Occupational health and safety in radiographic film processing in Limpopo province

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ABSTRACT

Background: Radiographic film processing chemicals contain hazardous substances which are known irritants, sensitisers, corrosives, carcinogens and endocrine disruptors. Radiology personnel have reported serious adverse health effects and some personnel have left the profession due to sensitisation to processing chemicals. Exposure is often due to lack of knowledge about occupational health risks, poor structural design, substandard personal protective equipment (PPE), and poor ventilation.

Objective: This study investigated occupational health and safety practices in conventional radiographic film processing personnel in Limpopo province, South Africa.

Methods: We conducted a cross-sectional descriptive survey in 10 conveniently sampled hospitals in Limpopo province. A self-administered questionnaire and a darkroom checklist were used to collect data on participants' demographic characteristics, types and usage of PPE, symptoms associated with exposure to processing chemicals, darkroom designs, and ventilation systems used in the darkrooms.

Results: In total, 57 radiographers and darkroom operators participated in the study. There was a shortage of PPE supplies, and the available PPE was inadequate for protection. Overall PPE usage was very high at 84.2% but the majority of participants (87.7%) reported work-related symptoms. Darkrooms were poorly designed and ventilated. There was no relationship between work-related symptoms and participants' socio-demographic characteristics. Failure to use gloves was significantly associated with fatigue (p=0.036) and severe headache (p=0.017). Symptoms were more prevalent in darkrooms where the entrance led straight into the X-ray room (p=0.000), or into offices and viewing areas (p=0.001).

Conclusion: Digital radiography will eventually completely eliminate occupational health risks associated with conventional film processing. However, because some health effects can manifest many years after exposure, monitoring the long-term health effects of exposure to processing chemicals is essential so that symptoms can be linked to occupational toxins.

Keywords: radiographers, darkroom operators, darkroom disease, radiographic film processing chemicals.

INTRODUCTION

Radiographic imaging is vital for the diagnosis and management of diseases. Modern radiographic imaging technology has advanced to digital radiography and has negated the use of chemicals to produce radiographs in many settings. However, developing countries, including Zimbabwe[1] and Nigeria,[2] continue to use chemicals for radiographic processing. In South Africa, a number of state hospitals still use chemicals, to varying degrees, as the primary means of image production, in tandem with digital imaging or as backup systems. Thus, radiographic film processing chemicals remain an occupational health risk among radiographers and darkroom operators who still use chemicals to produce radiographs.

Developer and fixer solutions contain hazardous substances which are known irritants, sensitisers, carcinogens[3] and endocrine disruptors.[4] These solutions contain glutaraldehyde, formaldehyde, hydroquinone, glycols, acetic acid, sodium sulphite, and ammonium chloride.[5] Radiographers and darkroom operators can be exposed through dermal and respiratory contact when cleaning processors, refilling chemicals, developing radiographs, and handling newly-processed radiographs.[5,6] Factors such as lack of knowledge about occupational health risks in radiographic film processing, substandard personal protective equipment (PPE), poor structural design, and inadequate ventilation, increase the risk of exposure and resultant adverse health effects.[6-8] The risk of

Radiographer receiving radiograph from the processor *Photo courtesy of Ms Botshelo Matabane*

developing health effects may also be increased by the synergistic effect of exposure to a cocktail of toxic substances within recommended occupational exposure limits which is often greater than the effect of exposure to a single toxic substance.[9] Synergistic effect is a serious challenge in radiographic film processing since safe exposure levels have not been established even though health effects have been reported when exposure was within recommended occupational exposure limits (OEL).[8,9]

The past 30 years has seen an increase in reports of Darkroom Disease (DD), a cluster of symptoms among radiology personnel associated with exposure to processing chemicals such as arrhythmia, tachycardia, headache, sore throat, sinusitis and dermatitis.[1-2,7-10] DD is a debilitating condition with a significant negative life impact.[7] People with pre-existing medical conditions and those with genetic susceptibility are more at risk as their conditions may be triggered or exacerbated at low doses of exposure to these chemicals.[9] The manifestation of DD is associated with multiple chemical sensitivity (MCS), an acquired disorder characterised by recurrent multiple symptoms in response to exposure to many toxic chemicals at low doses.[6,10] People with DD, like those with MCS, may react to low concentrations of chemicals in 'everyday' products, such as perfumes, hair products, cleaning and disinfectant products, food preservatives, and petrol and diesel fumes.[9,11]

In South Africa, about 16% of the adult population lives with some form of chemical sensitivity, and 1% with MCS.[11] In the absence of published literature on occupational health and safety in conventional radiographic film processing in South Africa, this study investigated the current state of occupational health and safety practices in conventional radiographic film processing in Limpopo province. We advocate for the control of occupational hazards in conventional radiographic film processing, and aim to create awareness while filling the knowledge gap.

METHODS

We conducted a cross-sectional descriptive survey among radiographers and darkroom operators at 10 conveniently sampled state hospitals in Limpopo province. The 10 hospitals fell into three districts, namely: Waterberg, Capricorn and Sekhukhune. Data were collected between June and July 2012, using a self-administered questionnaire and a darkroom checklist. The questionnaire was designed to collect data on participants' socio-demographic characteristics, usage of PPE, and health problems associated with exposure to film processing chemicals; while a checklist was designed to gather data on structural design and the type of ventilation system in the darkrooms. Due to possible recall bias of recurrent symptoms, the recall period for recurrent symptoms was limited to two or more episodes in the last six months.

We obtained ethical clearance from Sefako Makgatho Health Sciences University. Limpopo Department of Health granted permission to conduct the research in the province, and access into the study area was granted by hospital CEOs, clinical manager and heads of radiology departments. Participants were recruited voluntarily after obtaining their informed consent at their workplace in the morning before work began, and during tea and lunch breaks, to avoid disruption of service delivery.

Data analysis

The raw data were captured into a Microsoft Excel 2010 spreadsheet and imported into STATA 10 software for analysis. Descriptive statistics were used to summarise data and calculate the frequencies of events. We tested for associations between self-reported health problems and participants' socio-demographic characteristics, PPE usage and structural design of the darkrooms using the chi-square test.

RESULTS

Participants' demographic characteristics are presented in Table 1. In total, 57 participants, comprising 43 (75.4%) radiographers and 14 (24.6%) darkroom operators, took part in the study. Of these, 35 (61.4%) were female and 22 (38.6%) were male. More than half of the participants (57.9%; n=33) were younger than 41 years; ranging from 21 to 65 years, with a mean of 37 years (SD=12.3 years). The employment period at the current workplace ranged from 6 months to 33 years, with a mean of 12.9 years (SD=9 years).

Table 1. Participants' socio-demographic characteristics

Variable	Radiographers n=43		Darkroom operators n=14		Total n=57	
	n	%	n	%	n	%
Gender						
Male	19	33.3	3	5.3	22	38.6
Female	24	42.1	11	19.3	35	61.4
Age (years)						
21 – 30	20	35.1	0	-	20	35.1
31 – 40	12	21.1	1	1.8	13	22.8
41 – 50	5	8.8	7	12.3	12	21.1
51 – 65	6	10.5	6	10.5	12	21.1
Experience at the current workplace (years)						
< 1	4	7.0	2	3.5	6	10.5
1 – 5	21	36.2	1	1.8	22	38.6
6 – 10	8	14.0	2	3.5	10	17.5
11 – 15	3	5.3	4	7.0	7	12.3
16 – 20	7	12.3	4	7.0	11	19.3
21 +	0	-	1	1.8	1	1.8

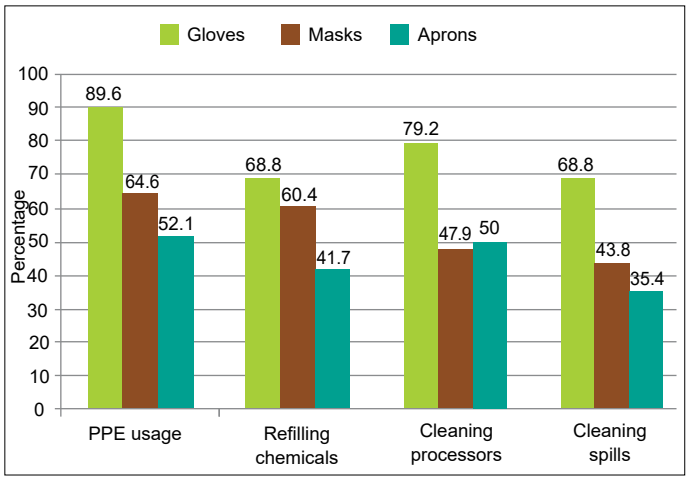

Figure 1. Overall PPE usage, and usage when performing various tasks

Personal protective equipment (PPE)

A summary of the type of PPE and its usage is presented in Figure 1. Available PPE comprised latex examination gloves, surgical masks and plastic aprons. Most participants (89.5%; n=51/57), but not all, reported that PPE was available to them and most (84.2%; n=48/57) used it. Gloves were the most commonly used PPE (89.6%, n=43/48), followed by masks (64.6%, n=31/48) and aprons (52.1%, n=25/48). PPE was used most often for cleaning processors (70.2%, n=40/48) and refilling chemicals (63.2%, n=36/48), and least for cleaning spills (59.6%, n=34/48). PPE use was higher among males (90.9%, n=20/22) than females (80.0%, n=28/35).

Darkroom design

In total, 10 darkrooms were inspected (Table 2). The entrances of the darkrooms led straight into the main corridor (20.0%), the viewing area and offices (60.0%), or the X-ray room (20%).

Table 2. Design of the hospital darkrooms (n = 10)

Variable		n	%
Entrance of darkroom	Leads straight into X-ray room	2	20.0
	Leads into offices/viewing area	6	60.0
	Leads into main corridor	2	20.0
Size of darkroom	5 – 9 m^2	5	50.0
	10 - 15.75 m^2	5	50.0
Height of darkroom	≤ 1 m above the door frame	7	70.0
	> 1 m above the door frame	3	30.0
Type of ventilation	Extractor fan	9	90.0

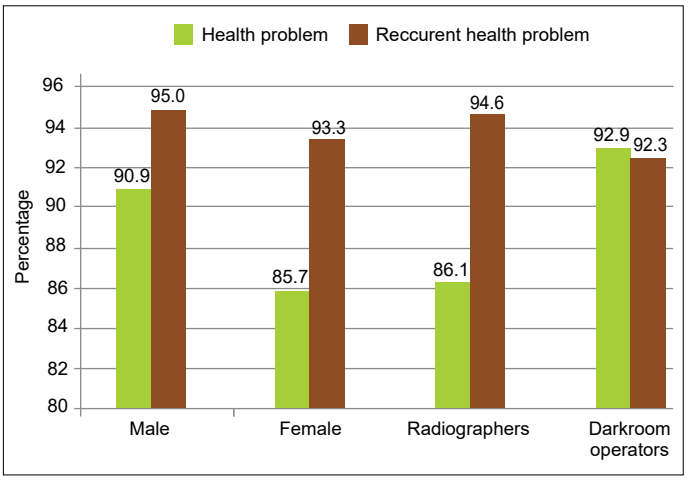

Figure 2. Summary of symptoms by gender and occupation

Ventilation was in the form of general room ventilation using an extractor fan situated either on the wall or ceiling, except for one darkroom which had only louvres on the door and walls adjacent to the X-ray rooms and no other ventilation.

Health problems associated with exposure to processing chemicals

Of the 57 participants, 50 (87.7%) reported health problems, of which 47 (94.0%) reported chronic health problems. The most frequently reported symptom was headache (58.0%), followed by persistent flu-like symptoms (56.0%) and sinus problems (56.0%) (Table 3). More males (90.9%, n=20/22) reported symptoms than females (85.7%, n=30/35) and more darkroom operators (92.9%, n=13/14) reported health symptoms than radiographers (86.1%, n=37/43), however, the differences were not statistically significant (Figure 2).

Association of health problems with sociodemographic characteristics, use of PPE and the design of the darkrooms

There were no relationships between work-related health problems and participants' socio-demographic characteristics or overall PPE use (Table 4). However, fewer participants who wore gloves experienced fatigue (n=14/43, 32.6%; p=0.036) and headache (n=18/43, 41.9%; p=0.017) than those who did not wear gloves. The majority of participants who worked in

darkrooms that led straight into offices or viewing areas experienced symptoms (n=38/39, 97.44%). This proportion was significantly higher than those working in darkrooms that led straight into the X-ray rooms (n=5/10, p=0.000).

DISCUSSION

We conducted this study at 10 of the 43 (23.3%) state hospitals[12] in Limpopo province. The high proportion of participants that reported health problems associated with exposure to chemicals used to produce radiographs despite using PPE suggests that the available PPE was substandard and did not provide adequate protection.

Occupational health regulations recommend long elbow gloves made of nitrile/neoprene/butyl rubber, and goggles or face shields, for adequate protection in the event of least exposure (rather than the latex examination gloves that were available), and masks.[3,6] However, radiographers and darkroom operators should not rely on these measures alone. Strict exposure control measures, including monitoring and compliance inspection, should be in place to protect employees from adverse health effects in conventional radiographic film processing.

Poor structural design, and substandard ventilation are common exposure risk factors which are associated with adverse health effects among radiographers and darkroom operators in conventional film processing.[5,8,13,14] The findings from this study indicate that radiographers and darkroom operators in the participating hospitals are at high risk of fume inhalation due to poor ventilation and poor structural design of the darkrooms. Chemical fumes from darkrooms, where the entrances opened straight into the X-ray rooms, offices or viewing areas, can pollute work areas that are in close proximity to the entrance of the darkroom in poorly ventilated work areas. The risk of fume inhalation during film processing and chemical air pollution necessitates that darkrooms are fitted with local exhaust ventilation (LEV) to prevent fumes from escaping into the operators' breathing zones and work areas.[6] Local exhaust ventilation provides effective exposure control in conventional film processing and can reduce exposures by up to 50%.[5,13] In the absence of LEV and indoor air monitoring, the concentration of chemical air pollutants can rise and exceed occupational exposure limits (OELs).[5]

The survey found a high prevalence of work-related health problems and provided evidence of DD symptoms among radiology personnel. The participants were aware of the symptoms they were experiencing, saying: "…wish something can be done about the smell of chemicals in the darkroom", and "…will like to know the effects and the extent of detrimental health effects of processing chemicals".

Some of the participants commented as follows: "symptoms get worse only after exposure to strong fumes", "symptoms occur during winter season", "symptoms get worse after inhaling fixer". However, only a few participants reported that their symptoms intensified at work and improved on off days, consistent with the literature. [8,13,15] It is therefore possible that many were not aware that their symptoms were work-related.

The most commonly reported symptom was headache, consistent with the results of studies conducted in other developing countries, e.g. Namibia[8], India[16] and Zimbabwe.[1] However, this finding differs from those from studies conducted in Nigeria,[2] Canada[17] and Palestine,[14] which reported respiratory symptoms as the main health problem. This might be attributed to different concentrations of chemicals used by different manufacturers in different countries.[13]

Symptoms were not associated with any of the participants' socio-demographic characteristics. However, since the participants had an average exposure of 12.9 years at the current workplace, health effects could be attributed to cumulative exposures. There was also no association between symptoms and PPE use in general. Nonetheless, there was high risk of dermal absorption of chemicals through any uncovered area of the skin. Tasks such as handling newly processed radiographs do not require wearing

Table 3. Health problems in order of decreasing frequency

Symptom	Reported symptoms n=50		Recurrent symptoms n=47	
	n	%	n	%
Severe headache	29	58.0	24	51.1
Persistent flu-like symptoms	28	56.0	22	46.8
Sinus problems	28	56.0	19	40.4
Sore throat/hoarseness	24	48.0	18	38.3
Sore eyes	23	46.0	18	38.3
Fatigue	23	46.0	21	44.7
Nasal discharge	22	44.0	11	23.4
Breathing difficulty	20	40.0	16	34.0
Nausea	18	36.0	11	23.4
Painful joints	18	36.0	15	31.9
Chest pain	16	32.0	12	25.5
Skin rash	7	14.0	3	6.4
Mouth ulcer	5	10.0	2	4.3

Table 4. Association of health problems with socio-demographic, use of PPE and the design of the hospital darkrooms

Variable		Reported health problems		p-value
		n	%	
Gender	Female (n = 35)	30	85.7	0.561
	Male (n = 22)	20	90.9	
Occupation	Radiographers (n = 43)	37	86.0	0.500
	Darkroom operators (n = 14)	13	92.9	
Design of hospital darkroom	Entrance leads into X-ray rooms (n = 10)	5	50.0	0.000
	Entrance leads into offices/ viewing areas (n = 39)	38	97.4	0.001
PPE	Use of PPE (n = 48)	41	85.4	0.221
	Use of gloves (n = 43)	37	86.0	0.500
Use of gloves and symptom	Headache (n = 43)	18	41.9	0.017
	Fatigue (n = 43)	14	32.6	0.036

Note: n in parentheses represents the no. of participants

gloves, thus dermal absorption can occur at these times, with adverse health effects.[4,9]

The reported health effects could be attributed to a synergistic effect of the different chemicals used. Safe exposure levels to chemicals used in radiographic film processing have not been established even though health effects have been reported at exposure levels below OELs over the past three decades.[9]

Study strengths

This is the first study to investigate occupational health and safety in conventional radiographic film processing in South Africa. The study has provided some evidence of symptoms of DD and adds to the existing knowledge of the burden of diseases attributable to occupational exposures to toxins among radiology personnel.

Limitations

The study was conducted at only 10 Limpopo province state hospitals, and the findings are not generalisable to the entire country. The levels of chemical exposures were not measured, so a direct link between exposures and health outcomes could not be ascertained. Symptoms and use of PPE were self-reported which could have resulted in reporting bias.

CONCLUSION AND RECOMMENDATIONS

There are poor occupational health and safety practices in conventional radiographic film processing in the state hospitals in the Limpopo province included in this study, resulting is some symptoms of DD. While modern imaging does not involve the use of chemicals to produce radiographs, conventional radiography is still widely used in Limpopo province and elsewhere in South Africa. Thus, there is a need to protect radiographers and darkroom operators who still use chemicals. There is also a need to make employees aware of occupational health risks so that they can adequately protect themselves during conventional film processing.

We recommend that occupational health services (OHS) be implemented at these hospital departments in compliance with the Occupational Health and Safety Act No. 85 of 1993 of the Republic of South Africa (amended, OSHA, 1993). We also recommend compliance with the World Health Organization's (WHO) global plan of action on workers' health to control occupational health risks in conventional radiographic film processing. These will minimise exposures and help monitor the health effects and the long-term effects of exposures. Lastly, digital imaging systems should be adopted to eliminate occupational hazards in radiographic film processing.

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DECLARATION

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this paper.

REFERENCES

1. Chingarande G, Bungu T, Mukwas C, et al. The prevalence and severity of the symptoms of darkroom disease among darkroom technicians in Harare, Zimbabwe. World J Med Sci. 2013; 8(2):113-117.
2. Okeji MC, Idigo FU, Anakwue AMC, et al. Knowledge of chemical hazards and prevalence of darkroom diseases among darkroom technicians and assistants in southeast, Nigeria. Am Med J. 2015; 6(2):27-30.
3. Occupational Safety and Health Administration. Best practices for the safe use of glutaraldehyde in health care. Washington: OSHA; 2006. Available at: www.osha.gov/Publications/glutaraldehyde.pdf (accessed 1 Jul 2011).
4. Bergman Å, Heindel JJ, Jobling S, Kidd KA, Zoeller RT, editors. State of the Science of Endocrine Disrupting Chemicals – 2012. Geneva: WHO; 2013. Available at: http://unep.org/pdf/9789241505031_eng.pdf (accessed 19 Jan 2017).
5. Teschke K, Chow Y, Brauer M, et al. Exposures and their determinants in radiographic film processing. AIHA J. 2002; 63(1):11-21.
6. Batch J, Nowlan P. Legal issues in radiography: darkroom disease. J Allied Health. 2003; 5:1-15.
7. Byrns GE, Palatianos KHC, Shands LA, et al. Chemical hazards in radiology. Appl Occ Environ Hyg. 2000; 15(2):203-208.
8. Damases C. An evaluation of sulphur dioxide fume levels and the prevalence of darkroom symptoms among radiology workers in Namibia [MTech dissertation]. Durban University of Technology; 2006. Available at: http://ir.dut.ac.za/handle/10321/40/Damases_2006.pdf?sequence=14 (accessed 19 Jan 2017).
9. Genton M. Shedding light on darkroom disease-progress and challenges in understanding radiology workers' occupational illness. Can J Med Radiat Tech. 1998; 29:60-65.
10. Killion J, Johnson J. Radiology department hazards: the cost of doing business. Eradimaging; 2006. Available at: http://www.eradimaging.com/site/article.cfm?ID=2 (accessed 19 Jan 2017).
11. Health24. Allergy. Multiple chemical sensitivity (MCS). August 17, 2011. Available at: http://www.health24.com/Medical/Allergy/About-allergy/Multiple-chemical-sensitivity-MCS-20130312 (accessed 19 Jan 2017).
12. Limpopo Department of Health and Social Development. Section 14 Manual on the Promotion of Access to Information Act (Act No. 2 of 2000 as amended). Available at: http://www.doh.limpopo.gov.za/wp-content/uploads/2014/11/paia_manual1_updated_version.pdf (accessed 19 Jan 2017).
13. Kakooei H, Ardakani MB, Sadighi A. Determinants of exposure to chemical pollutants in wet X-ray film processing in Iran. Pakistan J Biol Sci. 2007; 10(14):2341-2347.
14. Ajerami Y, Sirdah M. Effects of X-ray film processing on health status of medical radiographers at Gaza Strip, Palestine. J Al Azhar Univ Gaza (Nat Sci). 2008; 10:59-76.
15. Tarlo SM, Liss GM, Greene JM, et al. Work attributed symptom clusters (darkroom disease) among radiographers versus physiotherapists: associations between self-reported exposures and psychosocial stressors. Am J Ind Med. 2004; 45:513-521.
16. Prabhakara MPS, Lakshman RKV. Assessment of risk at workplace: A study on radiographers work practices in Vizag Steel. Indian J Occ Environ Med. 2005; 9:26-28.
17. Liss GM, Tarlo SM, Doherty J, et al. Physician diagnosed asthma, respiratory symptoms, and associations with workplace tasks among radiographers in Ontario. J Occup Environ Med. 2003; 60:254-526.
18. Republic of South Africa. Occupational Health and Safety Act [Act 85 of 1993]. Pretoria: Government Printer; 1993. Available at: http://www.labour.gov.za/DOL/downloads/legislation/acts/occupational-health-and-safety/amendments/Amended%20Act%20-%20Occupational%20Health%20and%20Safety.pdf (accessed 19 Jan 2017).
19. World Health Organization. WHO Global Plan of Action on Workers' Health (2008-2017): Baseline for Implementation. Global Country Survey 2008/2009. Executive Summary and Survey Findings. Geneva: WHO; 2013. Available at: www.who.int/occupational_health/who_workers_health_web.pdf (accessed 19 Jan 2017).