

Assessment of Chemical Safety and Chemical Security Preparedness in Select Beauty Care Facilities in Nairobi City, Kenya

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How to cite this paper: Sije, L.O., Aluoch, A.O., Otieno, G., Ng'endo, M.N. and Murunga, M.S. (2025) Assessment of Chemical Safety and Chemical Security Preparedness in Select Beauty Care Facilities in Nairobi City, Kenya. *Open Journal of Safety Science and Technology*, 15, 149-172.
<https://doi.org/10.4236/ojsst.2025.153009>

Received: June 28, 2025

Accepted: August 15, 2025

Published: August 18, 2025

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Abstract

The surging use of chemical-based cosmetics in rapidly growing urban beauty facilities has raised significant concerns regarding occupational and chemical safety, chemical security, and environmental pollution. Despite the widespread exposure to potentially hazardous chemicals, limited oversight and awareness of the associated risks among salon attendants remain. This study assessed the chemical safety and security preparedness in selected beauty care facilities in Nairobi City, Kenya. It utilized structured questionnaires, observational checklists, and interviews to evaluate chemical usage, safety practices, waste management, regulatory compliance, and awareness levels. The study found widespread use of chemicals of concern (CoCs) with known health risks or links to chemical weapon precursors. Most beauty care facilities demonstrated poor chemical safety practices, such as insufficient use of personal protective equipment (PPE), inadequate ventilation, improper storage, and unregulated waste disposal. Common health issues included skin irritation, eye discomfort, and respiratory problems, which are associated primarily with prolonged chemical exposure. The Spearman Rank Order correlation studies revealed significant relationships between key variables at a 0.05 significance level. Attendees' satisfaction with chemical safety measures correlated moderately with frequent PPE usage ($r = 0.558$). Knowledge of chemical hazards was linked to prior training ($r = 0.448$) and longer exposure to chemicals ($r = 0.355$). Frequent PPE use correlated noticeably with waste segregation ($r = 0.347$), while longer chemical exposure was associated with more health issues ($r = 0.367$). Negative correlations showed that longer chemical exposure was linked to poor waste segregation ($r = -0.384$), while limited knowledge of chemical hazards correlated with more reported health issues ($r = -0.349$).

The findings point to targeted safety training, stricter enforcement of occupational health regulations, and enhanced chemical security. Improving compliance with OSHA and OPCW guidelines, promoting sustainable waste management, and raising awareness of chemical hazards are essential to strengthening safety standards in the beauty industry.

Keywords

Chemical Safety and Security, Beauty Salons, Nairobi City, OSHA, OPCW

1. Introduction

Cosmetics are preparations intended for application to a part of the body, including the skin, hair, nails, lips, and teeth, to cleanse, perfume, change appearance, protect, or maintain in good condition. Cosmetic formulations often incorporate active ingredients combined with other carrier chemicals to prevent or decrease adverse effects on the skin [1]. Cosmetics consist of solvents, emulsifiers, thickeners, preservatives, pigments, coloring, glittering agents, emollients, and fragrances mixed in suitable compositions to achieve the intended purpose. Skincare products generally cleanse the skin, balance skin moisture, stimulate metabolism, and protect the skin from harmful ultraviolet rays. Hair care products strengthen the hair follicle and promote hair growth, while makeups enhance beauty and attractiveness and, when applied to the body, provides a pleasant and desirable scent [2].

The beauty and personal care industry is a significant sector globally, consuming cosmetic products that contribute to economic growth, employment, and entrepreneurship opportunities [3]. In 2023, the global cosmetics market was valued at approximately USD 103.82 billion and is projected to grow by 20.8% by 2027 [4]. Africa's beauty industry is also expanding, with an estimated cumulative annual growth rate (CAGR) of 8% between 2025 and 2030, reflecting the increasing demand for beauty care products [5]. Innovations in product formulation, sustainable packaging, and digital retail strategies have enabled the evolution of the African beauty and personal care market. The beauty industry remains an attractive investment in Kenya, with sales expected to grow at a CAGR of 6.78% between 2024 and 2028 [4] [6]. The awareness of the quality of beauty care products, the increasing demand for natural and organic ingredients, and the growing interest of male consumers in personal care products have rapidly fueled the growth of the cosmetics industry worldwide [7].

Nairobi City remains the most populous county in Kenya. The city's population was 4.397 million as of the 2019 census and is expected to number 5.767 million in 2025 [8]. The city's dense population and rapid urbanization have led to the proliferation of beauty care facilities. However, the increasing use of chemical-based beauty products and reports on the misuse of chemicals by terrorist groups such as Al-Shabaab [9] [10] raise concerns about occupational health, environmental safety, and chemical security, necessitating a thorough assessment of these

establishments' chemical safety and security preparedness.

Beauty facilities are expected to comply with the Occupational Safety and Health Act of 2007 (OSHA), which provides for workplace registration in Part V, general health requirements in Part VI, and general fire safety requirements in Part VIII; 78-82, chemical safety requirements in Part IX and protective clothing, eye protection, and medical surveillance in Part XI; 101-103 [11] [12]. Recent studies have shown that most small enterprises, including beauty care facilities and hairdressers, do not fully comply with the provisions of this act [13] [14]. The lack of structured training programs exacerbates the problem, as workers may not fully understand the risks associated with prolonged chemical exposure or the importance of adherence to safety guidelines. Moreover, chemical security measures, including secure storage and restricted access to hazardous substances, are often inadequate, increasing the risk of accidents, spills, and unauthorized use of potentially dangerous chemicals [15].

Due to the high demand for their use, vast amounts of cosmetic product residues are continuously released into the environment [16]. Cosmetic products, including hair dyes, relaxers, nail polishes, acetone-based removers, and skincare formulations, contain hazardous substances such as formaldehyde, toluene, methacrylic acid, and ammonium persulfate, which have been linked to adverse health effects, including respiratory problems, skin irritation, and reproductive disorders [2]. Prolonged exposure to these chemicals, often without adequate protective measures, increases salon workers' and clients' risk of chronic health conditions. These chemicals could also interact on release into the environment, forming secondary pollutants that could exacerbate harm to human health and the environment [17]. Current formulations are based on nanomaterials that could penetrate the skin and expose the public to toxic chemicals [18].

In addition, some chemicals used in cosmetic product manufacturing are categorized as chemicals of concern (CoCs). CoCs are substances with the potential to cause harm to human health or the environment [19]. CoCs could be used in the manufacture of chemical weapons precursors, which are a class of chemicals that are extremely dangerous and lethal [20]. These risks necessitate comprehensive safety practices, including proper ventilation, use of personal protective equipment (PPE), and adherence to waste disposal regulations to mitigate adverse effects on human health and the environment. Further, there's a need to utilize the hierarchy of controls in the use of cosmetic products and, where possible, limit the use of CoCs in the production of cosmetics [21]. The hierarchy of controls includes elimination, substitution, engineering controls, administrative controls, and using personal protective equipment (PPE) [22]. Consequently, all cosmetic products should be accompanied by safety data sheets (SDS) that outline, among other guidelines, their hazardous components, how to handle them, and how they should be disposed of [23].

Chemical safety refers to measures taken to prevent accidental releases of toxic chemicals into the environment and to mitigate the effects should such events oc-

cur, while chemical security relates to the measures taken to prevent misuse of chemicals, including their theft, diversion, or intentional release, to protect against potential harm, such as terrorist attacks or accidental incidents [24] [25]. Guidelines for ensuring chemical safety and security of small and medium enterprises, including beauty care facilities, have been developed by the Organization for the Prohibition of Chemical Weapons to foster peaceful uses of chemistry [15]. Managers of small and medium-sized businesses, such as beauty care facilities, are obligated to comply with existing regulations, codes, standards, and policies related to safety and security as outlined in the 2007 OHS Act and the indicative guidelines [11] [15]. Compliance with these measures will help reduce liability should an incident occur and allow for a systematic review to determine the performance of safety programs at a facility.

In the Indicative Guidelines, beauty care facilities should maintain a clean work environment with adequate ventilation to ensure free fresh air circulation. All workplaces should be equipped with easily accessible means of extinguishing fires, which must be sufficient and suitable, and they should also have adequate means of escape and evacuation procedures. The management should develop an appropriate system for the safe collection, recycling, and disposal of chemical waste, obsolete chemicals, and empty chemical containers to avoid risks to safety, worker health, and the environment. Employers should provide and maintain adequate, effective, and appropriate protective clothing and equipment, including, where necessary, gloves, safety boots, goggles, and headgear. Employees have the right to have their chemical exposure limits checked by trained medical personnel. Consequently, anyone who breaches the above provisions commits an offence punishable under the OHS Act 2007 [11] [15] [26].

This study assessed selected beauty care facilities' chemical safety and security preparedness in Nairobi City County. The research evaluated the types of chemicals used, the effectiveness of safety precautions, waste management practices, workers' exposure to toxic chemicals, adherence to safety regulations, and correlation studies between factors affecting safety and security. A survey-based approach that involved structured questionnaires, oral interviews, and on-site observations in multiple beauty care facilities across Nairobi was used. The collected data provided insights into the current state of chemical safety and security in the beauty industry and identified key areas requiring intervention. Additionally, this study determined the extent to which beauty care facilities aligned with regulatory standards and best practices for handling hazardous substances to ensure worker and customer safety. Also, correlation studies determined the relationships between various variables that affected chemical safety and security.

By identifying these challenges, this study provided evidence-based recommendations for improving chemical safety and security in Nairobi's beauty care facilities. The findings will help policymakers, regulatory authorities, and industry stakeholders in developing targeted solutions to enhance workplace safety, promote compliance with occupational health regulations, and mitigate environmental risks associated with improper handling of beauty care chemicals. Implement-

ing best practices in chemical safety, enforcing strict regulatory measures, and fostering industry-wide education on safe chemical usage will be crucial in safeguarding the health of salon workers, clients, and the broader community.

2. Methodology

2.1. Study Area and Population

The study was conducted in beauty care facilities within the seventeen sub-counties of Nairobi City County, namely, Dagoretti North, Dagoretti South, Embakasi Central, Embakasi East, Embakasi West, Embakasi South, Embakasi North, Kamukunji, and Makadara. Ruaraka, Roysambu, Kasarani, Starehe, Lang'ata, Westlands, Kibra, and Mathare. The study area is shown in **Figure 1**. The sub-counties were selected to ensure geographical diversity and representation of Nairobi's urban and peri-urban areas. The wards where the studies were conducted were identified through local government registries, and a random facility was approached for the study.

The study population comprised beauty care facilities and barber shops, irrespective of their duration of operation or size, to ensure a broad spectrum of practices were captured. Approval to conduct this study was sought from the Kenya Chemical Society. Informed consent was obtained from the respondents prior to their participation in the study.

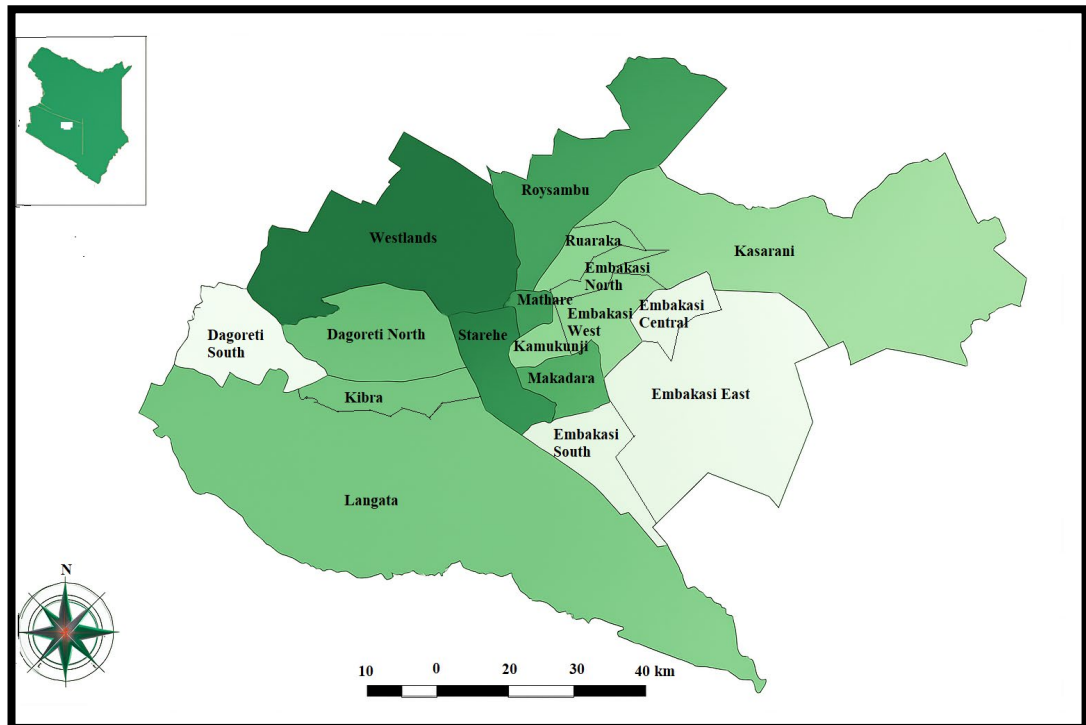


Figure 1. A map of Nairobi City County showing the sub-counties where the survey was administered.

2.2. Study Design

A cross-sectional design using quantitative methods of data collection was em-

ployed. Trained research assistants used pretested structured questionnaires and observational checklists to obtain data. The face-to-face interviews took place at the workplace to enable the participants to keep working during the data collection sessions. Where applicable, the respondents could fill in the questionnaires on their own, while most circumstances involved aided filling of the questionnaire with the research assistants. One data point was collected using Google Forms since it was convenient for the respondent.

The data collected was based on the structured questionnaire, which evaluated basic salon characteristics, including location, number of employees, and duration of operation. Chemical ingredients in the products used in the beauty care facilities were evaluated for chemicals of concern, with a reference list initially developed by Costanzi in his fan plot of chemical weapon precursors [27], and the National Institute for Occupational Safety and Health Database list of CoCs. Chemical safety practices were evaluated, including chemical usage and awareness of potential risks, safety precautions, and safety equipment availability. Health and safety concerns, waste management practices, training & awareness, and regulation compliance were also evaluated. Additionally, chemical storage, tracking & monitoring, and chemical access, safety & security protocols were assessed as part of chemical security awareness.

2.3. Sample Size

A simple random sampling method was used to collect data from 43 beauty care facilities representing seventeen sub-counties [28] [29]. Multistage sampling was performed, and the number of wards in each sub-county was identified. Based on their number, at least half were targeted for study. At least two wards from each sub-county were randomly approached during the study. One beauty care facility was used as a representation of each ward selected. This ensured geographic dispersion.

The sample size of 43 facilities was determined using prevalence-based calculation, targeting a 95% confidence level and a 15% margin of error for estimating the proportions of facilities with inadequate safety practices, assumed at 50% to maximize variability [30]. Equation (1) below was used to determine the number of facilities.

$$n = \frac{[Z^2 \times p(1-p)]}{e^2} \quad (1)$$

where n is the sample size, Z is the Z -score (1.96 for 95% confidence level), p is the assumed proportion at 50% (0.5), and e is the margin of error at 15% (0.15).

2.4. Data Analysis

Raw data was initially fed to a Google Form and analyzed using MS Excel and Sigma Plot 14. The data was presented in tables, pie charts, Sunburst charts, and bar graphs.

For beauty care facility characteristics, data on location, number of workers, and duration of operation, chemicals of concern in cosmetic products were compiled into tables. The percentage of beauty care facilities implementing safety measures such as ventilation, PPE use, and fire safety precautions was represented using clustered bar graphs for chemical safety practices. The prevalence of health effects such as respiratory issues, skin irritation, and eye discomfort was analyzed through bar charts for health and safety concerns. The types of generated waste were categorized using a sunburst chart. Training, knowledge & awareness, and compliance with regulations were presented as percentages, while chemical security assessment was analyzed in percentages and presented in tables. Potential biases, including social desirability and sampling limitations, were addressed via unannounced observations and geographic stratification to prevent bias. Results should be interpreted as reflective of Nairobi's formal and semi-formal salon sector, with informal operators likely underrepresented.

The dummy variables were converted to numerical values using MS Excel for correlation analysis. Satisfaction with safety measures was rated on a Likert scale of 1 - 5 (1 = very unsatisfied and 5 = very satisfied), while the frequency of use of PPE was measured on a scale of 1 - 3 (1 = never, 2 = sometimes, and 3 = always). Whether health issues were reported or not was represented as binary values (those that reported health issues = 0, while those with no health issues = 1). The attendant's training was gauged in binary units (trained = 1, untrained and unsure = 0). The knowledge about chemical hazards was gauged on a Likert scale of 1 - 5 (1 = very unknowledgeable and 5 = very knowledgeable). The waste segregation was represented on a 1 - 3 scale (1 = not segregated, 2 = partially segregated, and 3 = segregated), while the adequacy of waste management practices was gauged on a 1 - 3 scale (1 = not adequate, 2 = partially adequate, and 3 = adequate). The number of health issues and the hours the attendants used chemicals were reported directly from the survey.

The tabulated numerical variables were fed to Sigma Plot 14, and analyzed for Spearman Rank-Order Correlation at a p-value = 0.05 significance [31].

3. Results and Discussion

3.1. Beauty Care Facility Characteristics

The characteristics of the beauty care facilities are represented in **Table 1**. The beauty care facilities were evenly distributed within the seventeen sub-counties of the city. Selecting at least two wards per sub county and one facility per ward ensured coverage of diverse socioeconomic and operational contexts, further it avoided clustering and prevention of data overlap that could arise from shared similar practices due to proximity. The beauty care facilities varied in size, with 79.1% having five employees or fewer, while 20.9% have more than five employees. Most beauty care facilities were new, with 59.9% established within the last 5 years; 20.9% were 6 - 10 years old, while 23.3% were older than 10 years. This showed that new facilities were being set up to meet the rising demand for beauty care.

Table 1. Characteristics of the beauty care facilities.

Sub-county	Location (Coordinates)	No. of Workers	Duration of Operation
Dagoretti North	Kawangware (1°17'05.7"S 36°44'37.4"E)	3	1 - 5 years
	Kilimani (1°17'21.2"S 36°47'16.5"E)	15	6 - 10 years
Dagoretti South	Uthiru (1°16'27.7"S 36°42'19.1"E)	3	1 - 5 years
	Waithaka (1°16'58.5"S 36°43'03.2"E)	2	6 - 10 years
	Riruta (1°17'35.2"S 36°44'17.9"E)	2	1 - 5 years
Embakasi Central	Kayole (1°17'00.0"S 36°54'46.7"E)	3	1 - 5 years
	Matopeni (1°15'42.6"S 36°55'36.2"E)	3	Over 10 years
Embakasi East	Utawala (1°19'24.6"S 36°53'55.9"E)	2	1 - 5 years
	Donholm (1°17'35.1"S 36°53'42.1"E)	4	Over 10 years
	Mihang'o (1°16'58.5"S 36°57'32.3"E)	3	Over 10 years
Embakasi West	Umoja (1°17'00.3"S 36°53'13.3"E)	5	Less than 1 year
	Kariobangi South (1°15'47.5"S 36°53'02.8"E)	4	Less than 1 year
Embakasi South	Mukuru kwa Njenga (1°18'41.9"S 36°53'15.5"E)	1	1 - 5 years
	Pipeline (1°18'57.9"S 36°53'41.0"E)	4	6 - 10 years
	Imara Daima (1°19'25.9"S 36°52'58.9"E)	6	1 - 5 years
Embakasi North	Kariobangi North (1°15'21.8"S 36°52'50.2"E)	6	6 - 10 years
	Dandora (1°15'39.1"S 36°53'09.8"E)	4	1 - 5 years
Kamukunji	Eastleigh South (1°17'12.5"S 36°51'05.4"E)	1	1 - 5 years
	Gikomba (1°17'03.4"S 36°50'25.6"E)	4	1 - 5 years
	Eastleigh North (1°16'06.3"S 36°50'52.9"E)	6	Over 10 years
Makadara	Makongeni (1°17'47.8"S 36°50'56.9"E)	8	Over 10 years
	Harambee (1°16'58.9"S 36°52'26.5"E)	3	Less than 1 year
Ruaraka	Utalii (1°15'12.6"S 36°51'44.1"E)	3	Over 10 years
	Babadogo (1°14'42.6"S 36°53'23.8"E)	1	Over 10 years
Roysambu	Roysambu (1°12'49.7"S 36°53'14.8"E)	4	1 - 5 years
	Kahawa West (1°11'25.8"S 36°54'09.8"E)	1	1 - 5 years
	Zimmerman (1°12'35.7"S 36°53'45.8"E)	4	6 - 10 years
Kasarani	Ruai (1°15'21.7"S 36°59'10.9"E)	4	6 - 10 years
	Kasarani (1°13'13.3"S 36°53'36.1"E)	2	1 - 5 years
	Mwiki (1°13'28.5"S 36°55'20.7"E)	8	6 - 10 years
Starehe	Ngara (1°16'27.3"S 36°49'46.1"E)	5	1 - 5 years
	Pangani (1°15'59.4"S 36°50'19.4"E)	2	Less than 1 year
	Moi Avenue (1°16'56.9"S 36°49'20.3"E)	12	6 - 10 years
	Kenyatta Avenue (1°17'05.5"S 36°49'12.6"E)	8	Over 10 years
	Landimawe (1°17'45.3"S 36°49'47.3"E)	2	1 - 5 years

Continued

Lang'ata	Nairobi West (1°18'40.3"S 36°49'02.2"E)	1	1 - 5 years
	Nyayo Highrise (1°18'54.6"S 36°48'17.8"E)	3	1 - 5 years
Westlands	Kangemi (1°16'17.8"S 36°44'21.7"E)	4	Less than 1 year
	Mountain View (1°16'04.6"S 36°44'15.7"E)	2	Less than 1 year
Kibra	Lindi (1°18'53.6"S 36°47'31.5"E)	4	1 - 5 years
	Laini Saba (1°18'49.2"S 36°48'01.9"E)	6	6 - 10 years
Mathare	Huruma (1°15'30.8"S 36°52'12.6"E)	3	Over 10 years
	Kiamaiko (1°15'26.5"S 36°52'36.2"E)	2	Over 10 years

(Note: The actual names of the beauty care facilities were not used due to legal implications.)

3.2. Identified Chemicals of Concern

A majority of the beauty facilities used beauty products containing potentially harmful chemicals. 81.4% of the respondents acknowledged that they used chemicals known to have health effects, and 9.3% each reported that they were either not using them or were unsure. Among the products, hair dyes, nail polish and nail polish removers, hair relaxers, after-shave spirits, sunscreens, hair conditioners, bleaching creams, nail glue, primers, manicuring, and deep pedicuring products were reported to have known health effects.

To identify the CoCs, the ingredients in each product used in the salon were analyzed, and the potential precursors to chemical weapons were determined with reference to Costanzi's fan plot [27] and the National Institute of Occupational Safety and Health (NIOSH) database of guide to chemical hazards [32]. **Table 2** below summarizes the ingredients in the product used in beauty care facilities. The identified CoCs in the products have been highlighted in italics.

Table 2. Ingredients in cosmetic products and CoCs.

Product Type	Product	Ingredients and Highlighted Chemicals of Concern
	Facial scrub	Aqua, paraffinum liquidum, coco-glucoside, hydrated silica, Oryza Sativa germ powder, vegetable oil, methacrylic acid copolymer, C10 - C30 alkyl acrylate crosspolymer, disodium EDTA, hydroxypropyl cyclodextrin, Iodopropynyl butylcarbamate, panthenol, pantolactone, phenoxyethanol, sodium hydroxide, tocopheryl acetate. <i>Methacrylic acid</i>
Body care	Moisturizing cream	Aqua, glycerine, cetearyl alcohol, caprylic triglyceride, cetyl alcohol, cetareth-20, petrolatum, diethanolamine, potassium phosphate, ceramide NP, ceramide AP, EOP, carbomer, trichloroethylene, dimethicone, behentrimonium methosulphate, sodium lauroyl lactylate, sodium hyaluronate, cholesterol, formaldehyde, phenoxyethanol, disodium EDTA, dipotassium phosphate, tocopherol, phytosphingosine, xanthan gum, and ethylhexylglycerine. <i>Diethanolamine</i> <i>Trichloroethylene</i> <i>Formaldehyde</i>

Continued

	Sunscreen	Water, isododecane, polyester & glycerine, cetyl peg, axobenzene, dimethicone, potassium cetyl phosphate, homosalate, acetone, phenoxyethanol, cetearyl alcohol, disopropyl sebacate, dibutyl phthalate, sodium benzoate, cetyl alcohol, 1,2-hexanediol, potassium sorbate, formaldehyde, caprylyl glycol, myristyl alcohol, ammonium persulfate, wood oil, octinoxate, and octisalate. <i>Acetone</i> <i>Dibutyl phthalates</i> <i>Formaldehyde</i> <i>Ammonium persulfate</i> <i>Oxybenzone</i> <i>Octinoxate</i>
	Whitening cream	Aqua, propyl glycol, p-phenyl diamine, hydroxyphenol, parfum, ammonium persulfate, niacinamide, sodium sulfite, sodium metabisulfite. <i>p-phenyl diamine</i> <i>Ammonium persulfate</i> <i>Hydroxyphenol</i>
	Surgical spirit	Methylated spirit, methacrylic acid, methyl salicylate, and diethyl phthalate. <i>Methacrylic acid</i> <i>Diethyl phthalates</i>
	Massage and aromatherapy oil	Essential oils, carrier oils, and dibutyl phthalates. <i>Dibutyl phthalates</i>
	Hair foam	Aqua, VP/VA copolymer, aloe vera leaf extract, batulla aba extract, citric acid, formaldehyde, phenoxyethanol, ammonium persulfate, and natural fragrances. <i>Formaldehyde</i> <i>Ammonium persulfate</i>
	Shampoo	Deionized aqua, diethanolamine, CDE, SLES, xylene, trichloroethylene, fragrance and approved colours. <i>Diethanolamine</i> <i>Xylene</i> <i>Trichloroethylene</i>
Hair care	Hair dyes	Natural henna powder, amla powder, hibiscus, acetone, dibutyl phthalates, synthetic anthocyanins, toluene, glyceryl thioglycolate and ammonium persulfate. <i>Acetone</i> <i>Toluene</i> <i>Glyceryl thioglycolate</i> <i>Ammonium persulfate</i> <i>Dibutyl phthalates</i>
	After-shave balm	Aqua, glycerin, isopropyl palmitate, chamomile extract, bisabolol, methoxypropanediol, glycine soja oil, tapioca starch, tricetearyth-4 phosphate, trichloroethylene, sodium carbomer, caprylic triglyceride, phenoxyethanol, piroctone olamine, bht, linalool, limonene, geraniol and parfum. <i>Trichloroethylene</i>
	Hair conditioner	Water, oils, xylene, glycerin, hyaluronic acid, emollients, amino acids, citric acid, cetyl alcohol, stearyl alcohol, centrimonium chloride, stearammonium chloride, glyceryl stearate, and fragrance. <i>Xylene</i>

Continued

	Hair food oil	Paraffinum liquidum, avocado oil, vegetable oils, cocos, castor oil, formaldehyde, glyceryl thioglycolate, parfum, and ammonium persulfate. <i>Formaldehyde</i> <i>Ammonium persulfate</i> <i>Glyceryl thioglycolate</i>
	Hair relaxer	Aqua, ammonium bisulfate, glyceryl thioglycolate, paraffinum liquidum, steareth-2, stearyl alcohol, steareth-21, formaldehyde, disteardimonium, hectorite, and ammonium persulfate. <i>Formaldehyde</i> <i>Ammonium persulfate</i> <i>Glyceryl thioglycolate</i>
	Nail polish	Propylene carbonate, formaldehyde, soybean oil, methyl ester, toluene, acetone, ethyl acetate, tocopheryl acetate, dibutyl phthalate, styrene, and methacrylic acid. <i>Formaldehyde</i> <i>Dibutyl phthalate</i> <i>Toluene</i> <i>Acetone</i> <i>Ethyl acetate</i> <i>Styrene</i> <i>Methacrylic acid</i>
Makeup	Nail polish remover	Ethyl acetate, dimethyl glucarase, dimethyl adipose, methyl palmitate, acetone, toluene, PEG-30, carrier oils, PEG-8, dimethicone, octyldodecanol, acetonitrile, tocopheryl acetate, retinyl palmitate acid, silica, sodium propoxyhydroxypropyl thiosulfate silica and ceraniol. <i>Ethyl acetate</i> <i>Acetone</i> <i>Toluene</i> <i>Acetonitrile</i>
	Manicuring/deep pedicuring products	Aqua, isohexadecane, paraffinum liquidum, glycerin, cetyl alcohol, bees wax, steareth-21, glycol distearate, steareth-2, parfum, propyl parabens, phenoxyethanol, methyl paraben, disodium EDTA, Wheat germ oil, shear butter, acrylates, ethyl acetate, C10-30, alkyl acrylates crosspolymer, tocopheryl acetate, panthenol, rose extract, triethanolamine and BHT. <i>Ethyl acetate</i> <i>Propyl parabens</i> <i>Methyl parabens</i> <i>Triethanolamine</i>

The awareness of precursors to chemical weapons was generally low, with only 4.7% of the participants reporting that they were aware. This indicated a possibility of chemical diversion without the suppliers' and attendants' knowledge. Such cases have been reported in Syria, where Isopropanol, a common cosmetic solvent, was used for the preparation of sarin and chlorine gas against civilians during a civil war [33].

3.3. Chemical Safety Measures

To ensure safety due to the risks posed by chemicals identified in **Table 2**, includ-

ing flammability, corrosivity, respiratory effects, eye irritation, and concentration of chemicals, beauty care facilities were expected to put in place adequate measures such as fire extinguishers and alarms, gloves, masks, face shields, and proper ventilation systems. **Figure 2** below shows a bar graph of the percentage of beauty care facilities implementing each of the above measures. Beauty care facilities implemented various safety precautions, with most beauty care facilities implementing the use of gloves and ensuring proper ventilation systems. About 60% of the facilities used masks for respiratory protection and had fire safety measures in place. A smaller percentage of the facilities used face shields.

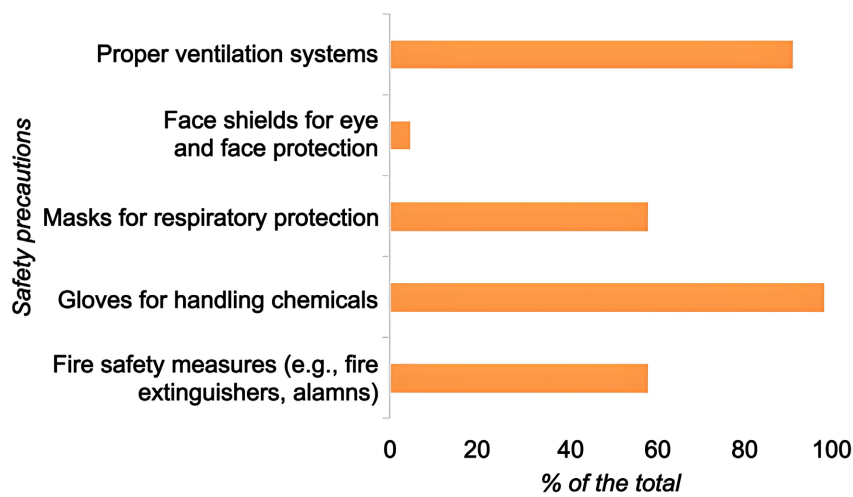


Figure 2. A clustered bar graph showing the percentage of beauty care facilities employing various safety measures.

Most facilities reported that personal protective equipment (PPEs) was provided occasionally or never. Only 37.2% were always provided with PPEs, and when provided, only 27.9% used them regularly. The PPEs used were mostly inappropriate; for example, most salons use latex gloves to handle all their chemicals. Additionally, the usage of PPEs was inconsistent, which left the attendants vulnerable to chemical exposure. Nearly half of the attendants working in the facilities felt neutral or unsatisfied with the current chemical safety measures.

3.4. Health and Safety Concerns

On average, attendants spent 6.26 hours working with chemicals daily. Identified health effects included skin irritations/rash, eye irritation, respiratory problems including coughing & shortness of breath, headaches/dizziness, and nausea/vomiting. The most prevalent effects were skin irritation and respiratory problems. These health effects were directly linked to chemical exposure and have been reported in the literature [34] [35]. The data is shown in **Figure 3** as a bar graph.

Despite the health risks, few had undergone medical examinations related to chemical exposure. Out of the 43 facilities, only 14% had conducted medical ex-

aminations for their staff at least once since they were onboarded. More than half (51.2%) of the respondents thought their work environment was unsafe or neutral to chemical exposure. Similar results have been reported in other studies in Kuwait [34], and such exposure has also been linked to reproductive disorders [36].

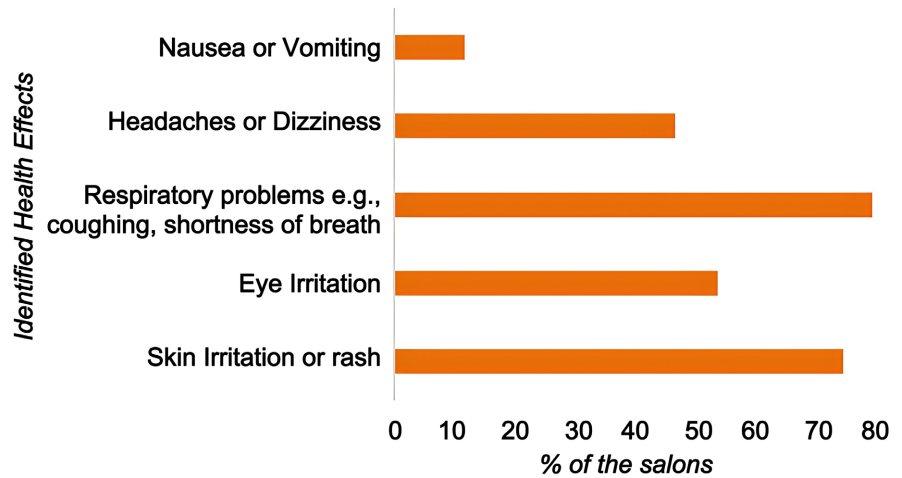


Figure 3. A clustered bar graph showing various health effects reported in the facilities.

3.5. Waste Management Practices

Nearly all beauty facilities generated wastes classified by type per the Sunburst chart in **Figure 4** below. Despite generating hazardous, non-hazardous, solid, and liquid wastes, they were not usually segregated. Most liquid wastes were disposed of directly in sewer systems without monitoring the levels of hazardous chemicals, thus endangering aquatic life. About 90.7% of the facilities did not segregate their

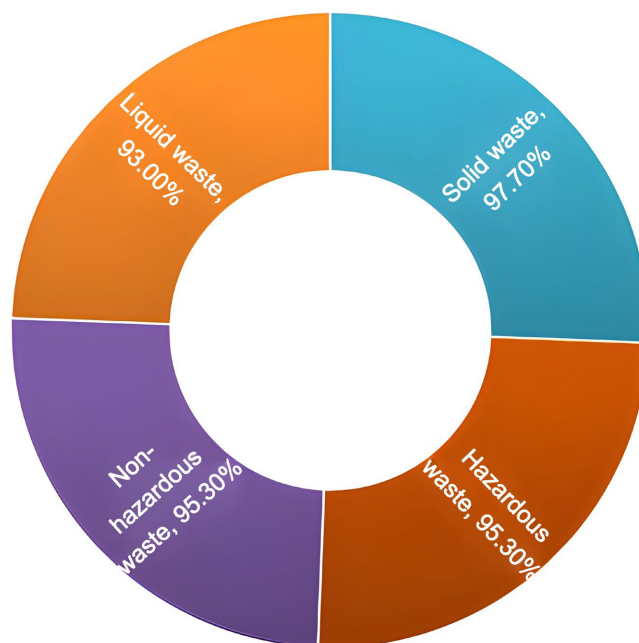


Figure 4. Sunburst chart showing the types of wastes generated in the facilities.

solid wastes or did it partially. This could result in an interaction between wastes, form secondary pollutants and complicate recycling efforts. Most beauty care facilities have reported disposal in regular bins (88.4%), and waste storage for later disposal (72.1%), which only exacerbates the problem of secondary interaction.

Disposal methods varied, and there were concerns about the adequacy of their current waste management practices, with more than half (51.2%) of the respondents reporting that the waste management approaches were either inadequate or they were unsure. Similar studies in Rustenburg, South Africa, have reported a lack of waste facilities and knowledge about waste management, which also manifests in this study [37].

3.6. Training, Knowledge, and Awareness

Formal chemical safety and handling training was found to be limited, and knowledge about chemical hazards varied. 62.8% had never received training on chemical safety, and out of the 37.2% who had been trained, 68.8% trained only once during onboarding. 60.5% of the respondents knew the potential hazards of the chemicals they work with, and 81.4% believe that more training and chemical safety awareness could improve safety standards in their facilities. These results agree with studies conducted in Coimbatore, India [38] and Limpopo, South Africa [39].

3.7. Compliance with Regulations

Compliance with health and safety regulations is inconsistent among beauty care facilities. 76.8% of the respondents were unfamiliar with the Occupational Safety and Health Act (OSHA) and its relevance to their work. 76.7% of the beauty care facilities partially complied with health and safety regulations, 7% did not comply, and 16.3% fully complied. The study highlighted the need for localization of national policies such as OSHA and its relevance to the beauty industry. Such gaps in implementing OSHA legislation have been reported in other sectors, including the sugar industry [40] and manufacturing industries in Kenya [41].

3.8. Chemical Security Awareness

3.8.1. Chemical Storage, Access, Tracking and Monitoring

Table 3 below summarizes the key findings on chemical storage, tracking, and monitoring.

More than half of the beauty care facilities stored their chemicals securely and inspected expiry dates, damage, or leakage for economic reasons to prevent losses. Notwithstanding, only 14% had systems for tracking and monitoring chemicals used, only 25.6% stored chemicals according to their compatibility, 25.6% had controlled access to chemicals, and another 14% had a designated person managing chemical safety and security.

Generally, chemical storage practices were not secure, with limited tracking and monitoring systems. Access to chemicals was not consistently restricted to author-

ized personnel. These beauty facilities risk unauthorized use, misuse, and potential security breaches. Failure to comply with regulatory requirements regarding handling chemicals and inadequate inventory management could result in waste, and ineffective tracking could lead to slow response in emergencies [42].

Table 3. Key findings on chemical storage, access, tracking, and monitoring.

Prompt	Yes (%)	No (%)	Not Sure (%)
Are chemicals stored securely in the salon?	55.8	41.9	2.3
Are chemicals stored according to their compatibility and safety guidelines?	25.6	74.4	0.0
Are chemicals regularly inspected for expiration, damage, or leakage?	79.1	20.9	0.0
Do you have a system for tracking and monitoring chemicals used in the facility?	14.0	79.1	6.9
Is access to chemicals restricted to authorized personnel only?	25.6	74.4	0.0
Do you have a designated person responsible for managing chemical safety and security?	14.0	86.0	0.0

3.8.2. Chemical Safety and Security Protocols Availability

Table 4 below summarizes the key findings of chemical information availability.

Table 4. Chemical information availability.

Prompt	Yes (%)	No (%)
Do you have written procedures or guidelines for safely handling chemicals used in the facility?	4.7	95.3
Are there emergency procedures in place for chemical spills or accidents?	7.0	93.0
Do you frequently review and update chemical safety and security protocols?	9.3	90.7

The results showed the lack of standardized safety and security protocols, as most beauty care facilities did not have procedures and guidelines for safer handling of chemicals or emergency procedures for chemical spills and accidents. The few with the protocols did not frequently review and update the safety and security protocols. Only 9.3% of those with the protocols reviewed them when needed. In determining the facilities' preparedness for preventing chemical misuse, accidents, or sabotage, 79% of the beauty care facilities were either neutral or unprepared. Similar reports have also been reported by the Coalition to Prevent Chemical Disasters' reports [43].

3.9. Correlation Studies

Table 5 below summarizes the results of the Spearman Rank-Order Correlation for a sample size of $n = 43$.

Table 5. Spearman rank-order correlation results.

		B	C	D	E	F	G	H
A	r	0.558	-0.105	0.0345	0.294	0.0714	-0.137	-0.0315
	p-value	0.000114	0.503	0.825	0.0554	0.647	0.379	0.840
B	r		0.0371	-0.0334	0.130	0.347	-0.0564	-0.264
	p-value		0.812	0.831	0.402	0.0230	0.718	0.0869
C	r			-0.0809	-0.349	0.113	-0.515	-0.236
	p-value			0.604	0.0222	0.471	0.000453	0.127
D	r				0.448	0.106	0.208	0.156
	p-value				0.00275	0.495	0.179	0.317
E	r					0.0600	0.0284	0.355
	p-value					0.701	0.856	0.0196
F	r						-0.112	-0.384
	p-value						0.471	0.0113
G	r							0.367
	p-value							0.0158

KEY: **A** = Satisfaction with safety measures, **B** = Frequency of PPE usage, **C** = Whether health issues were reported or not, **D** = Training, **E** = Knowledge about chemical hazards, **F** = Waste segregation, **G** = No. of health issues reported, and **H** = the time attendants spent working with chemicals. (p-value is significant at $p = 0.05$)

From the results of correlation studies, a moderate positive correlation was observed between the frequency of PPE usage and satisfaction with safety measures ($r = 0.558$ and $p\text{-value} = 0.000114$). This showed that salons that used PPE frequently were noticeably satisfied with the safety measures in place. Studies conducted in Kashan City, Iran, on personal protective equipment usage and its correlation with knowledge, attitudes, performance, and safety culture among workers in small and medium-sized enterprises [44], and a cross-sectional study on Knowledge, attitude and practice related to chemical hazards and personal protective equipment among particleboard workers in Ethiopia [45], have reported similar results. Though small salons cannot afford to provide PPE supplies consistently, workers who use PPE and are in stable work conditions associate PPE usage with overall safety satisfaction. Culturally, salons that enforce PPE use have management that is perceived as caring and thus have boosted morale towards work.

The correlation between frequency of PPE usage and waste segregation practices showed a weak positive correlation of $r = 0.347$ with $p\text{-value} = 0.0230$. Consequently, salons that used PPE frequently were likely to segregate wastes. Similar results have been reported in a study of healthcare workers and large-scale factory workers, respectively, in Ethiopia [46] [47]. Salons that invest in PPE often have better waste management infrastructure, but segregation could remain weak due to limited municipal waste services or training gaps in waste management. Cul-

turally, the links remain weak since the workers may emphasize using PPE as personal protection, while viewing waste management as the facility owner's responsibility.

A weak negative correlation has been reported for the number of health issues reported and the knowledge about chemical hazards ($r = -0.349$ and $p\text{-value} = 0.0222$). This showed that attendants with limited knowledge of chemical hazards reported noticeable health issues. Insufficient knowledge about chemical hazards and safety practices contributed to a lack of confidence in self-protection measures. This gap in knowledge has been linked to increased vulnerability to chemical exposures and associated health risks. Similar results have been reported in a study of textile dye workers in Abeokuta, Nigeria [48], and in a study of laboratory workers in Italy [49]. Low-income workers lack formal training and could face language barrier issues, so they learn through apprenticeships that view safety as secondary to skill to gain. Most SDS are often in English and may not be clear to those not conversant with the language. Culturally, health symptoms such as skin irritation may be dismissed as normal occupational hazards, reducing motivation to seek knowledge. Further, historical neglect of informal sectors breeds skepticism about safety advice from officials.

The correlation between training and knowledge about chemical hazards showed a moderate positive correlation of $r = 0.448$ with $p\text{-value} = 0.00275$. Thus, salon attendants who received training were noticeably knowledgeable about chemical hazards. Similar results have been reported in a study of beauty salon workers in Polokwane, South Africa [39]. Varied employer incentives, such as the capacity to sponsor training for employees, create safety knowledge gaps between employees. Culturally, traditional training focuses on technical skills rather than hazard education. Further, age hierarchy worsens collective facility safety measures as younger workers may defer with experiences over outdated practices.

The correlation between the time attendants spent working with chemicals and the knowledge about chemical hazards, and the time the attendants spent working with chemicals and waste segregation showed weak positive correlations of $r = 0.355$ ($p\text{-value} = 0.0196$), and $r = -0.384$ ($p\text{-value} = 0.0113$), respectively. Accordingly, attendants who spent more time working with chemicals were more knowledgeable about chemical hazards, but were less likely to segregate waste. Similar studies of dye workers in Nigeria [48] and a study of healthcare workers in Uganda suggested that workers with higher exposure scores had significantly better knowledge about chemical hazards, and increased exposure and training might lead to complacency or overconfidence, negatively impacting waste segregation behaviors [50]. Long-hour workers paid on a daily basis may not refuse hazardous tasks; they gain knowledge through harsh experiences, but neglect secondary protocols such as sorting waste. Culturally, veteran workers may develop false confidence from surviving prolonged exposure, ignoring safety protocols, while time-pressured services based on clients' demands may prioritize speed over safety.

From $r = -0.515$ ($p\text{-value} = 0.000453$) between whether health issues were re-

ported and the number of health issues shows an inverse correlation. Alternatively, the time the attendants spent working with chemicals and the number of health issues they reported were correlated by a weak positive correlation of $r = 0.367$ and $p\text{-value} = 0.0158$. Hence, the attendants who spent more time working with chemicals reported more health issues. Similar results have linked the number of health issues and the time spent working with chemicals to the lack of visibility and precarious employment conditions [51]. Low-wage workers may tolerate health risks to retain jobs in a competitive market where they lack insurance and treat symptoms ad hoc instead of seeking preventive care. Culturally, stigma and normalization of pain remain. Reporting health issues may be labelled as weakness discouraging complaints, while chronic health conditions may be treated as occupational trade-offs, respectively.

The socioeconomic and cultural barriers highlighted in the correlations reflect the Nairobi's beauty economy realities where cultural norms, poverty & gender intersect to shape chemical and occupational safety, and chemical security behavior.

4. Conclusions

The study revealed significant chemical safety and security challenges in beauty care facilities across Nairobi City County, Kenya. Without sufficient adherence to safety standards, a wide range of cosmetic products containing chemicals of concern and potential precursors to chemical weapons were commonly used. The usage and enforcement of chemical safety and security measures remain inconsistent and inadequate.

Major contributors to the widespread health concerns among salon attendants, such as respiratory issues, skin irritation, and eye discomfort, include prolonged exposure to hazardous chemicals, lack of formal training, and limited use of PPE. Inadequate waste management, particularly the failure to segregate hazardous and non-hazardous waste, further exacerbates the environmental and public health risks. Moreover, the study found a moderate link between inadequate training and low levels of chemical hazard awareness, which in turn correlated with increased health issues and poor safety practices.

Chemical security was notably weak, with most facilities lacking protocols for secure storage, access control, and inventory tracking. The absence of emergency response procedures and written safety guidelines points to a broader gap in preparedness and compliance with national regulations such as the Occupational Safety and Health Act (OSHA) and international indicative guidelines for the SMEs from the OPCW.

Overall, the findings underscore the urgent need for targeted regulatory enforcement, continuous training, improved chemical safety infrastructure, and awareness campaigns to enhance the health, safety, and security of salon workers, clients, and the broader community.

5. Recommendations and Further Research

From the research findings, the following are recommended:

1) Compulsory and periodic training programs should be implemented for all beauty care workers on safe handling, chemical hazard identification, and emergency response. Supplementary modules on PPE usage, reading safety data sheets (SDS), and spill management should be included.

2) Regulatory bodies such as DOSHS and local government, such as Nairobi City County (NCC) government, should:

i) Actively audit and enforce compliance with the Occupational Safety and Health Act, OSHA 2007, and the OPCW indicative guidelines tailored for small and medium enterprises.

ii) Educate workers on potential risks associated with cosmetic chemicals and empower them to adopt safer products and environments.

iii) Require that safety compliance be a requisite for licensing and renewing operation permits for beauty care establishments.

3) The management of beauty care facilities should:

i) Maintain the chemical inventory system with proper labelling, tracking expiry checks, and restricting access to hazardous chemicals, and assign a chemical safety officer for oversight.

ii) Ensure enough and appropriate PPE is available and introduce routine monitoring of PPE compliance and usage.

iii) Establish regular medical checkups, particularly for dermatological, respiratory, and reproductive health effects linked to chemical exposure.

iv) Develop and enforce waste segregation protocols, discourage chemical disposal into drainage systems, promote adoption and use of color-coded bins, and work with licensed waste handlers.

Further research should be done on chemical risk quantification, the effectiveness of substitution and safer chemical product alternatives, the impact of policy localization and decentralized enforcement, and chemical diversion risk assessment.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

Data Availability Statement

The data supporting the outcome of this research is available through this link:

<https://docs.google.com/forms/d/1xRNXM3HUVEN5pazM7krEeHmwn-LLHEQ7S9-zu1YxcTk4/edit#responses>

The Excel sheet with entered data can be accessed at:

https://docs.google.com/spreadsheets/d/1AzOy_ihJsxsH8rF4Hwojrt-GeLxdYVhc4rVUj1oO7aw/edit?resourcekey=&gid=619509666#gid=619509666

More numerical data on correlation studies can be requested from the corresponding author.

Author Contributions

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tion, Data Entry and Analysis, Methodology, Software, Validation, Visualization, Writing - original draft.

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Acknowledgements

The authors sincerely thank the Kenya Chemical Society for providing a permit to carry out this research.

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Abbreviations

CoCs—Chemicals of Concern

NIOSH—National Institute for Occupational Safety and Health

OPCW—Organization for the Prohibition of Chemical Weapons

OSHA—Occupational Health and Safety Act

PPEs—Personal Protective Equipment

SDS—Safety Data Sheet

SMEs—Small and Medium Enterprises