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Research Article

Cross-Sectional Analysis of Carcinogenic Chemical Exposure in Healthcare Facilities: A Case Study from Benghazi

Fawzeia H. Elmhalli* and Asma B. Elshebani

Department of Infectious Disease, Public Health Faculty, University of Benghazi, Libya

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ABSTRACT

Chemical substances used in hospital environments, including potential carcinogens, pose significant risks to both patients and healthcare workers. This study aimed to evaluate carcinogenic substances present in the formulations of selected chemicals used in hospitals and healthcare centres, including pesticides, air fresheners, detergents, and sterilisation agents. A cross-sectional study was conducted using two tools: a structured questionnaire and observational checklist to collect data from four healthcare centres in Benghazi (HGH, BMC, SAC, and SHC). A total of 94 participants were included, with the sample size calculated for an unknown population using a Z-score corresponding to an 80% confidence level. The identified products were categorised into four groups according to their function, and the presence of carcinogenic substances was analysed. Among the 54 chemical products assessed, 14 were found to contain highly hazardous compounds classified as prohibited by the World Health Organization. The results highlight the need for continuous monitoring and systematic documentation of chemical agents used in healthcare locations to reduce occupational and patient exposure to carcinogenic substances. It is recommended that Infection Control Offices maintain comprehensive records of all chemical agents in use and exercise direct oversight over their application.

*Corresponding author
Email address: fawzeia.almhalli@uob.edu.ly

1. Introduction

Health workers are exposed to many chemicals daily that may harm their health and cause health problems [1,2]. Therefore, the handling of these chemicals is considered a source of concern [3], and relevant staff must pay attention and monitor regular amounts used [4]. They are encountered in the context of diagnostic and therapeutic procedures, in laboratory work, in preparation and cleaning activities [1,5]. Health care is consistently one of the most labour-intensive industries, yet this issue has received little attention from those involved in occupational health and safety research and regulation [6]. Most chemicals commonly used in hospitals and other healthcare settings are not covered by national and international occupational exposure standards [7]. To date, little effort has been made in tracking the chemicals most used, let alone study the mechanisms and severity of exposure and the epidemiology of the effects on the healthcare workers involved **[**8]**.** Healthcare workers are regularly exposed to accidental chemical hazards through incidental contamination or prolonged exposure. APP (Accidental Poisoning and Pollution)[9]. Numerous chemicals used in healthcare are considered volatile organic compounds. [10]. Proper use of chemicals and pesticides is important for preventing contamination of the environment. Exposure to the chemical varies depending on whether it is a hospital or clinic and according to which department in the hospital. Chemicals can be categorized into several types, such as disinfectants, sterilizers, detergents, air fresheners, and pesticides [11, 4]. Carcinogenic chemicals cause malignant tumors, increase their incidence, and reduce the latency period required for tumor formation. [12].Through their use as air fresheners, pesticides, or detergents, these carcinogens are intentionally released. Excessive spraying and gas emissions may cause cancer and malignant tumours associated with pesticides, especially in children, who are the most highly sensitive group to the carcinogenic effects of pesticides.
Many pesticides are used in hospitals to eliminate pests [9], which are considered dangerous, more toxic, and cause chronic effects. More than 150,000 people die each year from pesticide poisoning. Most deaths result from self-poisoning through ingestion, not from occupational or accidental exposure, which is usually topical or through inhalation. [13]. There is evidence on the association between long exposure to pesticides in occupational locations and a higher incidence of chronic diseases [14], including different types of cancer [15]. However, data on non-occupational exposures are too scarce to allow for any conclusions to be drawn [16].

The aim of the study is to identify the chemical substances used in hospitals and health clinics, compare their components with the recently issued list of carcinogens from the World Health Organization, and determine the methods of selecting, using, and storing them, as well as their compliance with safety and security procedures..

2. Methodology

2.1 Study Area

The study was conducted in the city of Benghazi, the second most populous city in Libya, which had an estimated population of 1,207,250 in 2020. [17]. Located on the north-eastern Mediterranean coast, Benghazi is administratively divided into 30 zones and includes major healthcare facilities. The study was conducted at Al-Hawari General Hospital and Benghazi Medical Center, as well as at polyclinics including Al-Sabri Clinic and Shabna Clinic

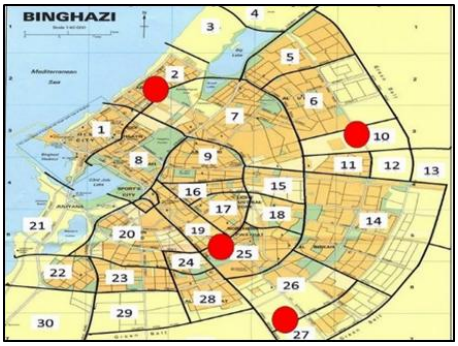

Figure 1.Locations of the selected healthcare facilities in Benghazi

2.2 Study Design

A cross-sectional quantitative design was employed to evaluate the presence of carcinogenic substances in chemical products, including pesticides, air fresheners, detergents, and sterilizing agents, used in selected healthcare facilities in Benghazi. A random sample of two hospitals and two polyclinics was evaluated. Data were collected using two tools: a structured questionnaire administered through interviews with infection control personnel and managers, and an observational checklist adapted from the
Integrated Pest Management Toolkit developed by the Statewide IPM Program and the California Department of Pesticide Regulation was used for on-site monitoring and inspection [18].

2.3 Study Participants

The sample size was 94 health workers from four health centres, determined using sample size formula unknown population: $N = Z^2 \times P (1 - P) / e^2$ (19). Where are: Z-score at 80 % Confidence Interval, Z= 1.28, Standard deviation, P = 0.5, Margin of error, e = 6.6 %, $N = 1.6384 \times 0.5 (1 – 0.5) / 0.004356$, N = 94.

Table1 : Hospital Names, Sample Size of Study ParticipantsAnd Time Of Data Collection

Hospitals	Sample	Date
HGH	40	February 13 to March 3
BMC	25	February 4 to February 27
SHC	15	February 4 to February 11
SAC	15	February 4 to February 20
Total	94	February 4 to March 3

Participants were selected using systematic sampling from four health care centres and hospitals showed in (Table 1). The study participants were from the infection control office, a cleaning company or were nurses. Collected data started in 4th of February until 3rd of March 2024.

2.4 Statistical Analysis

The questionnaire and the checklist collected the data, were analysed using the Statistical Package for the Social Sciences (SPSS) software (version 22) to generate descriptive statistics, including frequency tables and bar charts.

3. Results and discussion

31 A structured questionnaire

The results from the questionnaire indicate who is responsible for selecting the chemicals used in the four health centres (Figure 2). In BMC, the responsible party is the pest control company, with a small percentage of decisions influenced by the hospital's Infection Control Office. Al Hawari hospital shows similar results. In Al-Sabri, however, chemical selection is mainly the responsibility of the administration, followed by the pest control office. At Shabna Clinic, the responsible party is the Infection Control Office.

The questionnaire also showed that approximately 56.4% of the materials used were of unknown origin, and in 72% of cases, the containers did not include labels describing their internal contents (Figure 3).

Regarding storage methods, the study found that in 45% of the health centres, storage practices are determined by administrative decisions (Figure 4). Meanwhile, 55% do not follow international standards for the storage of these chemicals. The Infection Control Office is primarily responsible for setting prevention standards in all centres (57%), followed by hospital administration (23%). However, the actual rate of implementation of these protective standards among workers was only 51%.

Furthermore, 66% of workers reported cases of cancer occurring in these centres during their period of employment.

3.2 Observational Checklist

The results obtained from the observational checklist, based on interviews with managers and infection control personnel, the collected data were categorised into four groups: pesticides,(Table 2), sterilization (Table 3), air fresheners (Table 4) and detergents (Table 5), the four tables showed the carcinogenic substances that were present in the formulations of some chemicals used in hospitals and other health care centres. The substances were divided into two categories: approved or banned according to list of classifications of cancer substances to humans,

from the international agency for research on cancer (IARC) at WHO (IARC Monographs Volumes 1–135). Figure 5 indicated that 25% of the chemicals used at the four-study areas were carcinogenic. However, this percentage differed according to each of these materials that we listed and the percentage of their presence in each hospital

Figure 6 shows the frequency in the presence

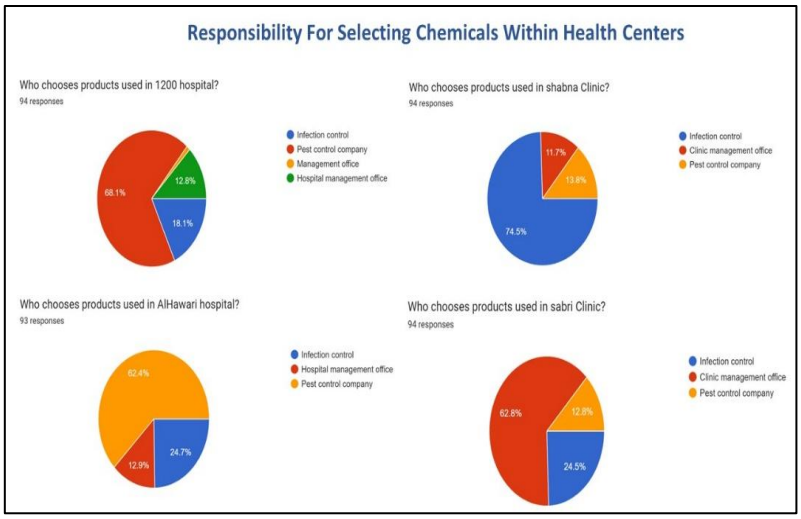

Figure 1. Responsibility For Selecting Chemicals Within Health Centers

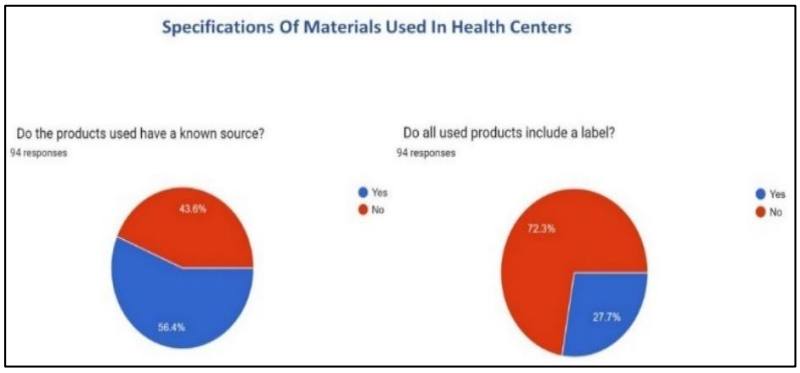

Figure 2. Charts show the percent of known sourcesthose without a labe

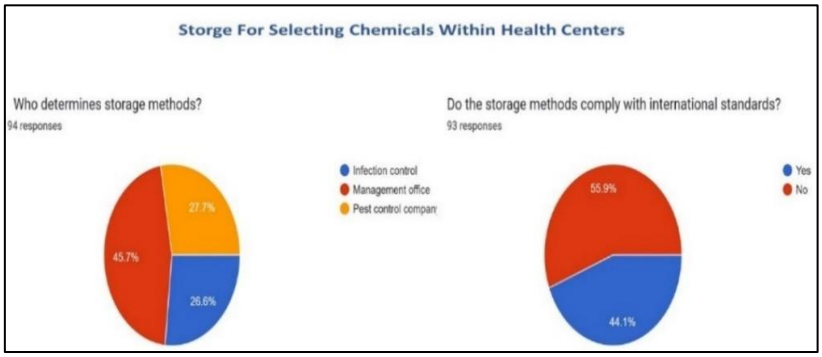

Figure 3 Storage For Selecting Chemicals Within Health Centers

of this substance and the percentage of its presence in each hospital. This leads us to the second part of this study with the results from the checklist. Out of the 54 products investigated throughout the four-health care facilities, around 14 of them had a highly

hazardous substances that is banned in other countries based on the database of pesticides action network [20] International and/or WHO [21] as class 1b. According to these database there are 8 pesticides each under the category of medium-risk (class II) and low risk (class III) pesticides, respectively. Twenty-seven pesticides are registered for use in Libya under Category U (unlikely to cause any hazard). The most used is the Helak pesticide, which contains Cypermethrin , Tetrametrine, and Germ off disinfectant. Quantitatively. In this study about 75% of the total pesticides found to be used, were classified as extremely or highly hazardous pesticides, which aligns closely with results from a recent study conducted in India [14]. Ethylene oxide which is the most widely used disinfectant currently, is considered a toxic substance of the first degree because it causes breast cancer and leukaemia [1]. Ethylene Oxide gas is widely used today as disinfectant in many health care settings, it has been linked to allergic contact dermatitis and serious health conditions, including breast cancer or leukaemia. Despite limited evidence for human cancers, it is also classified as Group 1 carcinogen [20,22]. Contamination can still occur in hospitals, even when trained staff carefully follow safety guidelines and monitoring procedures. This underscores the need for healthcare facilities to carry out regular monitoring and to continuously strengthen risk-management strategies and protective measures. Efforts should focus on developing monitoring systems that are practical, efficient and less expensive.

In this study, nearly 66% of healthcare workers knew someone who had been diagnosed with cancer during their years of work, so these finding suggest that long lasting monitoring and systematic records keeping could help identify the risks related to toxic chemicals exposure[4].

Table 2. Approval status of pesticides: 8 of 18 in use were approved

Pesticide	Chemical integrated	R.U	P.S	Hospital
1. Helak	cypermetrine, which has a deadly effect, tetrametrine, and piperonyl butexide	Yes	Banned	HGH, BMC
2. Raid	Sumithrin0.136%, prallethin 0.109%, DI water 52.432%, propellan, solvent & other ingredient 47.323%	Yes	Approved	BMC, HGH SHC, SAC
3. Cychloros 55% EC	Chlorpyrifos50%, Cypermethrin 5%	Yes	Banned	HGH
4. AbaMectin	Abamectin1.8%	Yes	Approved	HGH
5. Murin facuom past	Brodifaxoum, Denathonium Benzoatw, palatable substances &Co-formulates	Yes	Approved	HGH
6. AMP 2CL	Acetamiprid puro	Yes	Banned	HGH
7. Cyhpeno max	Cyphenothrin 10%	Yes	Approved	HGH
8. lambda cyhalothrin	Pyrethroids	Yes	Approved	HGH
9. bromadiolone	Broprodifacoum; Bromatrol	Yes	Approved	HGH
10. raviox	Difenacom	Yes	Approved	HGH, BMC
11. General Disinfectan	Chloroxylenol 0.36%	Yes	Approved	BMC
12. Cyperx	Cypermethrin 10%, Tetramethrin 2%PBO 10%	Yes	Banned	BMC
13. Delta_Vam 5 Sc	Deltamethrin 5%	Yes	Banned	BMC
14. DK10.2, Microcapsule	Cypermethrin (CASN.52315_07_8)10g	Yes	Banned	BMC
15. Tetra	Tetramethrin (CASN.7696-12-0) 2g	Yes	Banned	BMC
16. Piperonilbutossido, 17. Coformulanti	Piperonilbutossido,(CASN.51.03.6) 10g, Coformulanti q.b.a 100g	Yes	Banned Banned	BMC
18. Tornado CS	Lambda_cyhalothrin 10%	Yes	Banned	BMC

Equation 1. R.S> Ready to Use, P.S> product states

Table3 . Approval status of sterilizers: 4 of 17 in use were banned.

Sterilizers	**Chemical integrated**	**R. U**	**P. S**	**Hospital**
1. SaniBact.TRU	Unknown	Yes	Approved	All
2. Zhermack	Unknown	Yes	Approved	SHC
3. Cidex	Citrinex 15%	Yes	Banned	SAC, HGH
4. Novadex-DA	Glutaraldehyde 2% nasal toxicity	Yes	Approved	SHC
5. Kohersolin FF	Glutaraldehyde 50 mg/g, benzyl-C12-18-alkyldimethyl-ammonium chlorides 30 mg/g, chloride 30 mg/g	Yes	Approved	HGH
6. Prodex	5,75formencetale400g glutaraldehyde perthantal) Surfactants, conosion whetors, preservatetary.	Yes	Approved	BMC
7. DR. DEEP	Mineral Water, Shea Butter, Ceramide, BSASM, Jojoba Seed Oil, green tea, chamomile, Centella Asiatica, rosemary, licorice and more.	Yes	Approved	BMC
8. Povoiderm	Iodine	Yes	Banned	BMC
9. korsolex	Glutaral and 15,2 g, (ethylenedioxy) dimethanol: 19,7 g	Yes	Approved	SHC
10. Bactinyl 5M	Peroxides, quaternary ammoniums, and ethanol.	Yes	Approved	SHC
11. Germ _off	Alcohol 77% &Aloe vera	Yes	Banned	SHC, HGH
12. Seni hand	Alcohol> 70%	Yes	Banned	SHC
13. MYCARE	Alcohol75%	Yes	Banned	SHC
14. Alcohol	Methanol 96%	Yes	Approved	SHC
15. Quiclear	Active ingredient: benzalkonium chloride, Inactive: Aqua, benzalkonium chloride. Glycerin, perfume	Yes	Approved	SHC
16. Hand soap	Sulfate, Cocamidopropyl Betaine, Cocamide DEA, Cocamidopropylamine Oxyde, Citric Acid, Sodium Chloride, Glycerin, DMDMHydantoin	Yes	Approved	SHC, HGH
17. Dettol	Chloroxylenol, palm oil, titanium, mugo pine	Yes	Approved	HGH, BMC, SAC

Table4 . Approval status of air fresheners: 3 of those in use were approved

A.Freshener	**Chemecal integrated**	**R.U**	**P.S**	**Hospital**
1. Lamis	Stabilizers, perfumes, preservatives, purified water	Yes	Approved	HGH, BMC, SAC
2. Touri	Stabilizers, perfumes, preservatives, purified water	yes	Approved	HGH, BMC
3. Frida	Perfume, water, preservatives, and emulsifiers	Yes	Approved	HGH
4. Frisia	Unknown	Yes	Unknown	SAC
5. Fresh	Lilac and lavender perfume, preservatives	Yes	Unknown	SAC

Table5 . Approval status of Detergents: 6 of 12 in use were approved

Detergent	Chemical integrated	R.U	P.S	Hospital
1. Fema	Calcium carbonate 30%, industrial detergent and odor 50%	Yes	Approved	HGH, BMC, SAC
2. Vixal	Chlorine	Yes	Approved	HGH, BMC, SHC
3. Clorox	Sodium hypochlorite 5%	Yes	Approved	HGH, BMC, SAC
4. Vanish	Hydrogen peroxide, anionic surfactants,	Yes	Approved	HGH
5. Yeri _ sol	Unknow	Yes	Unknow	HGH
6. Happy	Unknown	Yes	Unknow	HGH, BMC, SAC
7. Fax	Unknow	Yes	Unknow	BMC
8. Cesris	Unknow	Yes	Unknow	BMC
9. Maxellmagic	Unknow	Yes	Unknow	BMC
10. Caled	Unknown	Yes	Unknow	BMC
11. Loryal	Non-ionic surfactants <0%, fragrance, methylchloroisothiazolinone,, methylisothiazolinone	Yes	Approved	HGH
12. Stainl steel	Unknown	Yes	Approved	HGH

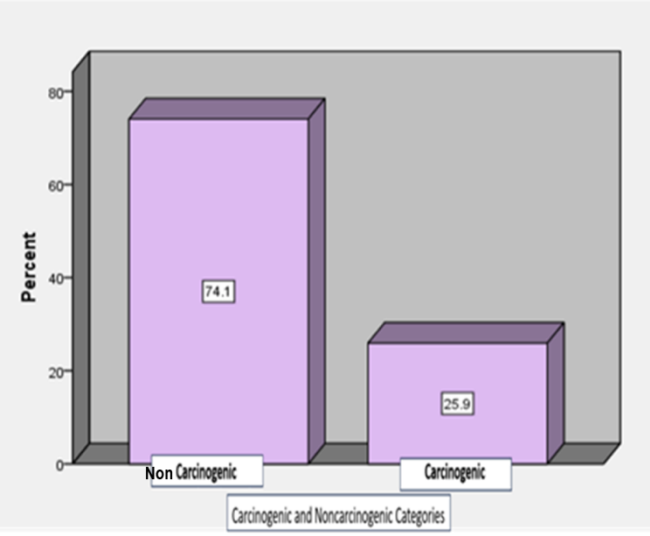

Figure 4. Carcinoginc and Non.Cacinogrnic Categories

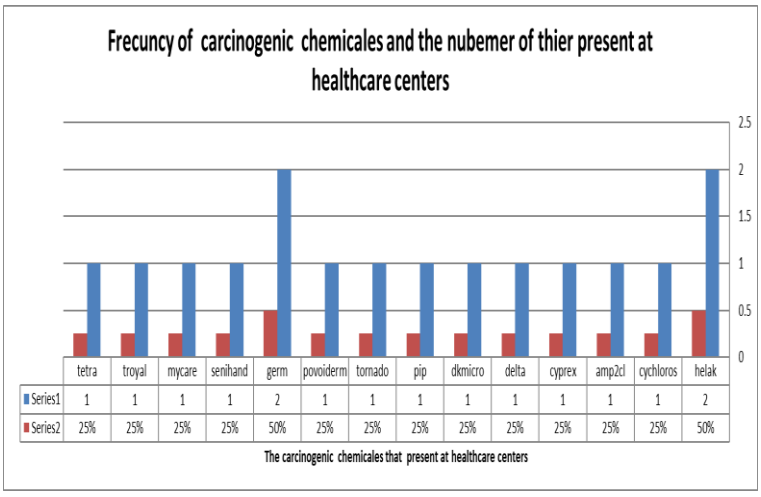

Figure 6. Frequency and percentage of the substance detected in each hospital

4. Conclusions

The study concludes that many materials used in health centres contain dangerous materials, and long-term exposure to these chemicals may lead to many diseases, including tumours and cancers. The questionnaire has proven that many workers in health centres are affected by tumours, as well as general absence of consideration in prevention procedures and prevention programs. The study therefore recommended that healthcare facilities be routinely monitored continuously to improve risk management plans. Protective equipment must also be used which makes monitoring simpler, faster, and less expensive. Ensuring the quality of chemicals while knowing their sources is very important. The place and methods of storage must comply with international health standards. The Office of Infection Control should also inspect the materials used, use them under their supervision, and train workers to protect themselves is necessary and imperative.

6. Ethical Consideration

The study protocol, being questionnaires, interviews, and the checklist were all authorized by the Administration at the Department of Public Health in the Public Health faculty. The study was authorized by the hospitals administration and the head of the Environmental Health Office in each of the four hospitals.

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Conflict of Interest

The authors declare no conflicts of interest.

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