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BRIEF REPORT

Occupational exposures to hazardous chemicals and agents among healthcare workers in Bhutan

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Abstract

Background: Occupational exposures to hazardous chemicals among healthcare workers can result in long-term adverse health outcomes. Research on such exposures from low- and middle-income countries is limited. The aim of this study was to estimate the prevalence of exposures to a range of chemicals used in healthcare settings among Bhutanese healthcare workers.

Methods: A cross-sectional study was conducted among healthcare workers (n = 370) working in three hospitals in the western region of Bhutan. Demographic and occupational information was collected, and exposures to asthmagens, carcinogens, ototoxic and other agents were assessed using a web-based tool. The prevalence of exposure to these chemicals was calculated and the circumstances resulting in such exposures were examined.

Results: The prevalence of exposure to one or more asthmagen, carcinogen, and ototoxic agent was 98.7%, 28.1%, and 7.6%, respectively; and was 6.2% for anesthetic gases and 2.2% for antineoplastic drugs. The most common exposures were to latex, and cleaning and disinfecting agents in the asthmagens group; formaldehyde in the carcinogens group; and *p*-xylene among ototoxic agents. The circumstances resulting in exposures were using latex gloves, using bleach and chlorhexidine for cleaning, using formaldehyde as a disinfectant and in the laboratory, and using *p*-xylene in the laboratory.

Conclusions: The results indicate that a large proportion of Bhutanese healthcare workers are occupationally exposed to chemicals linked to chronic diseases, with exposure prevalence higher than in high-income countries. The study provides information that can be used to formulate policies and to implement control measures to protect healthcare workers.

KEYWORDS

developing country, hazardous chemicals, healthcare workers, occupational exposures, prevalence

1 | INTRODUCTION

Healthcare workers are occupationally exposed to a wide range of hazardous chemicals that can result in long-term adverse health effects.[1] Exposures to cleaning and disinfecting agents and latex have been associated with occupational asthma among healthcare workers.[2] Ethylene oxide, antineoplastic drugs, and formaldehyde have been linked to cancers such as hematological, breast, and nasopharyngeal cancers.[3–5] Exposures to anesthetic gases and antineoplastic drugs have been associated with an increased risk of spontaneous abortions and congenital anomalies.[4,6]

Research on workplace exposures has highlighted these risks leading to the institution of safety standards to protect workers.[1] However, the majority of this study has been undertaken in high-income countries and research in this area from low- and middle-income countries (LMICs) is limited.[7] A review on occupational hazards among healthcare workers in developing countries conducted in 2016 describes exposures to infectious agents, musculoskeletal injuries, workplace stress, and violence but does not mention exposure to any chemicals except for latex exposure.[8]

In Bhutan, the context of this study, occupational health and safety (OHS) is still a relatively new concept and, therefore, has not yet attained a priority status as a public health problem. Although commitment to OHS was initiated in 2007 with the enactment of the Labour and Employment Act, the implementation of OHS management is still in its infancy, with the formulation of a health and safety policy still at the drafting stage, no baseline occupational health data, and no occupational diseases surveillance systems in place.[9] As such, research into OHS issues in Bhutan is scarce. The aim of this study is to estimate the prevalence of occupational exposures to asthmagens, carcinogens, ototoxic and other agents among Bhutanese healthcare workers and to describe the circumstances that lead to such exposures.

2 | METHODS

2.1 | Study design and procedures

This was a cross-sectional study carried out during October and November 2019 in three public hospitals in the western region of Bhutan (a tertiary hospital in Thimphu and two district hospitals in Paro and Wangdue). A list of healthcare workers employed in the three hospitals was obtained from the hospital administration. Stratified random sampling was carried out based on the hospitals and job categories. Based on the assumption of a 50% prevalence of exposure to chemical hazards, with a confidence interval of 95% and a 5% margin of error, a sample size of 384 was calculated. All healthcare workers who were 18 to 60 years of age, and were currently working in any of the three hospitals included in the study were eligible to participate. Administrative personnel and traditional medical practitioners were the only job categories that were excluded from the study as these occupation groups were determined as less likely to be exposed to the chemicals examined in the study.

Data were collected using a questionnaire that was adapted from one developed by the National Institute for Occupational Safety and Health (NIOSH).[10] The adapted questionnaire was pretested in a pilot study conducted in Bhutan in April–May 2019.[11] With the assistance of key contact people within the hospitals, hard-copy questionnaires were distributed among the healthcare workers. The questionnaires were self-administered by a majority of participants. For a minority of participants ($n = 41$) who had limited English language proficiency, the questionnaire was administered as an interview in the local language. Informed written consent was obtained from all participants.

The questionnaire collected demographic information including age, gender, ethnicity, and education level. For occupational history, participants were asked about their current job title, the hospital they were currently working in, and the duration of employment as a healthcare worker. Information was also collected on the tasks that were carried out as part of the participants' current job (e.g., suturing, operating diathermy equipment, sterilizing instruments, using various laboratory reagents, working with chemicals used in dental practice such as sodium hypochlorite during endodontic treatment, cleaning the workplace, administering anesthetic gases, and compounding and administering antineoplastic drugs; Table S1). In addition, information on work practices and control measures to minimize exposures was also obtained (e.g., the use of fume hoods in the laboratory, portable smoke evacuators for the removal of diathermy smoke, closed disinfection systems for sterilization, waste gas scavenging systems for the removal of waste anesthetic gases, biological safety cabinets when compounding antineoplastic drugs, and the use of personal protective equipment such as gloves, water-resistant gowns, masks, and goggles when handling chemicals).

The data from the questionnaires were entered into OccIDEAS, a computer application that assesses occupational exposures.[12] Based on the participants' responses to questions relating to specific tasks that have been identified as potential determinants of exposure to chemicals and the use of control measures, where appropriate, predetermined algorithms were applied to determine the likelihood of exposure to various asthmagens, carcinogens, ototoxic and other agents ("no," "possible" or "probable"). These algorithms were based on evidence from published literature, material data sheets, and expert opinion.[13] For example, if they used a sterilizing agent (e.g., glutaraldehyde) and handled it manually, they were considered as exposed to the agent; but if they used a closed disinfection system for sterilization they were considered as not exposed. The "possible" exposures that were automatically assigned by OccIDEAS were manually reviewed and categorized as either probable or no exposure using all available information.

2.2 | Analysis

Each of the participants' job titles was coded using the International Standard Classification of Occupations 2008 (ISCO-08). These codes were then classified into four major occupational groups containing occupations that were broadly similar with regard to exposure to the various chemical groups (medical doctors and dentists, midwifery and nursing professionals, other health professionals and technicians which included allied health professionals/technicians such as dieticians, physiotherapists, pharmacists, occupational therapists, laboratory technicians, X-ray technicians, anesthesia technicians, dental hygienists, and community health workers, and support staff; Table S2).

All analyses were carried out using STATA 14 (StataCorp). Frequencies were calculated to describe the prevalence of exposure in the occupation groups and the tasks that were associated with the most common chemical exposure (i.e., those with the highest prevalence) in each chemical hazard group.

3 | RESULTS

In total, 370 participants completed the questionnaires and were included in the study, resulting in a response fraction of 96.4%. Participants ranged in age from 21 to 58 years (mean = 34.2 years, *SD* = 8.1) and 55.7% were female. Almost half of the sample reported having a diploma certificate (45.1%) as their highest level of education, were Tsangla in ethnicity (45.9%), and were nurses by profession (47.6%). Two-thirds (65.9%) of the participants worked in the tertiary hospital, and almost two-thirds (63.5%) of the sample reported working as a healthcare worker for ≤10 years (Table 1).

The current prevalence of exposure to at least one asthmagen was very high at 98.7% (Table 2). These healthcare workers were exposed to seven different asthmagen groups, with a majority being exposed to latex (94.6%) and cleaning and sterilizing agents (87.3%). More than a quarter (28.1%) of the healthcare workers were exposed to at least one carcinogen. Of the five different carcinogens these healthcare workers were exposed to, the most common exposures were to formaldehyde (18.7%) and polycyclic aromatic hydrocarbons (PAHs; 17.3%). The current prevalence of exposure to at least one ototoxic agent was low at 7.6%. These healthcare workers were exposed to only two ototoxic agents, and the most common exposure was to *p*-xylene (7.6%). The current prevalence of exposure to the other agents assessed was also low at 6.2% for anesthetic gases and 2.2% for antineoplastic drugs.

The most common asthmagen exposure was to latex through the use of latex gloves, of which 96.0% reported the use of powdered latex gloves (Table 3). Among healthcare workers exposed to cleaning and sterilizing agents, the most frequent exposure circumstances were using bleach (79.6%) and chlorhexidine (63.5%) to clean the workplace and using glutaraldehyde for sterilization (34.7%). The tasks associated with exposure to the most common carcinogen, formaldehyde, were using it for instrument sterilization/disinfection (72.5%) and in the laboratory (31.9%). The exposure circumstance resulting in exposure to the ototoxic agent, *p*-xylene, was using it in the laboratory.

When exposure to individual chemicals was examined among the four occupation groups, other health professionals and technicians was the only occupation group exposed to all the chemicals assessed (Table 4). Physicians were mainly exposed to latex among the asthmagens, PAHs among the carcinogens, and anesthetic agents. Nurses were exposed to almost all the asthmagens, carcinogens formaldehyde and PAHs, antineoplastic drugs, and anesthetic agents, but not to ototoxic agents. Support staff were mainly exposed to asthmagens and formaldehyde.

TABLE 1 Demographic characteristics of the sample of healthcare workers in three hospitals in Bhutan

	N = 370; *n* (%)
Gender	
Male	164 (44.3)
Female	206 (55.7)
Age (years)	
18–34	222 (60.8)
35–60	143 (39.2)
Highest level of education	
High school or less	84 (22.7)
Diploma	167 (45.1)
Bachelor degree or higher	119 (32.2)
Ethnic group	
Ngalop	81 (21.9)
Tsangla/Sharchop	170 (45.9)
Lotshampa	74 (20.0)
Others	45 (12.2)
Hospital	
Jigme Dorji Wangchuk National Referral Hospital	244 (65.9)
Paro Hospital	58 (15.7)
Wangdue Hospital	68 (18.4)
Duration of working as a healthcare worker (years)	
≤10	235 (63.5)
>10	135 (36.5)
Monthly income in ngultrums[a]	
9000–15,000	65 (17.7)
>15,000–25,000	228 (62.1)
>25,000	74 (20.2)
Occupation group	
Medical doctors and dentists	59 (15.9)
Midwifery and nursing professionals	176 (47.6)
Other health professionals and technicians	94 (25.4)
Support staff/elementary occupations	41 (11.1)

[a]1 Ngultrum = USD 0.01.

4 | DISCUSSION

This study estimated the current prevalence of occupational exposures to asthmagens, carcinogens, ototoxic and other agents among healthcare workers in three hospitals in Bhutan. The prevalence of occupational exposures among Bhutanese healthcare workers in this study was high for asthmagens (98.7%) and low for ototoxic (7.6%) and other agents (6.2% for anesthetic gases and 2.2% for antineoplastic drugs). The prevalence of exposure to carcinogens was 28.1%.

The most common asthmagen exposure was to latex. The prevalence of latex glove use among Bhutanese healthcare workers (94.6%) was much higher than that reported from high-income countries such as Australia (63%)[14] and the United States (69.7%),[2] where substitution with less allergenic alternatives has been initiated in efforts to reduce exposures. The use of powdered latex gloves, however, is still thought to be prevalent in LMICs due to resource limitations,[15] though actual figures are not available for comparison. There has not been much research on occupational asthma among healthcare workers in these countries, but the few studies that have

TABLE 2 Prevalence of the most recent exposure to asthmagens, carcinogens, ototoxic and other agents reported among healthcare workers in three hospitals in Bhutan ($N = 370$)

Asthmagens	Exposed *n* (%)	Carcinogens	Exposed *n* (%)	Ototoxic agents	Exposed *n* (%)	Other agents	Exposed *n* (%)
Any asthmagen	365 (98.7)	Any carcinogen	104 (28.1)	Any ototoxic agent	28 (7.6)		
Any asthmagen excluding latex	328 (88.7)						
Latex	350 (94.6)	Formaldehyde	69 (18.7)	*p*-Xylene	28 (7.6)	Anesthetic gases	23 (6.2)
Cleaning and sterilizing agents	323 (87.3)	Other PAHs	64 (17.3)	Toluene	4 (1.1)	Antineoplastic agents	8 (2.2)
Ammoniacal compounds	201 (54.3)	Benzene	6 (1.6)	Ethyl benzene	0 (0)		
Acrylates	40 (10.8)	Chlorinated solvents	5 (1.4)	*n*-Hexane	0 (0)		
Acids	39 (10.5)	Trichloroethylene	5 (1.4)	Styrene	0 (0)		
Reactive dyes	26 (7.0)	Alcohol	0 (0)				
Epoxy	3 (0.8)	Aliphatic solvents	0 (0)				
Bio-aerosols	0 (0)	Diethyl/dimethyl sulfate	0 (0)				
Amines	0 (0)	Epichlorhydrin	0 (0)				
Isocyanates	0 (0)	Ethylene oxide	0 (0)				
Drugs	0 (0)	*Ortho*-toluidine	0 (0)				
Other reactive chemicals	0 (0)	Tetrachloroethylene	0 (0)				

Abbreviation: PAH, polycyclic aromatic hydrocarbon.

examined latex allergy reported a high prevalence among healthcare workers (16% in India,[16] 16.3% in Sri Lanka,[17] 18% in Thailand[15]). The prevalent use of powdered latex gloves among healthcare workers in this study is a cause for concern and warrants further research and interventions.

TABLE 3 Main tasks resulting in exposures to the most common asthmagen, carcinogen, and ototoxic agent among healthcare workers in three hospitals in Bhutan ($N = 370$)

	n (%)
1a. Latex (asthmagens; number exposed = 350)	
Use of latex gloves	350 (100)
Use of powdered latex gloves	336 (96)
1b. Cleaning and sterilizing agents (asthmagens; number exposed = 323)	
Using bleach to clean the workplace	257 (79.6)
Using chlorhexidine to clean the workplace	205 (63.5)
Using glutaraldehyde for sterilization/disinfection	112 (34.7)
2. Formaldehyde (carcinogens; number exposed = 69)	
Using formaldehyde for instrument sterilization/disinfection	50 (72.5)
Using formaldehyde in the laboratory	22 (31.9)
3. *p*-Xylene (ototoxic agents; number exposed = 28)	
Using xylene in the laboratory	28 (100.0)

Cleaning and sterilizing agents were the second most common asthmagen group the healthcare workers in this study were exposed to, with 87.3% being exposed to these chemicals. This finding is in line with previous research which have reported a similar high prevalence (78.3%–98.8%) in the use of cleaning and disinfecting chemicals among healthcare workers in the United States.[2,18] Exposure to cleaning and sterilization agents was high among all the occupation groups in this study, which is consistent with previous research reporting a range of occupation groups within the healthcare sector (nurses, medical technicians, dental assistants, laboratory technicians) besides cleaners engaging in a high frequency of cleaning and disinfecting tasks.[19] Though cleaning and disinfecting tasks are crucial for infection control, the increased incidence of work-related asthma among healthcare workers reported in epidemiological studies have raised concerns about the occupational health risks of cleaning and disinfecting agents.[2] Substitution with safer alternatives, such as green cleaners, have been initiated in high-income countries in an effort to reduce exposures.[1]

The most common task associated with exposure to cleaning and sterilizing agents in this study was using bleach to clean the workplace, which was reported by 79.6% of the participants exposed to cleaning and sterilizing agents and 69.5% of the total participants. The use of bleach as a cleaning agent seems to be more common among healthcare workers in this study than among those in developed countries (45.2% in France, 55.5% in the United States).[20,21]

TABLE 4 Prevalence of the most recent exposure reported in the occupation groups of the asthmagens, carcinogens, and ototoxic chemicals assessed among healthcare workers in three hospitals in Bhutan (*N* = 370)

	n (%)			
	Medical doctors and dentists (*N* = 59)	**Midwifery and nursing professionals (*N* = 176)**	**Other health professionals and technicians (*N* = 94)**	**Support staff/ elementary occupations (*N* = 41)**
Asthmagens				
Latex	56 (94.9)	173 (98.3)	87 (92.6)	34 (82.9)
Cleaning and sterilizing agents	40 (67.8)	157 (89.2)	87 (92.6)	39 (95.1)
Ammoniacal compounds	4 (6.8)	106 (60.2)	64 (68.1)	27 (65.9)
Acrylates	4 (6.8)	30 (17.1)	5 (5.3)	1 (2.4)
Acids	1 (1.7)	4 (2.3)	32 (34.0)	2 (4.9)
Reactive dyes	1 (1.7)	0 (0)	25 (26.6)	0 (0)
Epoxy	1 (1.7)	0 (0)	2 (2.1)	0 (0)
Carcinogens				
Formaldehyde	3 (5.1)	32 (18.2)	30 (31.9)	4 (9.8)
Other PAHs1	18 (30.5)	38 (21.6)	8 (8.5)	0 (0)
Benzene	1 (1.7)	0 (0)	5 (5.3)	0 (0)
Chlorinated solvents	1 (1.7)	0 (0)	4 (4.3)	0 (0)
Trichloroethylene	1 (1.7)	0 (0)	4 (4.3)	0 (0)
Ototoxic agents				
p-Xylene	1 (1.7)	0 (0)	27 (28.7)	0 (0)
Toluene	1 (1.7)	0 (0)	3 (3.2)	0 (0)
Other agents				
Antineoplastic agents	0 (0)	7 (4.0)	1 (1.1)	0 (0)
Anesthetic gases	6 (10.2)	10 (5.7)	7 (7.5)	0 (0)

Abbreviation: PAH, polycyclic aromatic hydrocarbon.

This finding has implications for interventions as exposure to bleach has been shown to be independently associated with work-related asthma among healthcare workers.[21,22]

Using glutaraldehyde to sterilize instruments was another common task associated with exposure to cleaning and sterilizing agents, and was reported by 34.7% of participants exposed to these agents and by 30.3% of the total participants. This is similar to the use reported from high-income countries (38%).[21] Engineering controls such as the use of a closed automated disinfection system is one of the control measures that helps in reducing exposures and is used quite commonly in high-income countries such as the United States (48%).[23] However, such systems are not available in Bhutan and disinfection with glutaraldehyde is done manually (as determined in the pilot study), thus increasing exposure levels to this chemical.

Formaldehyde exposure (18.7%) was the most common carcinogenic exposure in this study and was mainly used for instrument sterilization and in the laboratory. This prevalence is slightly lower than reported in previous studies from high-income countries (26.5%–27.2%).[20, 21] Various guidelines have been published in developed countries setting occupational exposure limits to formaldehyde[24]; however, such standards do not exist in most LMICs including Bhutan. Chemical substitution where possible, effective ventilation, and good work practices are recommended to reduce workplace exposures.[1]

The prevalence of exposure to ototoxic agents was low in this study (7.6%). The main exposure circumstance resulting in exposure to *p*-xylene, the most common ototoxic agent, was using it in the laboratory. Medical laboratory workers have previously been identified as a high-risk occupation group for noise-induced hearing loss,[25] and ototoxic chemicals such as xylene have the potential to act in synergy with noise to cause hearing loss.[26] Further research on exposure to ototoxic agents is required in this occupation group.

The prevalence of exposure to the other agents assessed in this study was also low, especially for exposure to antineoplastic drugs (2.2%). Specialized cancer care services have only been recently introduced in Bhutan and is still in its infancy.[27] Cancer patients are referred to India for treatment due to the lack of specialized facilities and human resources in the country.[28] The expansion of cancer

services to tackle the growing incidence of cancer in Bhutan[27] will result in a higher proportion of healthcare workers being potentially exposed to antineoplastic drugs in the near future and will require the formulation of policies and implementation of control measures to protect from occupational exposures.

This study has some limitations. First, levels of exposures were not assessed and hence, the prevalence reported is an assessment of the number of people exposed, regardless of frequency and duration, and not a calculation of time-weighted exposure. Further, the data were based on self-reports which is subject to bias and may have resulted in some errors in exposure classification. However, it is unlikely that there was a substantial effect on the data as participants were asked about specific tasks, and task-specific questions have been shown to provide more accurate information on exposures.[29] Lastly, the hospitals included in this study were purposively selected, which may have affected the representativeness of the sample. However, because of the structure of the healthcare system in Bhutan, the findings are likely to be generalizable to other healthcare workers in the country and in other countries with similar healthcare systems. The health system in Bhutan is predominantly publicly financed and managed, and health services are delivered through a three-tiered structure: basic health units at the primary level, district hospitals at the secondary level, and regional and national referral hospitals at the tertiary level.[28] Each health facility is equipped according to a standard equipment list based on the level/tier of the facility, the drugs/chemicals and equipment are mainly centrally supplied and staff move to different hospitals regularly. Therefore, the health facilities in each tier are similar in terms of the services provided and facilities available and hence, are likely to be similar in their chemical exposure profiles. In terms of strengths, this is the first study assessing occupational exposures to chemicals among Bhutanese healthcare workers, exposures to a wide range of chemicals were assessed, and a high response fraction (96.4%) was achieved.

5 | CONCLUSION

The results indicate that a large proportion of Bhutanese healthcare workers in all professions are occupationally exposed to chemicals linked to chronic diseases, with exposure prevalence higher than in high-income countries. This study provides information to guide interventions and policies to protect healthcare workers in Bhutan and other LMICs.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John D. Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHOR CONTRIBUTIONS

Rajni Rai contributed to the design of the study, data collection, manuscript preparation, and analysis of data under the direct supervision of Lin Fritschi; Sonia El-Zaemey and Nidup Dorji were involved in the design of the study and contributed to revising the paper. All authors have given final approval of the version to be published.

ETHICS APPROVAL AND INFORMED CONSENT

The study was approved by the Research Ethics Board of Health, Bhutan and the Human Research Ethics Committee, Curtin University (approval numbers: REBH 2018/090 and HRE2019-0079-02, respectively). Written informed consent was obtained from all participants.

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SUPPORTING INFORMATION

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