

Pharmacy Infection Control: Environmental and Workplace Policy

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ABSTRACT

Objectives: In this study, we aimed to illustrate pharmacy infection control environmental and workplace policy as a new initiative in Saudi Arabia. **Methods:** This is a narrative review. It relates to pharmacy infection Prevention and control. The following databases were searched for literature review-medline, PubMed, and Google Scholar. Topics were explored in line with the objectives of the study. The period of the search was from 1960 to October 2021. The search language was English. The literature search included narrative review, systemic review, meta-analysis, and related guidelines. The search also included policies related to hospitals as well as community pharmacy services. A research team was formed. It included clinical pharmacists, expert pharmacists, and infection control specialists. The policy was drafted by the some authors. The other pharmacists were vested with the responsibility of reviewing the draft. The infection control specialist reviewed issues related to the field of its specialty. The review highlighted pharmacy environmental Infection Prevention and Control (IPC) and workplace policies and procedures. **Results:** The environmental and workplace policies of pharmacy infection control consisted of various items. For example, policies regarding the handling of carpet and furniture, clothes, water and solutions, air handling systems, sinks and toilet, and the kitchen. In addition to the maintenance of sterile and nonsterile compounding areas, the point of dispensing at ambulatory care services, drug distribution at inpatient pharmacy, and the types of disinfectants to be used, including their indications and safety. **Conclusion:** Environmental and workplace policies and procedures are new initiatives for Pharmacy Infection Prevention and Control (PIPC) in Saudi Arabia. Such initiatives would keep the preparation of medication and dispensing area clean and sterile by preventing the growth of any bacteria or any other microorganisms. The quality of safe drug dispensing and patient safety are being ensured too. Therefore, environmental and workplace policies are highly recommended for implementation in Saudi Arabia.

Keywords: Pharmacy, Infection control, Environment, Workplace, Saudi Arabia.

INTRODUCTION

A clean environment is a necessary aspect of preventing hospital-associated infections. Several factors can affect the transmission of diseases, such as healthcare facilities, water, air quality, laundry systems, and waste management.¹⁻³ To achieve a low microbial environment, regular cleaning of textiles (e.g., chairs, lab coats, scrub suits, and curtains) and housekeeping surfaces (e.g., floor, sidewalls, tables, and door handle) is mandatory. The sterilization process is also essential for many reasons. One of the medical reasons is to avoid complications during patient care, and the non-medical reasons are to improve the quality of services. The reasons for preventing and controlling hospital-associated infections are as follows: 1) to protect the host from disease-causing pathogens; 2) to use the disinfectants in an appropriate concentration when required, and 3) to break the chain of disease transmission, known as the "Epidemiologic Triangle (agent, host, and environment)".⁴ Modifying the inanimate environmental sources is intended to interrupt infection transmission.¹⁻³ Therefore, the schedule for cleaning and disinfecting the surfaces should be more frequent. Many factors affect the efficacy of the cleaning and disinfection process, such as load, type, and site of microbes; microorganism's ability to resist the disinfectants; the cleaning step before disinfection; the nature

of the equipment; and the style, concentration, potency, and exposure time of the disinfectant.^{1,5} Nosocomial infections are those infections that a person gets in a healthcare facility; in other words, these infections are not recorded in a patient at the time of admission. Nosocomial infections are also referred to as healthcare-associated infections (HAIs). Some of the reasons for nosocomial infections, especially in developing countries, are poor environmental hygiene and waste management system, inadequate equipment, lack of knowledge and practice of necessary infection control measures, and lack of procedures.^{1-3,6-7}

Unfortunately, infection control has not experienced a parallel with the development of pharmacy settings compared to other hospital-established infection control. As a result, insufficient data describes infection control policies and procedures in pharmacy settings. A recent cross-sectional survey study addressed the awareness and response of community pharmacists toward infection and sanitation control during the COVID-19 outbreak. According to their results, out of 137 pharmacists, 34% did not practice infection control measures well; around 48% were not using the gloves when cleaning, observing, or almost 19% only among then performing the sanitation procedures;⁸

and. Furthermore, pharmacists participating at the community level is essential in preventing blood-borne infections, including hepatitis (C and B) viruses and HIV, by counseling patients about safe needle disposal.⁹ Various studies have discussed the infection control guidelines and regulations concerning the environmental and workplace policies in a healthcare organization.^{1-3,10} However, there are no studies on pharmacy infection control measures emphasizing environmental and workplace policies to the best of our knowledge. Therefore, in this review, we focused on outlining the basic principles of environmental infection control and prevention in the pharmacy care department.

MATERIALS AND METHODS

It is a narrative review of pharmacy infection control. The literature search was performed using various databases, including PubMed, Medline, and Google Scholar, about specific topics related to infection control in pharmacy practice. The search period was from the 1960s until October 2021. The searched terms were in English and included narrative review, systemic review, meta-analysis, and guidelines. Policies of the last 10 years were explored across all hospitals or community pharmacy services. The pharmacy services included inpatient, outpatient, or ambulatory care pharmacy, satellite pharmacy, extemporaneous preparation, repackaging units, pharmacy store, drug information center, and clinical pharmacy services. Moreover, the national and international guidelines of infection control in pharmacy and hospital practice were used as guides for writing the review,^{11,12} including guidelines from the Centers for Disease Control and Prevention (CDC) of the United States of America, the Saudi Center of Diseases Control (SCDC), General Directorate of Infection Prevention and Control in Healthcare Facilities (GDIPC), American Society of Health-System Pharmacist (ASHP), and World Health Organization (WHO), and the United States Pharmacopeia (USP).^{3,5,13-24} The committee of pharmacy infection control consists of various experts, including clinical pharmacists, community pharmacists, and infection control specialists. Some authors drafted the policy guidelines, and the other authors reviewed them. The infection control specialist revised the draft. The policy included topics including environmental and workplace policy emphasizing the current review, staff immunization, occupational safety, basic pharmacy hygiene, quality of pharmacy infection control, competency of pharmacy infection control, and education and training of pharmacy infection control. The Appraisal of Guidelines, Research, and Evaluation (AGREE) guided the reporting of the results of this review.²⁵

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RESULTS

The pharmacy staff should review Steps’ suggested policy and procedures for cleaning, disinfection, and sterilization in the pharmacy setting for implementation in practice. The pharmacy staff should be aware of some terms, Symbols, and Abbreviations definitions used in pharmacy infection control, as explored in table 1 and 2.

Table 1: Some term definitions used in pharmacy infection control environmental and workplace.

Definitions	
Anti-room:	ISO Class 7,8, or cleaner room where garbing procedures, personnel hand hygiene, and other activities generate high particulate levels.
Biofilm:	A concentrated mass of bacteria and extracellular material is firmly adhered to a surface and cannot be removed.
Buffer-room:	ISO Class 7 or better air quality under negative pressure where PEC(s) generate and maintain an ISO Class 5 environment is physically located.
Category1: A	It compounded sterile preparation assigned a Beyond-use date of ≤12 hr in controlled room temperature or ≤ 24 hr refrigerated.
Category2:	A Compounded sterile preparation assigned a Beyond-use date of >12 hr in controlled room temperature or > 24 hr refrigerated.
Classified area:	A place with an air quality classification based on the ISO standards.
Cleanroom:	A classified place consists of both an ante-room and buffer room.
Cleaning:	Removing organic and inorganic material from objects and surfaces is usually performed manually or mechanically using water with detergents or enzymatic products.
Cleaning agent:	Products are used to remove residues from surfaces.
Critical items:	Items access sterile tissue or the vascular system.
Disinfectant:	Products are used on surfaces and items to destroy fungi, viruses, and bacteria.
Disinfection:	The removal of numerous or all pathogenic microorganisms.
Housekeeping surfaces:	floors, walls, and tabletops
ISO class:	Classification of air quality from the International Organization for Standardization.
Medical/ Pharmaceuticals equipment surfaces:	knobs or handles on Unit Dose machines, compounding machines, instrument carts, and j cabinet.
Noncritical items:	items used in contact with intact skin but not mucous membranes.
Negative pressure:	room air is blocked from moving out of the room and into adjacent areas
One-step disinfectant cleaner:	A product with an EPA-registered (or equivalent) can clean and disinfect a non-porous surface in one step.
Pass-through:	It is located between two places to minimize particulate shift while moving materials from one space to another
Positive pressure:	room air from passageways and adjacent areas is restricted from accessing the room.
Segregated compounding area (SCA):	A designated, unclassified area with a fixed perimeter includes a PEC and is specific for the preparation of Category 1 CSPs only.
Semi-critical:	Items contact mucous membranes or non-intact skin.
Sporicidal disinfectant	products are considered a particular type of disinfectant that also are active against bacterial and fungal spores.
Sterilization:	A method that kills or eliminates all forms of microbial life.

Table 2: Some symbols and abbreviations definitions used in pharmacy infection control environmental and workplace.

Symbols and Abbreviations			
EPA	Environmental Protection Agency	HVAC	Heating, ventilation, and air conditioning
FDA	Food and Drug Administration	ACPH	Air changes per hour
SFDA	Saudi Food and Drug Administration	CSPs	Compounded sterile preparation
WHO	World Health Organization	CVE	Containment ventilated enclosure
CDC	Centers for Disease Control and Prevention	BSC	Biological safety cabinet
ISO	International Organization for Standardization	CACI	Compounding aseptic containment isolator
PPE	Personal protective equipment	SCA	Segregated compounding area
HDs	Hazardous drug	CNSP	Compounded nonsterile preparation
PEC	primary engineering control	APIs	Active pharmaceutical ingredients
IPA 70%	Isopropyl alcohol	HEPA	High-efficiency particulate air

Cleaning, disinfection, and sterilization procedures

General principles^{1-3,5-7,13-22}

All the following recommendations can be applied at all units, including inpatient and outpatient pharmacy, IV room, narcotics and controlled office, drug information office, clinical pharmacy office, extemporaneous preparation area, repacking room, medications safety officer, pharmacy quality management office, and pharmacy store, and patients waiting for place and patients counseling room.

1. Regular cleaning scheduling is essential to ensure a clean, dust-free pharmacy environment.
2. More frequently touched surfaces in the pharmacy need to be cleaned more regularly.
3. Special consideration should be given to heavily contaminated areas.
4. Cleaning is a necessary step for the optimal disinfection process.
5. Natural detergent solutions should be used for effective cleaning [Reference?].
6. Follow manufacturer instructions for use, dilution, compatibility, storage, shelf life, and disposal of disinfectants.
7. Different equipment should be used for other areas in the pharmacy setting.
8. An appropriate personal protective equipment (PPE) should be worn before cleaning.
9. Hand hygiene should be performed, and hand hygiene posters should be available and visible in pharmacy settings.
10. Droplet precautions should be considered, such as wearing the glasses or plastic panels at desk pharmacy counters with distant physical 2 meters between staff and patients.
11. Easy access to alcohol-based and handwashing solutions.
12. Spills of hazardous medications or other potentially harmful chemicals or infection materials should be appropriately cleaned and documented.
13. Maintain appropriate safe water supply (quantity, quality, and access) from the pharmacy setting.
14. Maintain proper air exchange per hour by natural or mechanical ventilation and monitor areas with special ventilation.
15. Follow the basic- working environmental infection control standards in all pharmaceutical and non-pharmaceutical wastages management activities.
16. Supplies and equipment must be available to perform primary pharmacy infection control.
17. Choosing the disinfectant agent to use for different surfaces or equipment in the pharmacy practice; depends on various factors such as heat-sensitive items/devices, concentration tests are available from the manufacturer, and spermicidal activities, as explained in Figures 1 and 2, and Tables 3-5
18. The surfaces should be left dry after cleaning.
19. All hard surfaces, including walls, floor, tables, and offices, should be cleaned with soapy water to remove dust, soil, and bleach (sodium hypochlorite, 5.25% diluted to 1:100), as explained in table5. It should be at least thrice per week and is preferable on the night shift when fewer people are around.
20. All soft surfaces should be cleaned with soap and bleach (1% sodium hypochlorite) during the early night shift at each pharmacy unit explained in Table 6.
21. All metal surfaces should be cleaned with soap and 60–70% isopropyl alcohol (IPA) thrice a week and daily, respectively. Cleaning should preferably be done in the early morning before the morning shift.
22. All housekeeping and toilets should be cleaned daily at night with soap and bleach (sodium hypochlorite 5.25 % to 1:100) as explained in Table 6.

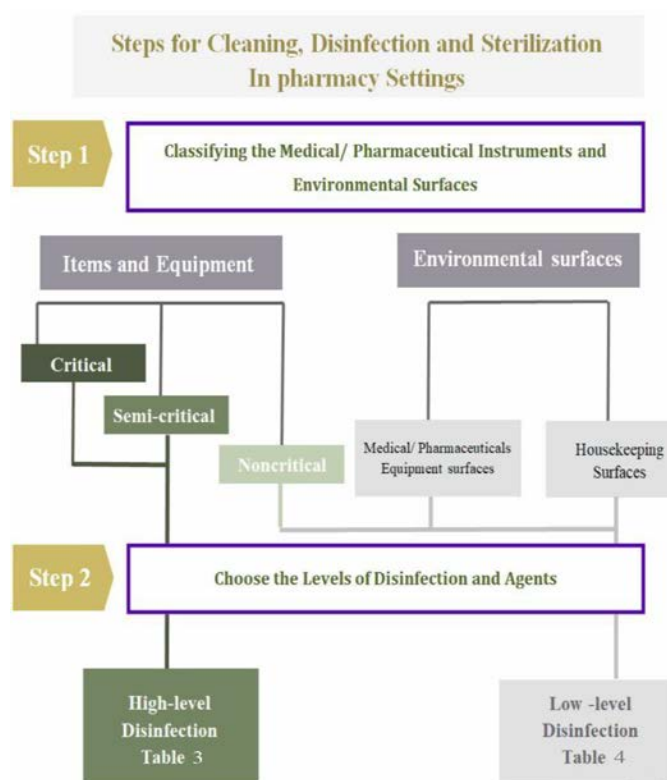












Figure 1: Flow diagram of choosing the disinfectant for environmental and workplaces.^{1-3,7,10,26,33,34}











23. All metal equipment at extemporaneous preparation units should be cleaned with soap and IPA (60–70%).
24. The pharmacy equipment used for unit dose preparation should be cleaned by hand with soap, IPA (60–70%), gloves, and a mask.
25. All pharmacy unit dose equipment should be cleaned daily with soap and disinfected with IPA (60–70%). The pharmacy should have two trolleys. The first one should be filled with a unit dose package and sent to the nursing unit. According to the healthcare institution's policy and procedures, the other should send back to the pharmacy unit with unfilled or unused medications.
26. Never dispense stock or bulk of medications for more than one patient; use a separated oral syringe for each dosing to maintain infection control for medication preparations.
27. The intravenous (IV) admixture room equipment should be cleaned daily with soap and disinfected with IPA (60–70%), emphasizing the sterile area.
28. Try to keep the laminar air flow hood (LAFH) operating continuously.
29. Keep monitoring and changing the high-efficiency particulate absorbing (HEPA) filter every 6 months with documentation.
30. Disinfect the entire area of LAFH with IPA (60–70%).
31. All rooms should be ISO 7 with class 100 for parenteral medication preparations according to Unite State Pharmacopeia 797 standards.
32. All members of the staff should clean their hands properly and wear surgical gloves with gowns before preparing the sterile medications
33. Do not drink, eat, or smoke in the preparation area.
34. Follow update 797 sterile compounding elements during the preparation of medications.
35. Air disinfection in all pharmacy rooms is not recommended for general infection control.
36. Hand sanitizers and IPA (60–70%) should be available beside

Table 3: Factors Influence the Choice of Disinfection Procedure for Environmental (High level).

High-level disinfection													
Type Of Microorganism	Agents	Contact Period	Monitoring										
Bacteria: Vegetative Tubercle bacillus Spores Fungi Viruses	Glutaraldehyde ¹ 2%	HLD: 20-90 min ² Sterilization: 10 h ²	Exposure time temperature test strips ³ Glutaraldehyde vapor										
	Accelerated ^{4,5,7} hydrogen peroxide 7% ^{2B}	HLD: 30 min ² Sterilization: 6 h ²	Test kits ³										
	Orthophthalaldehyde ^{1,4,5,7} (OPA) (0.55%)	HLD: 12 min at 20° & 5 min at 25 °C ₇ sterilization: no claim	Test strips ³										

1. For Heat-sensitive items/devices 2. Temperature at 20°–25 °C. 3. Concentration test are available from the manufacturer (daily or with each load) 4. Compatibility concerns with brass, zinc, copper, and silver 5. May cause eye damage with contact 6. Repeated exposure for bladder cancer patients may cause hypersensitivity 7. Slow spermicidal

Table 4: Factors Influence the Choice of Disinfection Procedure For Environmental (low level)

Low -level disinfection													
Type Of Microorganism	Agents	Contact Period	Monitoring										
Bacteria: Vegetative Fungi Viruses	Alcohols (60-95 %)	Not required	Not required										
	Chlorines ¹ and chlorine compounds	Not required	Not required										
	Accelerated ² Hydrogen peroxide 0.5-3 %	Not required	Not required										
	Iodophors	Not required	Not required										
	Phenolics ³	Not required	Not required										
	Quaternary ⁴ Ammonium com- pounds (QUATs)	Not required	Not required										

1. Should be used in well-ventilated areas 2. Contraindicated (do not use on copper, brass, carbon-tipped devices, and anodized aluminum) 3. Cause residual film on surfaces 4. Narrow microbicidal spectrum

the doors and near each preparation and dispensing area of all pharmacy departments and elevators.

37. Pests such as cockroaches, dogs, cats, flies, ants, snakes, scorpions, mosquitoes, mites, mice, rats, lizards, and pigeons should be controlled through the implement the following:
38. Use an air conditioner from outside to inside the housing unit.
39. Use pesticides periodically.
40. Keep the wall side clean with pesticides to prevent bugs or pathogenic microorganism transmission.
41. Use a door rubber gasket.
42. Keep all pharmacy unit stores free from all pests.
43. Never mix housekeeping bleach agents for additional cleaning or more potent disinfectant.

Carpeting and cloth furnishings.^{1-3,8,10,26-31}

1. Use good-maintained equipment to minimize dust when vacuum carpeting.
2. Deep cleaning of carpets and furniture should minimize the production of aerosols which leaves little or no residue.
3. Avoid carpeting in high-traffic zones or where spills are likely.
4. Must replace the carpet if blood and body liquids spill on the carpet.
5. To prevent the growth of the fungi, dry the wet carpet, and if it remains wet even after 72 hr, it should be replaced.
6. Maintain furniture in good condition.

Effective use of mops, cloths, and solutions^{1-3,10,13-14}

1. Cleaning solutions must be prepared daily or as needed and replaced frequently.

2. Mop heads are preferred to be made up of microfiber cloths as their capacity to absorb dirt and microorganisms is higher than the cotton ones. However, microfiber cloths are pH-sensitive and easily damaged by chlorine-base disinfectants. Moreover, they are expensive and require separate laundering from cotton or linens.¹⁴ Two- or three-bucket system for mopping is considered the best practice.^{13,14} The mop heads and the disinfectant solution used should be changed-
 - a. As per the requirements,
 - b. When soiled visibly,
 - c. After completion of cleaning of each isolation room,
 - d. After using every third patient room, or
 - e. Hourly.
 - f. All used mops should be sent for laundering daily.¹³
3. The mop head must be changed at the beginning of the day, as needed, or after cleaning up large blood spills or other body substances.
4. Mops and cloths should be cleaned after use and dried before reuse, or use disposable mop heads and materials.
5. Prevent contamination of mop heads and cleaning cloths by regular decontamination. Using heat disinfection with detergent and drying at 80°C for 2 hr daily or immersing the fabric in hypochlorite solution (4000 ppm) for 2 min should be done. Alternatively, dust-attracting mops (microfiber material) may be used, especially for critical care areas and high dependency units.

**Special areas in pharmacy
Hazardous Drug (HD)^{15,16}**

The personnel performing deactivation, decontamination, cleaning, and disinfection must wear PPE during chemotherapy.

1. All protective tools, including the Gloves and impermeable disposable gowns, eye protection and face shields, and respiratory



Figure 2: Some symbols and signs definitions used in disinfectant of environmental and workplaces.

- protection.
2. The decontaminated agents used should be applied through wipes wetted with the solution. The selection of deactivating, decontaminating, cleaning, and disinfecting agents must be appropriate for the type of HD as explained in Figure 3.

Cleaning and Disinfecting Steps^{16,27}

1. Deactivation: compound inactive by Environmental Protection Agency (EPA) registered oxidizers (e.g., sodium hypochlorite and peroxide formulations)
2. Decontamination: Physically remove Hazards material residue using alcohol, water, hydrogen peroxide, or sodium hypochlorite.
3. Cleaning: Remove organic and inorganic material from water, germicidal detergents, surfactants, and other chemical solvents.
4. Disinfection: Kill the microorganisms by using an appropriate concentration of alcohol.

Nonsterile Compounding Area^{1-2,27}

1. Work surfaces should be cleaned and sanitized at the start and end of each shift when spills occur and also when the surface is suspected or known to be contaminated.
2. Floors should be cleaned and sanitized daily when spills occur and

Table 5: Antimicrobials in Textiles.	
Agents	Comment
Triclosan	<ul style="list-style-type: none"> • It accumulates in the environment • Has adverse effects on marine life • Has potential risk on the endocrine system and found to be distributed in human tissues
Metallic Compounds (metallic silver, silver salts, silver-polymer composites, silver-impregnated zeolites, or silver nanoparticles, copper)	<ul style="list-style-type: none"> • The only antimicrobial solid surface that has gained EPA registration are copper alloys and polymeric • No copper implanted on textiles has received such EPA registration.
Titanium dioxide (TiO ₂)	<ul style="list-style-type: none"> • No antimicrobial activity without UV radiation and possibly deteriorate the textile under UV radiation
Quaternary Ammonium Compounds (QAC)	<ul style="list-style-type: none"> • A hospital disinfectant with tuberculocidal EPA registration. • QAC used in textiles are long-chained (12–18 carbon atoms), with a dominant compound being a linear alkyl ammonium QAC based on silane quaternary ammonium compounds
Polybiguanides	<ul style="list-style-type: none"> • Broad-spectrum antimicrobial with low toxicity • Antimicrobial efficacy is inhibited when cotton fabrics dyed with anionic reactive dyes
N-Halamines	<ul style="list-style-type: none"> • It has been used in many fibers, including cotton, polyester, polypropylene, acrylic, and nylon • Fast-acting • Staining and odor on surfaces

when the surface is suspected or known to be contaminated.

3. Walls should be cleaned and sanitized once every 3 months or when spills occur or when the surface is suspected or known to be contaminated.
4. Ceilings should be cleaned and sanitized when visibly dusted or soiled and when the surface is suspected or known to be contaminated
5. Storage shelving should be cleaned and sanitized once every 3 months or when spills occur or when the surface is suspected or known to be contaminated.

4. Floors should be cleaned and disinfected daily.
5. Wall, door, door frame, ceiling, storage shelving, and bins should be cleaned and disinfected monthly.
6. Spermicidal should be applied at all sites mentioned above every month.

Sterile Compounding Area^{13,15-16}

1. Personnel performing decontamination, cleaning, and disinfection, must take appropriate steps to minimize microbial contamination, including wearing PPE and following hand hygiene.
2. Pass-through should be cleaned and disinfected daily.
3. Worksurface outside the primary engineering control should be cleaned and disinfected daily.

Cleaning and Disinfecting Steps for Sterile Compounding Area.⁵

1. Visible items, particles, or remains should be removed using sterile water (for injection or irrigation) using low-lint, sterile wipers.
2. Apply a cleaning agent, then disinfecting agent by low-lint, sterile wipers, or EPA-registered one-step disinfectant cleaner to all Primary Engineering Control (PEC) interior surfaces.
3. Apply a sporicidal agent or an EPA-registered one-step disinfectant sporicidal cleaner.
4. Should implement manufacturer contact time that needs for agents for complete disinfectant properties.
5. Apply sterile IPA (70%) to all interior surfaces of the PEC with low-

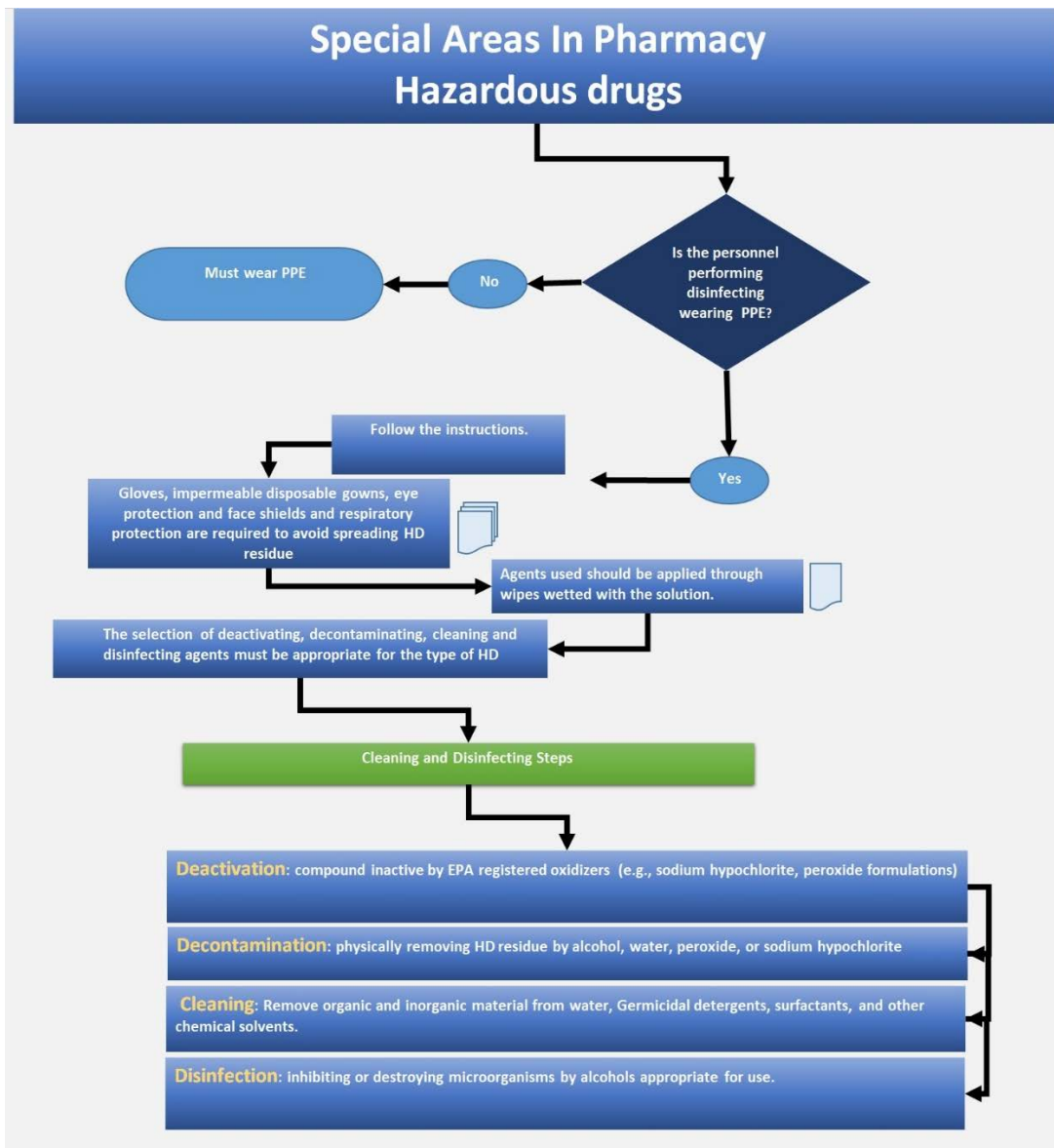


Figure 3: The personnel performing steps of deactivation, decontamination, cleaning, and disinfection during chemotherapy flow chart.

Table 6: Sodium hypochlorite preparation.

Sodium hypochlorite type	Chlorine concentration	Amount of Sodium hypochlorite	Amount of water	Final concentration
Liquid bleach	3.5%	1 part	6 parts	0.5%
		1 part	2.5 parts	1%
		1 part	0.7 parts	2%
liquid	5%	1 part	9 parts	0.5%
		1 part	4 parts	1%
		1 part	1.5 parts	2%
NaDCC* powder	60%	8.5 g	1 litre	0.5%
		17 g	1 liter	1%
		34 g	1 liter	2%
NaDCC 1.5g / tablet	60%	6 tablets	1 litre	0.5%
		11 tablets	1 litre	1%
		23 tablets	1 litre	2%
Chloramine powder	25%	20 g	1 litre	0.5%
		40 g	1 liter	1%
		80 g	1 liter	2%
Household bleach	5.25% - 6.00% - 6.15%	1.5 cups ¹	1 gallon ²	10% (1:10)
		0.25 cup ¹	1 gallon ²	1%(1:100)

*sodium dichloroisocyanurate

¹ 1 cup =250 ml

² 1 gallon =3.78541 L

Table 7: Definition of ISO level and workplace in the pharmacy setting.

The separate operational	ISO Class	Particle Count (particles per cubic meter (p/m))
Category 1 and Category 2 areas	5	3,520
Anterooms negative pressure Buffer room	7	352,000
Anterooms positive pressure	8	3,520,000

lint, sterile wipers.

- Ensure that the completely dry area before beginning the compounding of sterile medications.

Air-Handling Systems in Pharmacy¹⁻³

General principles:

- Ensure optimal performance of ventilation systems (removal and elimination of particulates and excess moisture).
- Monitor air conditioning through the Heating, Ventilation, and Air-Conditioning System (HVAC) filters, ventilation, and heat to prevent air leakages and dust overloads.
- Daily monitor negative air pressure with documentation.
- Seal windows, doors, and air intake and exhaust port properly.
- Install self-closing doors.
- Avoid using fans in high-risk areas (they can spread airborne pathogens).
- To reduce the potential for microbial proliferation, incorporate a

Table 8: Limiting amounts of water contaminants.

Contaminant	values
PH	6.5 to 8
Evaporation residue	≤15 mg/L
Conductivity	≤ 50 µs/cm
Hardness	≤ 0.1 mmol/L
Chloride	≤ 3 mg/L
Iron	≤ 0.2 mg/L
Lead	≤ 0.05 mg/L
Phosphate	≤ 0.5 mg/L
Silica	≤ 2 mg/L
Other heavy metals	≤ 0.1 mg/L

steam humidifier.

- Air intake and exhaust outlets should locate appropriately in the construction of new facilities and renovation of existing facilities:
- Exhaust outlets should be at >25 ft. from air-intake systems.
- The outdoor air intake should be at ≥6 feet above ground or ≥3 feet above roof level.
- To minimize exhausted air recirculation, exhaust outlets from contaminated areas should be above the roof level.
- Bag dust-filled filters should immediately be removed to prevent the dispersion of fungal spores and dust:
- Close or seal the discarded filter containing the bag.
- Discard the filter as regular solid waste, regardless of the area from which they were removed.
- To prevent mites and fungal spores from penetrating the ventilation system, remove bird roosts and nests near air intakes.
- Always keep emergency doors and exits from PE rooms closed except during an emergency; equip emergency doors and exits with alarms.
- A contingency plan for backup capacity in a general power failure must be made.
- Once the system is operational, allow sufficient time for Automated Cleaning House (ACH) to clean the air.
- Provide ventilation to ensure equal or more than 12 ACH for renovated rooms and new rooms and ≥6 ACH for existing AII rooms.

Non-sterile Compounding Areas⁵

- The temperature, lighting, humidity, and ventilation should be appropriate and must not directly or indirectly impact the products during their compounding and storage.
- Pipework, light fittings, ventilation, and other services should be designed and sited to avoid creating difficult to clean recesses. In addition, the maintenance process should be accessible from outside the manufacturing or compounding areas.
- Compounding personnel must monitor temperatures in the storage area at least once daily on days that the facility is open or by a continuous temperature recording device to determine whether the temperature remains within the appropriate range and documented
- All temperature monitoring equipment must be calibrated or verified for accuracy as recommended by the manufacturer every 12 months if not specified by the manufacturer.

Sterile Compounding Areas^{1-3,5-6,10,16,26-28,30}

1. The ISO standards for air quality in controlled environments and workplaces at pharmacy units are defined according to the number of particles in the air, as explained in Table 7.
2. Sterile compounding facilities should be designed and controlled to provide the following:
 - i. proper lighting and a comfortable working environment.
 - ii. Cleanroom suite should be maintained at 20° or cooler and with a humidity of < 60% (monitor every day) (to reduce the risk for microbial proliferation and comfortable conditions for compounding personnel).
 - iii. Entrance to the Security Exchange Commission (SEC) should be restricted.
 - iv. Separate the anteroom and buffer room from the surrounding areas.
 - v. Control air balance between different ISO classification areas using airlocks and interlocking doors.
 - vi. Entries should be hands-free.
3. Only Category 1 compounding sterile preparations (CSPs) can be compounded in the segregated compounding area. In addition, they must be located away from unsealed windows and doors that connect to the outdoors and traffic flow.
4. Air changes per hour (ACPH) may need to be higher to maintain the required ISO classification and microbial state of control, depending on the following factors:
 - A) Number of personnel working in the area, particulates generated from activities, and equipment.
 - B) The room temperature, pressure, and equipment
5. The water column with 0.020-inch is required between each ISO classified area as minimum differential positive pressure. Between ISO classified area and the unclassified area should not be less than a 0.020-inch water column.
6. If preparing a Category 2 CSP from nonsterile components, pre-sterilization procedures, such as weighing and mixing, must be completed in no worse than an ISO Class 8 environment.
7. Pre-sterilization procedures must be performed in single-use containment glove bags, containment ventilated enclosure (CVE), Biological Safety Cabinet (BSC), or Compound Aseptic Containment Isolator (CACI) to minimize the risk of airborne contamination. CVE, BSC, or CACI used for pre-sterilization procedures must be certified at least every 6 months, and frequent maintenance/validation of the efficacy of filters should be performed (following manufacturer's requirements).
8. Components must be stored in closed containers under temperature, humidity, and lighting conditions consistent with those indicated in official monographs or specified by the suppliers or manufacturer.
9. ACPH Requirements for non-HD sterile compounding areas:
 - i. must supply a minimum of 30 total HEPA-filtered ACPH to ISO Class 7 rooms
 - ii. must supply a minimum of 20 total HEPA-filtered ACPH to ISO Class 8 rooms

Water -Handling Systems in pharmacy Facilities¹⁻³

- A. General principles
 - ⇒ Controlling and eliminating the spread of waterborne microorganisms and metals are requirements, as explained in Table 8.
 - ⇒ Practice hand hygiene to prevent the transfer of waterborne pathogens and use gloves as precautions.
 - ⇒ Clean and disinfect sinks and washbasins regularly using an EPA-registered product asset by facility policies.
 - ⇒ Hot water temperature should be at the highest temperature allowable by state regulations or codes, preferably ≥51°C (≥124°F), and cold water temperature at <20°C (<68°F).

- ⇒ To minimize the risk of burning, if the temperature of hot water is at ≥124°F (≥51°C), explore engineering options (e.g., install preset thermostatic valves in point-of-use fixtures).
- ⇒ If the temperature of the hot water cannot be above the range of 40.6°C–49°C (105°F–120°F) for hospitals, then chlorinate the water and flush it through the system.
- B. Water in sterile compounding facilities:
 - ⇒ The compounding sterile preparations (CSPs) prepared facility must be designed so that activities such as garbing and hand hygiene will not adversely affect the PEC's ability to function as designed.
 - ⇒ Sinks should enable hands-free use. Surfaces of the sink(s) must be cleaned and disinfected daily, and a sporicidal agent must be applied at least monthly.
 - ⇒ If compounding is not performed daily, the sink must be cleaned and disinfected before initiating compounding.
 - ⇒ In facilities with a cleanroom suit, place the sink inside or outside the anteroom for better hand hygiene. If the sink is outside the anteroom, it must be found in a clean space to reduce the risk of contamination into the anteroom.
 - ⇒ If the sink is inside the anteroom, it is better to place it on either the clean or the dirty side of the anteroom.
 - ⇒ In a facility with a segregated compounding area (SCA) design, the sink must be accessible but located at least 1 meter away from the PEC. In addition, the sink must not be located inside the perimeter of the SCA.
 - ⇒ When storage tanks are used, they should be routinely drained and disinfected.
 - ⇒ Water for injections should be produced, stored, and distributed to prevent microorganism growth, for example, by constant circulation at a temperature above 70°C.
- C. Water in nonsterile compounding areas:
 - ⇒ A hot/cold water supply and an easily accessible sink must be available for compounding.
 - ⇒ Before cleaning any equipment used in nonsterile compounding, the sink should be free of items and cleaned when visibly soiled.
 - ⇒ The plumbing system should be free of defects that may contribute to the contamination of any Compounded non-sterile preparations (CNSP).
 - ⇒ Pure distilled water or reverse osmosis water should be used for rinsing equipment and utensils.
 - ⇒ Distilled, deionized, and where appropriate, other water pipes should be sanitized frequently.
 - ⇒ The use of water in producing active pharmaceutical ingredients (API) should be determined to be suitable for its intended use.

Sinks used for decontamination should have the following characteristics:^{1-3,6,10,16-17,26-28,32}

- I. It should be large, deep, with water ports for flushing, and should be at an appropriate height for staff with minimal movement between steps.
- II. It should not be with an overflow.

Do not!^{1-3,5,10,13,16,27}

1. Avoids splashes in heavily contaminated areas
2. Avoid using fans in high-risk areas (they can spread airborne pathogens)
3. Avoid shutting down the entire HVAC system at one time.
4. Free-standing humidifiers and air conditioners must not be used within the classified area.
5. Avoid seals and sweeps at doors between buffer and anterooms.
6. Avoid placing decorative fountains and fish tanks.
7. Avoid bending, recap, or breaking used syringe needles before discarding them into a container.
8. Avoid using high-level disinfectants for disinfection of any

environmental surfaces.

9. Avoid using alcohol to disinfect large environmental surfaces.
10. Avoid performing disinfectant fogging in patient-care areas.
11. Avoid carpeting in high-traffic zones or where spills are likely.
12. There is no recommendation for using fungicidal or bactericidal treatments for carpeting in public areas of a healthcare facility.
13. Avoid dusting methods that disperse dust.
14. Avoid applying contaminated cleaning solutions from spray bottles/equipment.
15. Avoid using solutions after the day's use.
16. The surfaces should not be wet after cleaning.
17. Disinfectant fogging is not recommended (the recommendation was based on studies in the 1970s that stated a lack of microbicidal efficacy) (CDC seems not yet to guide these newer technologies); avoid mats with tacky surfaces at the access to operating rooms or infection-control suit.

Pharmacy Environmental and workplace during COVID-19:^{13,30,31,33}

The individual national health system, legislation and community where the hospital is located. The elements to be assessed have been divided into the following area: establishment of a core team and key internal and external contact points, human, material and facility capacity, communication and data protection, hand hygiene, personal protective equipment (PPE)^{13,30-31,33}

1. Wear PPE before the beginning of environmental cleaning; if there is a shortage, wear a minimal PPE set containing a surgical mask, disposable long-sleeved water-resistant gown, and gloves.
2. Perform hand hygiene.
3. Provide ventilation for 1–3 hr if the room is not under negative pressure and use HEPA filtration in no windows rooms.
4. Clean the area and surfaces, first with neutral detergent, then decontamination with disinfectant or 0.05% sodium hypochlorite solution or at least 70% ethanol can be used for surfaces damaged by sodium hypochlorite.
5. Avoid splashes when cleaning sanitary facilities.
6. Clean textiles by hot-water cycle (90°C) with laundry detergent; if the hot-water is not used, add bleach or any other product for decontamination.
7. Single-use disposable cleaning equipment is preferred if not placed in disinfectant solution/ 0.1% sodium hypochlorite or discarded all cleaning material.
8. All disinfectant solutions used should be effective against viruses.
9. Use different cleaning equipment for each other areas.
10. If there is a shortage of cleaning material, start from the cleanest to the dirtiest areas.
11. Waste management staff should wear PPE, and waste should be treated as infectious clinical waste (WHO; category B).
12. Use two different concentrations of sodium hypochlorite (0.05% as surface disinfectant and 0.1% for toilets and equipment).

CONCLUSION

The study's policy and procedures of cleansing hands using sanitizer and disinfecting surroundings and offices are essential for pharmacy infection control. It aimed to prevent any contamination discrepancies in the preparation and dispense of pharmaceutical products. Moreover, it will enhance the protection of pharmacy surroundings from infection-related problems. Therefore, implementing hand sanitizer and disinfectant in the pharmacy departments enhances infection-related safety of dissemination at healthcare services. Thus, pharmacy infection control emphasizing environmental and workplace policy and procedures is more critical to implement at all healthcare establishments

in Saudi Arabia.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Consent for Publications

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<https://www.hhs.gov/ohrp/regulations-and-policy/decision-charts-2018/index.html>

ABBREVIATIONS

PIPC: Pharmacy Infection Prevention and Control; **IPC:** Infection Prevention and control; **HAIs:** Healthcare-associated infections; **HIV:** Human Immunodeficiency Virus; **COVID-19:** Coronavirus Disease 2019; **CDC:** Centers for Disease Control and Prevention of the United States of America; **SCDC:** Saudi Center for Diseases Control; **GDIPC:** General Directorate of Infection Prevention and Control in Healthcare Facilities; **ASHP:** American Society of Health-System Pharmacists; **WHO:** World Health Organization; **UPS:** United States Pharmacopeia; **AGREE:** Appraisal of Guidelines, Research, and Evaluation; **PPE:** Personal Protective Equipment; **IPA:** Isopropyl alcohol; **IV:** Intravenous; **LAFH:** Laminar Air Flow Hood; **HEPA:** High-Efficiency Particulate Absorbing; **HD:** Hazardous Drug; **EPA:** Environmental Protection Agency; **PEC:** Primary Engineering Control; **HVAC:** Ventilation, and Air-Conditioning System; **ACH:** Automated Cleaning House; **CSPs:** Compounding Sterile Preparations; **ACPH:** Air changes per hour; **CVE:** Containment Ventilated Enclosure; **BSC:** Biological Safety Cabinet; **CACI:** Compound Aseptic Containment Isolator; **CSPs:** Compounding Sterile Preparations; **SCA:** Segregated Compounding Area; **CNSP:** Compounded non-sterile preparations; **API:** Active Pharmaceutical Ingredients (API).

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