assess the condition of the lungs and also diagnose various pathological lung conditions as described by Miller, 2005 [14]. The MicroGP spirometer used in this study is a flow-type spirometer which measures how quickly air flows past a detector and then derives the volumes by electronic means [15] and compares these against reference/predicted values which are based on healthy subjects and are pre-set in the machine.

During the testing process, the spirometer was first adjusted to the subject's gender, age, height and ethnicity. The subject was then asked to take in the deepest breath possible through their mouth to fill their lungs. After that he or she was then asked to breathe out into the spirometer through a sterile mouthpiece as hard, fast and completely as they could. This was repeated four times and values for the forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1) and FEV1 to FVC ratio at BTPS (body temperature and pressure with saturated water vapour) for each trial were noted. The values were expressed in litres and then as a percentage of the predicted values. The best trial, which was defined as the largest FEV1 and largest FVC, was then used to assess the respiratory status of the subject by comparing the values obtained against the normal predicted values (Miller et al, 2005). FVC is the maximal volume of air exhaled with maximally forced effort from a position of maximal inspiration. It is expressed in litres at body temperature and ambient pressure (BTPS). FEV1 is the volume air exhaled in the first second of a forced expiration from a position of full inspiration, expressed in litres at BTPS (Miller et al, 2005). %FVC, %FEV1 and %FEV1%/FVC values obtained from the spirometer were used to deduce whether the subject's results were normal or not. These values are a result of calculating the values obtained for the FVC or FEV as a percentage of the expected value for a healthy person of the same gender, age, height and ethnic origins. Normal values for %FVC and %FEV1 were taken to be those which were greater or equal to 80% whereas for %FEV1%/FVC, values greater than 70% were regarded as normal. Spirometry tests were performed on 17 subjects who consented to taking part in these tests. A spirometer was used for collecting data on the lung function of the darkroom technicians as it was the only instrument for performing pulmonary function tests that was easily accessible to the researcher.

2.3 *Data analysis*

Data obtained from questionnaires was coded using numbers and entered and analysed using SPSS version 22. For the respiratory status of the darkroom technicians was spirometry test results of FEV1≥ 80% and FVC≥70% were taken to represent the absence of respiratory problems while values lower than these reflected respiratory problems of varying degrees. Using the questionnaire, subjects who answered affirmatively to experiencing any of the various respiratory symptoms were regarded as having respiratory problems while those who answered negatively were regarded as not having any respiratory problems.

Work relatedness of the symptoms was assessed through questions and only in cases where symptoms were confirmed to be better when away from work, were the symptoms taken to be work-related. Both spirometry test and questionnaire data was used to calculate prevalence of respiratory diseases by comparing the number of participants with and without respiratory diseases and expressing as a percentage of the total study sample. The respiratory status of the darkroom technicians who frequently carried out high exposure job tasks (e.g cleaning chemical spillage, freeing a film jam and unblocking a clogged processor) was compared to that of those who carried out less of those tasks. Correlation analyses were also performed in order to find out the degree of association between the respiratory symptoms and the job tasks. Workplace characteristics were defined as the presence of well-functioning ventilation systems, the effectiveness of the drainage systems, processor leakages, length of working hours per day and the number of years in the profession. The respiratory status of the participants who were subjected to workplace characteristics that increase their exposure to chemical fumes was compared to that of those getting lower exposures. Correlation analyses were also conducted to investigate if any correlations existed between the symptoms and the work characteristics.

Since this study was conducted on a small group of darkroom technicians based in government hospitals and private practices in Harare, the data collected is only valid for the darkroom technicians working at these centres. The Cronbach’s alpha, which is a coefficient of internal consistency, was used as an estimate of the reliability of the questionnaire. The Cronbach’s alpha for the questionnaire was 0.882. This study was conducted after ethical clearance from the Joint Parirenyatwa and College of Health Sciences Ethics Committee (Approval number – JREC/102/13)

3. Results

Twenty one out of 23 questionnaires were completed, giving an overall participant response rate was 91.3%, 28.6% of which were female and 71.4%were male. 23.8% of the darkroom technicians who participated in this study had a work experience of 0-5years, another 23.8% had worked as darkroom technicians for 6-10 years, 19% had a work experience ranging from 11-20 years and the remaining 33.3% had been employed as darkroom technicians for more than 20 years.

Sneezing was the most commonly experienced symptom as whereas chest tightness, a runny nose and catarrh were the least experienced. Symptoms were only considered to be work-related if the subject confirmed that the symptoms were better whilst away from work and work-relatedness of the symptoms are presented in Figure 2.

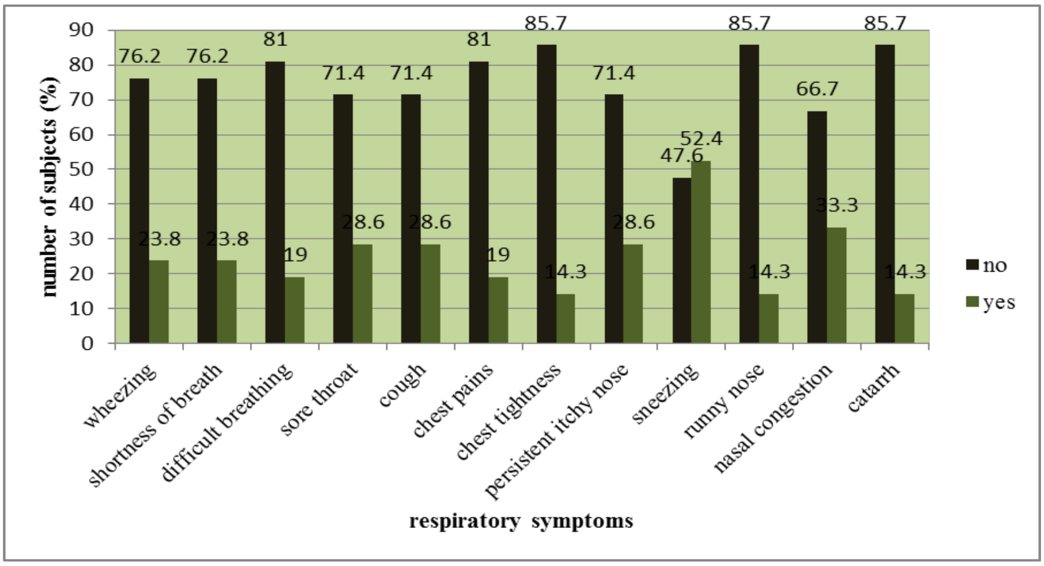

Fig. 1- Distribution of respiratory symptoms amongst subjects

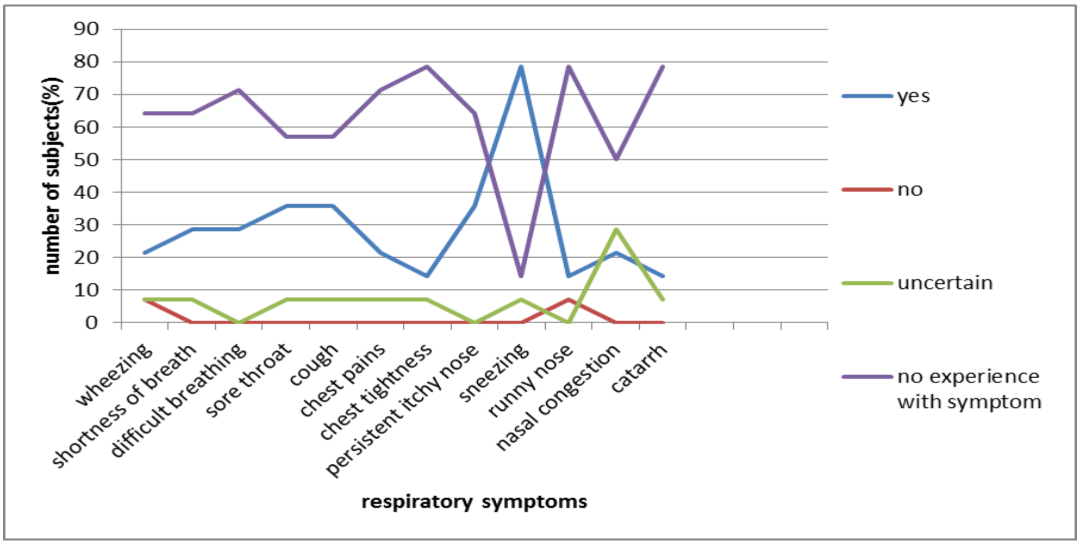

Fig. 2- Opinion on work-relatedness of symptoms among subjects who reported experiencing various respiratory symptoms.

The influence of other factors apart from processing chemicals was evaluated and stratified data analysis was carried out to improve the accuracy of the investigation. Participants were classified into those who had no history of smoking, no prior respiratory diseases before being employed as darkroom technicians and no family history of asthma (the pure sample), those who had a history of smoking, those who had a family history of asthma and who had respiratory problems prior to being employed as darkroom technicians. Results of the various classifications are presented in Table 1.

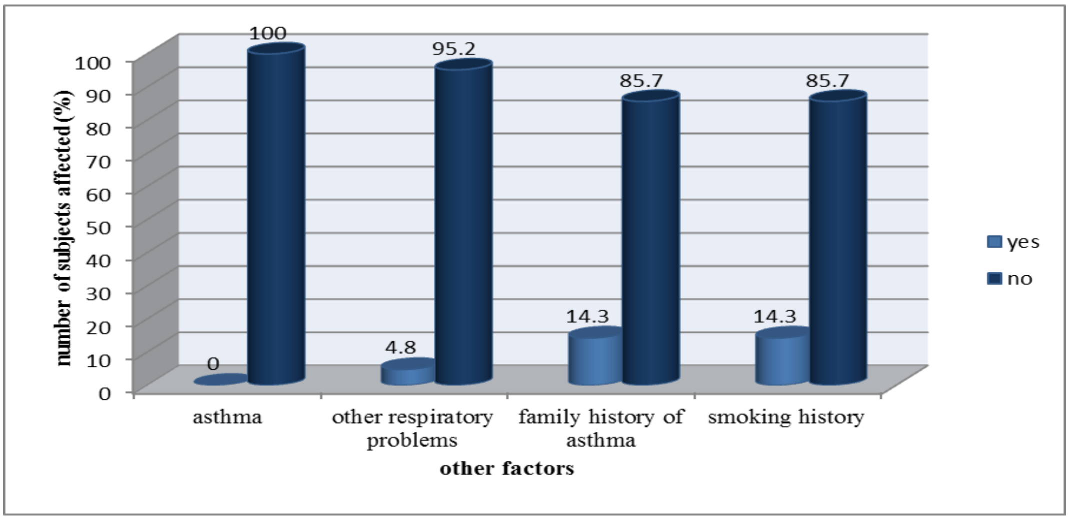

Fig. 3- Other factors that could have influenced the respiratory status of the participants.

Table 1 shows that out of the 17 participants on whom spirometry tests were done, 41%(n=7) and 35.3%(n=6), had %FEV1 values less than 80 and %FVC less than 70 respectively.

Workplace characteristics such as general ventilation systems, local exhaust ventilation, processor leakages, drainage systems, work experience and length of working hours, were used to gauge the level of exposure to chemical fumes that the darkroom technicians were subjected to. Correlations analyses were done to test for a relationship between workplace characteristics and work related respiratory symptoms and also between workplace characteristics and general respiratory symptoms. Clogged floor drain had a statistically significant positive relationship with both work-related respiratory symptoms [r=0.642, p=0.002] and general respiratory symptoms [r=0.472, p=0.031]. Considering the specific symptoms and workplace characteristics at 0.05 level of significance, clogged floor drains were significantly correlated to chest pains [r=0.592, p=0.005] and nasal congestion [r=0.653, p=0.001]. Processor leakage was significantly correlated to nasal congestion [r=0.555, p=0.009], chest pains [r=0.496, p=0.022] and shortness of breath [r=0.439, p=0.047]. Windows were significantly correlated to nasal congestion [r=-0.555, p=0.009], shortness of breath [r=0.439, p=0.047], cough [r=0.496, p=0.022] and wheezing [r=-0.158, p=0.034] whereas number of working hours was only significantly correlated to wheezing [r=-0.636, p=0.002]. The frequency of carrying out high exposure tasks which result in the generation of aerosols or vapours from chemical solutions such as cleaning chemical spillage, freeing film jams and unblocking blocked processor drains was also used as a measure of the extent to which the darkroom technicians are exposed to chemical fumes. Overally, the relationship between general or work related respiratory symptoms and the high exposure tasks (jobs) was not statistically significant. However, on a more specific note, cough and spillage clean up were correlated [r= 0.536, p=0.012], as shown by a 2-tailed Pearson's correlation analysis. Spillage clean-up was also positively correlated to sore throat [r=0.434, p=0.049]. Unblocking blocked processor drains was also significantly and positively correlated to chest pains [r=0.444, p=0.004].

Table 1- Respiratory system outcomes among subjects as per classification.

		Outcome				
Category	**Participant Reference Number**	**General respiratory symptoms**	**Work-related respiratory symptoms**	**[1]%predicted FVC**	**[2]%predicted FEV1**	**[3]%predicted FEV1%/FVC**
A	1	6	6	65	79	120
	2	0	0	100	113	122
	3	5	4	87	56	64
	4	4	2	90	101	111
	5	12	12	59	72	118
	6	1	0	89	92	93
	7	0	0	83	87	104
	8	0	0	102	95	92
	9	1	0	72	73	97
	10	0	0	80	84	98
	11	4	4	.	.	.
	12	2	2	.	.	.
	13	1	1	.	.	.
	14	1	1	.	.	.
B	15	7	6	95	116	122
	16	9	5	61	63	101
	17	0	0	84	82	96
C	18	5	1	66	79	118
	19	5	4	91	101	111
	20	0	0	64	66	102
D	21	0	0	87	103	118

A - those who were "never smokers" with no family history of asthma or prior respiratory problems

B - those with a smoking history

C - those with a family history of asthma

D - those with prior respiratory diseases

. No spirometry test was done on participants.

[1]***percentage of the expected value for a healthy person of the same gender, age, height and ethnic origin***

[2]***percentage of the expected value for a healthy person of the same gender, age, height and ethnic origin***

[3]***percentage of the expected value for a healthy person of the same gender, age, height and ethnic origin***

4. Discussion

The results of this research indicate presence of respiratory disease symptoms amongst darkroom technicians. The participants' questionnaire responses and spirometry tests results were used to deduce the respiratory status of the darkroom technicians. Even though presence of the symptoms varied from as much as 52.1% (sneezing) to as little as 14.3% (chest tightness, runny nose and catarrh), the fact that most of the respiratory symptoms considered in this study were present in more than 20% of the participants as shown in Figure 1 is something worth noting. Almost half of the participants in a Zimbabwean study by Chingarande et al [13] on the incidence of darkroom symptoms (which include respiratory symptoms) among darkroom technicians in Zimbabwe had work-related respiratory symptoms such as breathing difficulties and sore throat. This study however did not separate patients based on whether they had a prior history of asthma or based on their smoking status. This study was done in the same target area with more or less the same participants and an almost similar sample size. [13].

If FVC and FEV1 were greater than 80%, and FEV1/FVC was greater than 70%) then spirometry tests results were interpreted to be normal as reported in NIOSH Spirometry Training Guide 2-11, 2004. Having 41% (n=7) and 35.3% (n=6) of the participants having %FEV1 values less than 80 and %FVC less than 80 respectively also indicates presence of respiratory problems amongst darkroom technicians. A survey done to investigate the symptoms and respiratory function of endoscopy workers and their relationship to glutaraldehyde exposure revealed that 'most symptomatic workers had a non-significant trend to a lower FEV1values' [16]. Results from the current study agree with this finding. Most of the subjects who suffered from more than 5 general and more than 2 work-related respiratory symptoms had abnormal respiratory patterns as characterised by their low %FEV1 values (Table 1). Similarities between the results of these two studies could have arisen from similarities in the research design.

A comparison between results for the current study and those obtained from an analogous study by [10] revealed that the prevalence of 3 or more work-related respiratory symptoms for the current study was about 3 times higher than that for Liss' study. These differences may be accounted for by the huge differences in the sample sizes of the two studies (n=1110 in Liss' survey and n=14 in the current study). Another explanation for the difference could be that Liss' study focused on respiratory symptoms experienced within the previous 12 months whereas the current study focused on symptoms experienced over an indefinite period of time. The difference can also be accounted for by dissimilarities in working environments.

Most of the processing chemical constituents have been linked to the development of obstructive respiratory diseases. For example glutaraldehyde has been reported to cause asthma [17, 18], acetic acid has been linked to bronchitis function and sulphur dioxide to chronic obstructive pulmonary disease (Occupational Health: Recognizing and Preventing Work-Related Disease, 1995 in Byrns and his colleagues, 2000) [3]. However, in the current study restrictive abnormalities were more dominant than obstructive abnormalities.

The correlations analyses done to examine the relationship between the respiratory symptoms and workplace characteristics such as ventilation systems, processor and floor drainage systems, processor leakages, number of years in the profession and the number of working hours per day showed a strong relationship for example between clogged floor drains and both general and work related respiratory symptoms. [10] also reported workplace characteristics to be strongly associated respiratory symptoms, more importantly work related respiratory symptoms as compared to general respiratory symptoms as most of the workplace characteristics resulted in chemical exposure due to the generation of vapours or aerosols.

Correlation analyses were also done to evaluate the relationship between respiratory symptoms and high exposure job tasks such as cleaning chemical spillage, freeing film jams and unblocking a blocked processor. The association between chemical spillage clean up and both couching and sore throat that is reported in this article agrees with findings from Dimich's work which reported that symptoms such as cough, dyspnea and chest tightness were associated with cleaning chemical spillage [19]. [10] reported that cleaning spillage was mostly associated with the presentation of 2 or more work-related respiratory symptoms in individuals, This relationship has been explained in literature by the fact that chemical spillage results in volatile components of the processing chemicals such as glutaraldehyde and acetic acid being release into the air [20]. Unblocking a blocked processor was associated with chest pains. Concentrations of substances such as glutaraldehyde which usually have insignificant airborne concentrations are found in higher concentrations just above the chemical solution tanks [21] therefore because darkroom technicians come into close proximity with high concentrations of the processor chemical solutions when they try to unblock processors. Unlike what has been reported before, that freeing film jams is associated with developing two or more work related respiratory symptoms and new onset asthma [10], there was no evidence of a correlation between freeing film jams and any of the symptoms reported in this study.

5. Conclusion

This article reported results of a study that sought to assess the respiratory status, prevalence of respiratory symptoms amongst darkroom technicians, whether their respiratory symptoms were work related or not and the relationship between respiratory symptoms and such factors as work characteristics and high exposure job-tasks. The results presented and discussed show that respiratory symptoms are a problem amongst darkroom technicians in Harare. Findings reported in other studies in literature also indicate that this may not be a problem for darkroom technicians in Harare only but also for all other professional that are exposed to the chemicals discussed in this article. The result of this research, even though they raise an issue of concern amongst darkroom technicians in Harare, cannot however be generalised to people of different demographics or geographical location. It may be necessary to adopt the improvements in technology that enable x-ray imaging without use of these chemicals to process the images such as digital filmless radiography. Due to the various nature of these symptoms, a cohort study in which people exposed to these chemical as the darkroom technicians are followed over time may also be necessary.

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