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Environmental, Health, and Safety Guidelines

HEALTH CARE FACILITIES

2025

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CONTENTS

1 INTRODUCTION

1. The Environmental, Health, and Safety Guidelines (EHS Guidelines) are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP).1 They are comprised of the General Environmental, Health, and Safety Guidelines (General EHS Guidelines) and Industry-specific Sector Guidelines (Industry Sector EHS Guidelines). The General EHS Guidelines present common environmental, health and safety (EHS) issues that potentially apply across industry sectors. The Industry Sector EHS Guidelines present EHS issues specific to each industry sector.

2. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as described in their respective policies and standards. The Industry Sector EHS Guidelines are designed to be used together with the General EHS Guidelines. For complex projects, multiple Industry Sector EHS Guidelines may be relevant. A complete list of Industry Sector EHS Guidelines can be found at www.ifc.org/ehsguidelines.

3. The EHS Guidelines specify the performance levels and measures that are generally considered to be GIIP and achievable in new facilities by using existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve establishing site-specific targets, with an appropriate timetable for achieving them.

4. The applicability of EHS Guidelines should be tailored to the hazards and risks identified for each project based on results of an environmental assessment that considers site-specific variables, such as host country context, assimilative capacity of the environment, and other project-specific factors. The applicability of specific technical recommendations should follow GIIP and be based on the professional opinion of qualified and experienced professionals. When host country's regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent measures than those in the EHS Guidelines are appropriate due to specific project circumstances, a detailed justification for any proposed alternatives is needed as part of the site-specific assessment and should demonstrate that alternate performance levels are protective of human health and the environment.

2 APPLICABILITY

5. The EHS Guidelines for Health Care Facilities (HCF) include information relevant to major HCF, such as large district-level or general hospitals with multiple specialties or trauma facilities; minor or specialized HCF, such as primary care centers, specialist clinics, outpatient, ancillary and ambulant facilities; and temporary HCF, such as field hospitals, disaster-related temporary facilities, and alternate health care sites. Ancillary facilities may include medical laboratories and research facilities, mortuary centers, and blood banks and collection services. See Annex A for a description of industry activities.

[1] GIIP is defined as the professional skill, diligence, prudence, and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of prevention and control techniques available to a project may include, but are not limited to, varying levels of EHS capabilities and capacities, and financial and technical feasibility.

3 DESIGN CONSIDERATIONS

6. This section summarizes key aspects related to project siting and design for this industry sector. Design considerations for buildings and ancillary facilities that are common to various industry sectors, such as water availability, climate resilience, resource efficiency, life and fire safety, greenfield or brownfield development requirements, road safety, or universal access are detailed in the General EHS Guidelines.

7. Project siting criteria for new facilities should minimize risks to human health and the environment. For HCF, this primarily includes reducing exposure to pollutants and hazardous materials; securing water and energy availability; identifying waste and effluent management alternatives, including on-site or off-site disposal and incineration; maximizing emission dispersion; and other considerations on a case-by-case basis**.** Consult internationally recognized references for HCF in the planning and design phase.[2]

8. HCF design may impact infection rates and communicable disease.[3] Good design practices consider infection prevention and control measures during planning, design, construction, maintenance and renovation of all HCF.[4] An infection control risk assessment (ICRA) should be conducted during planning or before construction and regularly updated so controls are suitable to the site. Refer to table 1 for design considerations, which should be tailored to each facility and jurisdiction.

Table 1. Design considerations for health care facilities

	Type of facility		
	Major HCF	**Minor/Specialized HCF**	**Temporary HCF**
Examples by type of facility	• General-purpose or multifunction hospitals or clinics with high patient capacity (>100 beds), multiple specialists, and a complex waste profile[5] • Research institutes with a complex waste profile	• Single-function hospitals, generic health clinics or centers with small patient capacities (<100 beds) and a simple waste profile • Rural health centers or posts • Radiology clinics • Pregnancy and birth centers • Blood banks • Stand-Alone Medical Laboratories • Hospice homes • Mental health clinics • Ambulant facilities • Alternative medicine clinics (e.g., accupuncture) • Research institutes with a simple waste profile	• Modular or field HCF, commonly referred to as Alternate Care Sites (ACS), including: o Pop-up vaccination facilities o Field hospitals or clinics o Facilities housed in temporary structures, generally with a single function and a simple waste profile
Common HCF design considerations	Siting, structural design safety, life and fire safety, infection control, potable water supply, energy and resource efficiency, accessibility, hazardous (e.g., pathological, infectious, cytotoxic, radiological, chemical) and non-hazardous (e.g., uncontaminated packaging/solids) waste management and final disposal options		

[2] AHIA, *Australasian Health Facilities Guidelines*; FGI, *Design and Construction for Hospitals*; IAHSS, *Design Guidelines for Healthcare Facilities*; IFC, *EDGE Hospitals*; JCI, *Design and Construction for Health Facilities.*
[3] US CDC, *HAI Prevention Toolkits*; HSE, *National Guidelines Nosocomial Aspergillosis*; Zilberberg et al., "Epidemiology of Invasive Aspergillosis," 727-735.
[4] ASHE, *ASHE ICRA 2.0™ Toolkit*; AHIA, *Australasian Health Facilities Guidelines*.
[5] This figure varies by context and jurisdiction and should be considered alongside other major HCF characteristics. A "simple waste profile" includes general non-hazardous waste, while a "complex waste profile" includes multiple types of hazardous waste.

	Type of facility		
	Major HCF	**Minor/Specialized HCF**	**Temporary HCF**
Examples of specific HCF design considerations	• On-site waste/effluent treatment • Infrastructure and planning to support a diverse range of specialties and general practice • Waiting rooms with high patient capacity, infectious patient segregation • Design standardization for rooms and distance minimization for patient transfers • Sophisticated HVAC systems to control airborne infectious disease outbreaks • Emergency/backup electricity generation • Vertical and floor design to increase patient and worker safety • Vertical transportation system • Vehicle traffic and crowd management • The containment of microbiological, chemical, radiological, and physical hazards appropriate to the level of assessed risks in work areas	• On-site or off-site waste/effluent treatment • Specialty-specific EHS considerations (e.g., ionizing radiation, hazardous sharps) • Emergency/backup electricity generation • The containment of microbiological, chemical, radiological, and physical hazards appropriate to the level of assessed risks in work areas • Other case-by-case considerations, in line with Major or Temporary HCF	• Off-site waste/effluent treatment (or temporary on-site treatment e.g., portable systems or storage) • Sustainable/reusable/salvageable materials when such facilities are commissioned/decommissioned • Redesign, adaptation, or conversion of existing facilities (e.g., hotels, stadiums, schools) • Other case-by-case considerations, in line with Major or Minor HCF

9. Most HCF are public access buildings with patients unable to self-evacuate during emergencies. Key design considerations:

- Choose layouts that facilitate infection control, ergonomics, waste segregation, and patient and staff flow, including during outbreak or pandemic scenarios.
- Design for storage, maintenance, and safe removal of personal protective equipment (PPE).
- Use materials that support sterilization, infection control, and worker and patient safety (slip-resistant, nontoxic, nonallergenic).
- Isolate infrastructure, such as heating, ventilation, and air conditioning (HVAC), plumbing, electrical, and waste management systems from hazardous, infectious, or radioactive agents, with adequate redundancy.
- Include life and fire safety (LFS) features for partial or full evacuations.
- Provide emergency power generation or storage for essential operations during power supply disruptions.
- Provide an emergency potable water supply in case supply is interrupted.
- Consider emergency supplies, such as medical gases (i.e., oxygen, carbon dioxide).

10. Renovation, demolition, and maintenance of HCF pose serious infection risks. Infection control plans should prevent harm to patients, staff, and visitors. For example, demolition activities may divert waste or disrupt HVAC systems, and in turn spread dust contaminated with bacteria, fungi, or asbestos fibers. Conduct a pre-construction risk assessment (PCRA) and an infection control

risk assessment (ICRA) to establish precautions, considering the type of work and proximity to areas occupied by patients, staff, and visitors.[6]

11. Temporary HCFs, or Alternate Care Sites (ACS), can be set up during emergencies or epidemics to provide additional medical care capacity. An ACS is reconfigured, repurposed, constructed, or temporarily converted building for urgent health care needs, not physically linked to a purpose-built major/minor HCF such as a hospital, although it may be near one. Examples of ACS include hotels, offices, stadiums, tent cities, modular containers, and former hospitals.

12. ACS guidelines vary widely and require site-specific assessments for logistics, accessibility, infection control, waste, life and fire safety, and HVAC concerns, as well as security and patient management.[7]

4 CONSTRUCTION AND OPERATIONAL CONSIDERATIONS

13. This section provides a summary of sector-specific EHS risks typically associated with the operational phase and provides guidance for mitigation and management measures. Where there are unique aspects to the construction, refurbishment, and decommissioning of this industry sector, guidance is also included. Recommendations for EHS issues and management common to the construction, refurbishment, and decommissioning phases of various sectors are provided in the General EHS Guidelines.

14. An ongoing identification of impacts and risks and the implementation of mitigation, monitoring and management measures should be done through an integrated management system for environmental, health and safety aspects. References to risk identification, mitigation, plans and programs included in these guidelines should be understood to be part of this management system.[8]

4.1 Environment

15. Key environmental issues for HCF include waste management, air emissions, and wastewater. The following sections provide guidance on managing these issues.

4.1.1 Waste Management

16. Health care waste can be divided into two groups:

- General non-hazardous waste, similar to domestic waste, from administrative, housekeeping, and maintenance activities.
- Hazardous health care waste, including sharps and clinical waste, including infectious, pathological, pharmaceutical, chemical, cytotoxic, and radioactive wastes.[9] Management options for these waste categories are detailed in table 2.

[6] ASHE, *ASHE ICRA 2.0™ Toolkit.*
[7] ASHRAE, *Alternate Care Site HVAC;* IAHSS, *Design Guidelines – Alternate Care Sites*; ICC, Structures for Temporary Healthcare Use; IMERT, *Temporary Medical Treatment Stations.*
[8] Please refer to IFC Performance Standard 1 and IBRD Environmental and Social Standard 1 for details on a management systems. In some cases, companies may decide to establish and maintain specific management systems for different topics, for example an OHS Management System.
[9] Infectious waste can be categorized as waste contaminated with blood and other bodily fluids (e.g., from discarded diagnostic samples), cultures and stocks of infectious agents from laboratory work (e.g., waste from autopsies and infected animals from laboratories), or waste from patients with infections (e.g., swabs, bandages, and disposable medical devices). Pathological waste can be categorized as human tissues, organs or fluids, body parts, or contaminated animal carcasses.

17. HCF operators should regularly assess waste quantities and categories for waste management planning and minimization and should refer to guidance on solid and hazardous waste management in the General EHS Guidelines. The HCF operator should establish and maintain a Health Care Waste Management System (HWMS) suitable for the facility's scale, activities, and waste streams. The HWMS may include the following components depending on the HCF's scale and type.

Waste Minimization, Reuse, and Recycling

18. HCFs should minimize waste generation and maximize reuse and recycling of materials without compromising patient hygiene and safety protocols. In addition to the recommendations in the General EHS Guidelines and more comprehensive guidance from the World Health Organization (WHO), specific considerations for HCF are below:[10]

- Reduce waste toxicity: neutralize or transform materials with active or expired medicines[11]
- Source reduction: use physical cleaning practices (e.g., using microfiber mops) over chemical ones if doing so meets hygiene and safety standards for patients, staff, and visitors
- Maximize safe equipment reuse: where the scale of the HCF makes this possible, sterilize and disinfect equipment for reuse (e.g., sharps containers, refilling empty pressurized gas cylinders)
- Efficient stock management: implement stock rotation and holding time into procurement processes to minimize discard stock (e.g., frequent small orders, using oldest products)
- Recycling: recycle non-hazardous waste and some hazardous waste if it can be efficiently segregated and sterilized

Waste Segregation Strategies

19. At generation source, HCF waste should be identified and segregated with the following considerations:[12]

- Collect non-hazardous waste (paper, cardboard, glass, aluminum, and plastic) separately for recycling or disposal per local regulations and viability of recycling facilities.
- Segregate and compost food waste where possible.
- Identify, collect and segregate at the source infectious and/or hazardous wastes using a color-coded system, as detailed in table 2.
- Avoid mixing general and hazardous health care waste to reduce disposal costs.
- Treat mixed non-hazardous and hazardous waste as hazardous. Staff should not correct segregation errors by removing or combining waste receptacles.
- Collect mercury-containing waste separately and manage with trained personnel.[13]

[10] WHO, *Safe Management of Wastes*.
[11] Health Care Without Harm, *Waste Minimization and Recycling.*
[12] WHO, *Safe Management of Wastes*. This guidance provides a comprehensive guideline on waste segregation in HCF.
[13] WHO, *Mercury in Health Care Settings.*

- Collect waste with a high heavy metal content (e.g., cadmium, thallium, arsenic, and lead) to prevent entry into wastewater streams that are intended for off-site discharge without further treatment.
- Collect infectious waste separately and minimize hazardous waste designated for incineration.
- Collect radioactive waste in labelled, lead-lined, leak-proof containers.
- Collect and move residual chemicals to proper disposal containers to reduce contaminated wastewater and avoid mixing with different hazardous chemicals.
- Establish separate collection of urine, feces, blood, vomit, and other waste from patients treated with genotoxic drugs—this waste is considered hazardous and should be treated according to table 2.[14]
- Collect aerosol cans and gas containers separately to avoid incineration disposal and related explosion hazards.
- Collect sharps in leak- and puncture-proof single use containers, not exceeding the fill line.
- Collect health care products containing polyvinyl chloride (PVC), e.g., gloves, tubing, and fluid-holding/dispensing bags, separately to avoid incineration (see Section 4.1.2) or landfill disposal.

On-site Handling, Collection, and Storage of Hazardous Wastes

20. Recommended actions for handling, collecting, transporting, and storing hazardous HCF waste should be specified, as needed, in the HCF HWMS and include the following:[15]

- Only authorized personnel should handle hazardous waste.
- Collect health care waste at the source in double plastic bags or sharps containers, seal them, and place them in suitable plastic containers for transport.
- Use leak-proof, puncture-resistant, tightly sealed containers to prevent spills and exposure to harmful materials.
- Seal and replace waste bags and containers (e.g., single use sharps containers) when once three-quarters full.
- Label waste bags and containers as recommended in table 2.
- Designate storage with proper access for authorized transport vehicles.
- Locate health care waste storage areas within the facility grounds, sized proportionately to the quantities of waste generated, with these design considerations:
    - Locate in areas that minimize exposure risk to patients and communities.
    - Use hard, impermeable floors with drainage for frequent disinfection.
    - Secure with locks and restricted access.
    - Allow access for authorized cleaning staff and vehicles (e.g., external waste transport services).
    - Protect from the sun and animals, especially rodents.
    - Provide sufficient lighting, ventilation, signage, and visible cleaning logs.

[14] Genotoxic drugs or substances/waste contaminated with genotoxic drugs may have mutagenic (cause genetic mutation), teratogenic (cause defects in an embryo or fetus), or carcinogenic (cause cancer) properties.
[15] ICRC, *Medical Waste Management.*

- Segregate from food supplies and preparation areas.
- Stock with protective clothing and spare bags/containers.

- In cases where there is no refrigeration, limit storage times between waste generation and treatment to:
  - Temperate climate: 72 hours in winter, 48 hours in summer.
  - Warm climate: 48 hours in cool season, 24 hours in hot season.
- Store mercury separately in sealed, impermeable containers in a secure location.
- Store cytotoxic waste separately in a secure location.
- Store radioactive waste in containers behind lead shields for at least 10 half-life times of the contained radioisotopes if they possess a half-life of less than 90 days. Decontaminate infectious radioactive waste before disposal. Decant and dispose of liquids as non-radioactive waste after decay, in consideration of any hazardous chemical classifications.

Off-site Treatment

21. Off-site treatment of health care waste, including liquid hazardous wastes such as chemicals and cytotoxic wastes, is suitable if regulated or if the HCF, such as temporary or disaster-related facilities, do not have the necessary infrastructure for on-site treatment. Use licensed facilities that meet GIIP for off-site treatment of hazardous health care waste.

Transport

22. Waste destined for off-site facilities should be transported according to General EHS Guidelines guidance on hazardous waste/dangerous goods transport.[16] Transporting hazardous health care waste from HCF should consider the following:

- Use an inner, watertight layer of metal or plastic with a leak-proof seal. Outer packaging should be of adequate strength and capacity for the specific type and volume of waste.
- Use puncture-proof containers for sharps.
- Label waste with the substance class, packaging symbol (e.g., infectious waste, radioactive waste), waste category, mass/volume, place of origin within hospital, and destination.
- Use dedicated vehicles with sealed compartments for carrying waste.
- Employe licensed contractors for waste transport.
- Regularly audit transport services and external facilities.

Treatment and Disposal Options

23. The General EHS Guidelines describe non-hazardous waste treatment and disposal. Avoid open burning or uncontrolled incineration (i.e., without equipment or containment) of health care waste, as it can produce pollutants and hazardous chemicals generated from

[16] Dangerous goods are substances that, when transported, are a risk to health, safety, property, or the environment.

incomplete combustion (e.g., dioxins and furans), which are harmful to human health and the environment.[17] Consider alternative methods in table 2.

24. Facilities handling hazardous health care waste should have all applicable national operational permits and capacity to manage specific waste types. Treat each waste category according to methods in table 2, considering the HCF's waste profile and site conditions. When selecting a disposal technology, consider potential health and environmental impacts. The main treatment and disposal technologies are described below.[18]

25. **Incineration.** Incineration is a high-temperature (850°C to 1100°C) dry oxidation process that reduces organic, combustible waste to smaller quantities of inorganic or incombustible matter, or gaseous material that is combusted further (gasification). Specialized incineration methods like gasification and pyrolysis require temperatures above 1000°C and specialized equipment. For "highly chlorinated wastes," optimal combustion conditions are a minimum of 850°C in a primary combustion chamber and 1100°C with a two-second residence time in the secondary chamber.[19] Incineration may produce gaseous air emissions, ash residues, and wastewater. HCF may operate on-site incinerators or transport waste to an off-site facility.[20] Implement GIIP practices like waste segregation and alternative treatments to minimize unnecessary incineration. Incinerators should have permits to accept hazardous health care waste and be properly operated and maintained.[21] Manage incineration residue such as fly ash, bottom ash, and liquid effluents from flue gas cleaning as hazardous waste as they may contain high concentrations of Persistent Organic Pollutants (POPs), including dioxins and furans, as well as toxic metals and phosphate from carcasses. Bottom and fly ash should be disposed of in compliance with national or local regulations and not buried on-site, as doing so can represent a direct route for dioxins and furans into waterways and soil, the food chain, and other human exposure.[22] Dispose of ash in hazardous waste landfills using double-walled containers, solidification or thermal post-treatment.[23] Further guidance on incineration emissions is in Section 4.1.2.

26. **Autoclaving (wet thermal treatment).** Autoclaving disinfects waste by exposing shredded waste to high temperature steam in a tank, potentially emitting wastewater and odors. Commonly used to sterilize medical equipment, autoclaving can complement or replace incineration, depending on the waste profile.[24] Avoid autoclaving solutions with hypochlorite, ethanol, or formaldehyde due to volatility, and hazardous chemicals like bleach, mercury, or radioactive material should never be autoclaved.

[17] Stockholm Convention, *Persistent Organic Pollutants Annex C*.
[18] WHO, *Safe Management of Wastes*; US EPA *Notebook on Health Facilities*; Health Care Without Harm, *Alternative Medical Waste Technologies*. These resources provide further detail on waste management and disposal methods and technologies.
[19] UNEP, *BAT and BEP on POP*. See also update to Section V, Part II, Annex C on Waste Incinerators https://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-BATBEP-GUID-GUIDELINES-02.En.docx
[20] WHO, *Safe Management of Wastes*, 116; EEA, *Emission Inventory Guidebook*.
[21] Health care waste should be disposed of using pyrolytic or rotary kiln incinerators. Single-chamber incinerators should only be used in emergency situations (e.g., acute outbreaks of communicable disease) when other incineration options for infectious waste are not available.
[22] UNEP, *BAT and BEP on POP*. POPs remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms, and are toxic to humans and wildlife. Under Article 5 and Annex C of the Stockholm Convention on POPs, participating governments are required to reduce or eliminate releases from unintentional production of POPs—in particular, polychlorinated dibenzo-p-dioxins (dioxins) and dibenzofurans (furans). The UNEP Guidelines provide incinerator process requirements and emissions guidelines specific to achieving the aims stipulated in Article 5 and Annex C of the Stockholm Convention.
[23] UNEP, *BAT and BEP on POP;* EU, *Council Directive 2024/1786; EU, 1999/31/EC/Annex I;* MMIS, *Incinerator Guidebook;* WHO, *Incineration of Healthcare Waste*.
[24] Health Care Without Harm, *Non-Incineration Project Tanzania*.

27. **Chemical disinfection.** Chemical disinfection uses chemicals to kill pathogens in health care waste. Waste is shredded prior to treatment, which involves using hazardous chemicals and disposing of residues at off-site certified facilities. Manual chemical disinfection is considered unreliable. While chemical disinfection is typically done on-site, commercial, self-contained, and automatic systems are available and may be operated remotely.[25]

28. **Dry thermal disinfection.** Dry thermal disinfection shreds, heats, and compacts waste in a rotating auger, generating air emissions, wastewater, and residues that require disposal.

29. **Microwave irradiation.** Microwave irradiation destroys microorganisms by heating water in the waste. After irradiation, the waste is compacted and disposed of with the municipal waste stream, potentially generating contaminated wastewater.

30. **Inertization.** Inertization mixes waste with substances like cement to minimize toxic leaching into ground or surface water. It is typically suitable for high-leaching wastes like pharmaceutical incineration ashes with a high metal content.

31. **Landfill disposal.** Dispose of non-hazardous health care waste in sanitary landfills. Classify treated hazardous for landfill disposal based on its characteristics. Use properly designed and operated landfills to prevent air and groundwater contamination. Avoid dumping waste in dump sites without environmental controls. Pretreat waste (including incineration ash and inertization products) prior to landfill disposal, possibly through encapsulation, such as filling containers with waste and immobilizing material and sealing the containers). If pretreatment is not possible at the HCF, use a licensed, engineered, and managed landfill for hazardous waste.

32. **Radioactive waste.** Dispose of radioactive waste through a specialized disposal service. Before disposal, segregate and store radioactive waste in clearly labelled, lead-lined, leak-proof containers. If specialist disposal service is not available, label and store waste in radiation-proof repositories to decay naturally.

33. The risks of exposure to health care waste and its by-products are mitigated by adopting GIIP disposal and treatment strategies, which often require complex processing. HCF staff, especially those responsible for waste management, should be trained in all aspects of HWMS.[26] Regularly evaluate off-site waste disposal facilities and review all permits and licenses to confirm that waste generated from the HCF is appropriately managed and disposed of.

[25] Exner et al., "*Chemical Disinfection in Healthcare*."
[26] Healthcare, "*Healthcare Waste Management Methods.*"

Table 2. Treatment and disposal methods for categories of HCF waste

Type of waste	Summary of treatment and disposal options
Sharps: Includes needles, scalpels, blades, knives, infusion sets, saws, broken glass, and nails.	**Waste segregation strategy:** Yellow or red color code, marked "Sharps." Rigid, impermeable, puncture-proof container (e.g., hard plastic) with cover. Sharps containers should be placed in a sealed, yellow bag labeled "infectious waste." **Treatment:** Chemical disinfection; autoclaving; microwave irradiation; encapsulation; incineration.[a] • Following incineration, residues should be landfilled. • Sharps disinfected with chlorinated solutions should not be incinerated due to risk of generating POPs. If sharps are to be disinfected prior to incineration, disinfection methods that do not involve chlorinated disinfectants should be used. • Needles and syringes should undergo mechanical mutilation (e.g., milling or crushing) prior to wet thermal treatment.
Infectious waste: Includes waste suspected to contain pathogens (e.g., bacteria, viruses, parasites, or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts. Includes pathological and anatomical material (e.g., tissues, organs, body parts, human fetuses, animal carcasses, blood, and other body fluids), clothes, dressings, equipment/instruments, and other items that may have come into contact with infectious materials.	**Waste segregation strategy:** Yellow- or red-colored bag/container, marked "infectious" with international infectious symbol. Strong, leak-proof plastic bag, or container capable of being autoclaved. **Treatment**: Chemical disinfection; autoclaving; microwave irradiation; sanitary landfill; incineration. • Highly infectious waste, such as cultures from lab work, should be sterilized using wet thermal treatment, such as autoclaving. • Anatomical waste should be treated using incineration (rotary kiln or pyrolytic incinerator).
Pharmaceutical waste: Includes expired, unused, spoiled, and contaminated pharmaceutical products, drugs, vaccines, and serums that are no longer needed, including containers and other potentially contaminated materials (e.g., drug bottles, vials, tubing etc.).	**Waste segregation strategy:** Brown bag/container. Leak-proof plastic bag or container. **Treatment:** Sanitary landfill; encapsulation; return expired, spoiled or recalled drugs to supplier if possible; incineration.[b] • Small quantities: Landfill disposal acceptable; however, cytotoxic and narcotic drugs should not be landfilled. Incineration, provided pharmaceuticals do not exceed 1 percent of total waste to avoid hazardous air emissions. Intravenous fluids (e.g., salts, amino acids) should be landfilled. Ampoules should be crushed and disposed of with sharps. Active pharmaceuticals, such as antibiotics and antimicrobials should be thermally, chemically or enzymatically deactivated through validated methods or incinerated. • Large quantities: Incineration at temperatures exceeding 1200°C. Encapsulation in metal drums. Landfilling not recommended unless encapsulated in metal drums and groundwater contamination risk is minimal.

Table 2. Treatment and disposal methods for categories of HCF waste

Type of waste	Summary of treatment and disposal options
Genotoxic/cytotoxic waste: Waste may have mutagenic, teratogenic, or carcinogenic properties and typically arises from the feces, urine, and vomit of patients receiving cytostatic drugs, and from treatment with chemicals and radioactive materials. Cytotoxic drugs are commonly used in oncology and radiology departments as part of cancer treatments.	**Waste segregation strategy:** See above for "infectious waste." Cytotoxic waste should be labeled "Cytotoxic waste." **Treatment**: Return expired, spoiled or recalled drugs to supplier; chemical degradation; encapsulation;[b] inertization; incineration (double chamber). • Cytotoxic waste should not be landfilled or discharged to sewer systems. • Incineration is the preferred treatment option. Waste should be returned to the supplier where incineration is not an option. For particular drugs, incineration should be undertaken at specific temperatures and time specifications. Municipal or single-chamber incinerators are not adequate for cytotoxic waste disposal. Open burning of waste is not acceptable. • Chemical degradation may be used for certain cytotoxic drugs—refer to WHO (2014) Annex 3 for details. • Encapsulation and inertization should be a last resort waste disposal option.
Chemical waste: Waste may be hazardous, depending on the toxic, corrosive, flammable, reactive, and genotoxic properties. Chemical waste may be in solid, liquid, or gaseous form and is generated through use of chemicals during diagnostic/ experimental work, cleaning, housekeeping, and disinfection. Chemicals typically include formaldehyde, photographic chemicals, halogenated and nonhalogenated solvents, organic chemicals for cleaning/disinfecting, and various inorganic chemicals (e.g., acids and alkalis).[c]	**Waste segregation strategy:** Brown bag/container. Leak-proof plastic bag or container resistant to chemical corrosion effects. **Treatment:** Return unused chemicals to supplier; encapsulation; incineration (pyrolytic incinerator); treatment/conversion and temporary safe disposal for remote HCF premises for some chemical waste.[d] • Facilities should have permits for disposal of general chemical waste (e.g., sugars, amino acids, salts) to sewer systems. • Small hazardous quantities: Incineration, encapsulation, or landfilling. • Large hazardous quantities: Transported to appropriate facilities for disposal, or returned to the original supplier using shipping arrangements. Large quantities of chemical waste should not be encapsulated or landfilled. • Formaldehyde: A request for disposal may be submitted to local authorities or private hazardous waste disposal companies. Alternatively, a laboratory may develop a formaldehyde treatment procedure where the lab treats their formaldehyde waste for disposal in the sink (this procedure requires consultation with local authorities).
Radioactive waste: Waste includes solid, liquid, and gaseous materials that have been contaminated with radionuclides. Radioactive waste originates from activities such as organ imaging, tumor localization, radiotherapy, and research/clinical laboratory procedures, among others, and may include glassware, syringes, solutions, and excreta from treated patients.	**Waste segregation strategy:** Lead-lined leak proof box, labeled with the radioactive symbol. **Treatment**: Radioactive waste should be managed according to national requirements and current guidelines from the International Atomic Energy Association (IAEA) 2019. Predisposal Management of Radioactive Waste from the Use of Radioactive Material in Medicine, Industry, Agriculture, Research and Education. No. SSG-45. Annexes III to V of IAEA (2019) provide detailed flowcharts for the disposal solid, biological, and disused source (equipment) radioactive wastes. The main common steps in all radioactive waste treatment processes involve waste minimization, segregation, storage in radiation-proof containers, allowing time for sufficient natural decay, and further waste treatment/disposal depending on the residual waste characteristics.
Waste with high content of heavy metals: Waste includes batteries, broken thermometers, blood pressure gauges (e.g., mercury and cadmium content).	**Waste segregation strategy:** Waste containing heavy metals should be collected separately from general health care waste. **Treatment:** Safe storage site designed for final disposal of hazardous waste. • Waste should not be burned, incinerated, or landfilled. Transport to specialized facilities for metal recovery.

Table 2. Treatment and disposal methods for categories of HCF waste	
Type of waste	**Summary of treatment and disposal options**
Pressurized containers: Includes containers/cartridges/ cylinders for nitrous oxide, ethylene oxide, oxygen, nitrogen, carbon dioxide, compressed air, and other gases.	**Waste segregation strategy:** Pressurized containers should be collected separately from general health care waste. **Treatment**: Recycling and reuse, send reusable containers to specialized gas refilling facilities. For disposal, crush the containers followed by landfilling or recycling. • Incineration is not an option due to explosion risks. • Halogenated agents in liquid form should be disposed of as chemical waste, as described above.
General health care waste: Includes food waste and paper, plastics, and cardboard**.**	**Waste segregation strategy**: Black bag/container. Halogenated plastics such as PVC should be separated from general health care facility waste to avoid disposal through incineration and associated hazardous air emissions from exhaust gases (e.g., hydrochloric acid and dioxins). **Treatment:** Disposal as part of domestic waste. Segregate and compost food waste. Segregate and send for recycling component wastes including paper, cardboard, recyclable plastics (PET, PE, PP), and glass.

Source: WHO, *Safe Management of Wastes*; UNEP, *BAT and BEP on POP*.

Notes:

a. Use starved-air (pyrolytic), multiple chamber, and rotary kiln incinerators. Use of single-chamber and drum/brick incinerators are not GIIP and may only be considered as a last resort in exceptional circumstances, such as if recommended GIIP methods are overwhelmed or not operational.

b. Small quantities only. Burial of hazardous health care waste is not considered good practice. In emergency infection control situations, the HCF can designate a temporary safe disposal area with adequate technical measures to prevent pollutants from entering soil and groundwater, including exposure to people.

c. Formaldehyde is extensively used in pathology laboratories. As a suspected carcinogen and irritant gas, it must be stored, used, and disposed of under strict protocols. Halogenated and nonhalogenated solvents (e.g., chloroform, trichloroethylene (TCE), acetone, methanol) are usually a laboratory-related waste stream for fixation and preservation of specimens in histology/pathology and for extractions in labs.

d. Low-level infectious waste only. Low-level liquid waste only.

4.1.2 Air Emissions

34. HCF air emissions sources include HVAC exhaust, medical gas ventilation, and fugitive emissions from waste storage, medical technology areas (MTAs), and isolation wards. Emissions may also come from waste incineration exhaust, anesthetic gases, metered dose inhalers, and power generation combustion.[27] Prevention and control for power generation combustion emissions are addressed in the General EHS Guidelines.

35. Exhaust air from MTAs, isolation wards, laboratories, and waste facilities may be contaminated with biological agents, pathogens, or other toxic materials and should be treated by conveying the exhaust air to combustion air to render it non-toxic and non-contagious before discharge. Condensate and blowdown liquids should be classified as health care wastewater and treated accordingly (see Section 4.1.3). A stack sufficiently tall to eliminate odor nuisances and optimize dispersion should be used. Stack heights for all waste treatment facilities should be determined in accordance with the General EHS Guidelines.

Incineration

36. Large general hospitals may be equipped with their own incinerator plants, which is the major source of air emissions and wastewater for such facilities. Only a small portion of medical waste should be incinerated, and the need for a hospital waste incinerator (HWI) should be carefully evaluated against the other waste management technologies.[28] Potential emissions from HWIs include:

- Heavy metals
- Organics in the flue gas (vapor phase or condensed or absorbed on fine particulates)
- Organic compounds (e.g., dioxins, furans (PCDD/Fs), chlorobenzenes, chloroethylenes, and polycyclic aromatic hydrocarbons (PAHs)), which are generally present in hospital waste or can be generated during combustion and post-combustion processes.
- Hydrogen chloride (HCl), fluorides, and other hydrogen halides (e.g., of bromine and iodine)
- Combustion products, including GHGs (sulfur oxides (SOX); nitrogen oxides (NOX); volatile organic compounds (VOCs), including non-methane VOCs; methane (CH4); carbon monoxide (CO); carbon dioxide (CO2); and nitrous oxide (N2O)[29]
- Nuisance odors

37. Pollution prevention and control measures that represent GIIP for waste incinerators include:

[27] Controlled-air incineration (also referred to as pyrolytic, starved-air, two-stage incineration, or modular combustion) is the most widely used hospital waste incinerator (HWI) technology. Single-chamber and drum/brick incinerators should be used only as a last resort or emergency option.
[28] Health Care Without Harm, *Non-incineration Treatment Technologies*; Healthcare, *"Healthcare Waste Management Methods."* Infectious and pathological waste, selected pharmaceuticals (combustibility to be determined from the manufacturer's specifications) and chemicals, and sharps may be combusted in a pyrolytic incineration facility designed for this purpose. The types of waste incinerated typically include a heterogeneous mix of some, or all, of the following: human- and animal-infected anatomical waste; absorbents; alcohol and other disinfectants; glass; fecal matter; gauze, pads, swabs, garments, paper, and cellulose; plastics, PVC, and syringes; sharps and needles; and fluids and residuals.
[29] UN, *Paris Agreement*. Medical waste incinerators are likely to emit greenhouse gases, of which a national inventory should be maintained by party countries under Article 13 of the Paris Agreement of the United Nations Framework Convention on Climate Change Pollutants.

- Siting in open areas for maximum dispersion, away from sensitive receptors.
- Segregate waste destined for incineration and remove halogenated plastics (e.g., PVC), pressurized gas containers, large amounts of active chemical waste, silver salts, radiographic waste, high heavy metal content items (e.g., broken thermometers, batteries), and sealed ampoules or ampoules containing heavy metals that should not go in the incinerator.
- Verify incinerators have authorized regulatory agency permits, are operated and maintained by trained employees to allow for proper combustion conditions (temperature, time, and turbulence specifications necessary for adequate combustion of waste.[30] These include implementation of operational controls, including combustion and flue gas outlet temperatures (combustion temperatures should be above 850°C), immediate quenching of flue gases to avoid formation and reformation of POPs, and use of flue gas cleaning devices meeting international standards.
- For countries that are signatories, comply with the Stockholm Convention on POPs by phasing in best available technologies within four years of signing.[31]
- Install continuous emission monitoring systems (CEMS) for large incinerators with a capacity of >10 tons/day) to monitor opacity (particle surrogate), SO2, CO, O2, NOx, HCl, Hg and continuous monitoring of temperature and other parameters (e.g., pressure drop across filters).[32] See also General EHS Guidelines.

38. Air pollution control measures for hospital waste incinerators include:

- Use wet, semi-dry, or dry scrubbers to control acid gas emissions (e.g., HCl, sulfur dioxide (SO_2), and fluoride compounds).
- Control of particulate matter may be achieved through use of cyclones, fabric or ceramic filters, and/or electrostatic precipitators (ESPs). Efficiencies depend on the particle size distribution of the particulate matter from the combustion chamber. Particulate matter from hospital incinerators is commonly between 1.0 and 10 micrometers (µm).
- Control of volatile heavy metals depends on the temperature at which the control device operates. Fabric filters and ESPs typically operate at relatively high temperatures and may be less effective than those that operate at lower temperatures. Venturi quenches and venturi scrubbers are also used to control heavy metal emissions. The volatile heavy metals usually condense to form a fume (less than 2 µm) that is only partially collected by pollution control equipment.
- Management of incineration residues such as fly ash, bottom ash, and liquid effluents from flue gas cleaning as a hazardous waste as they may contain high concentrations of POPs (see section on 'Waste Management' and also refer to the General EHS Guidelines**).**
- Conduct annual performance tests for fugitive emissions from ash handling.[33]

[30] WHO, *Safe Management of Wastes*; US EPA, *Medical Waste Incinerators;* UNEP, *BAT and BEP on POP*. These resources include technical information on the GIIP operation and maintenance of hospital waste incinerators. The UNEP resource provides guidance relevant to Article 5 and Annex C of the Stockholm Convention on POP.
[31] Stockholm Convention on Persistent Organic Pollutants. *UN Treaty Collection: CHAPTER XXVII;* WHO, *Safe Management of Wastes*; UNEP, *BAT and BEP on POP*. Only modern incinerators operating at 850–1100°C and fitted with special gas-cleaning equipment can comply with the international emission standards for dioxins and furans.
[32] EU (2010) on incinerator emission levels indicates continuous monitoring for large incinerators (>10 tons/day). Batterman, "*Small-scale Incinerators"* Proposes CEMS in small scale incinerators.
[33] US EPA, *Requirements for Hospital/Medical/Infectious Waste*.).

Greenhouse Gas Emission Reduction

39. Strategies to reduce greenhouse gases (GHG) emissions depend on individual facility factors, including building age and space use, etc. Specific measures, besides those related to energy conservation and efficiency for buildings, to reduce GHG in HCF operations include:[34]

- Reduce air changes in unused operating rooms overnight and weekends.
- Minimize air changes per hour (ACH) based on infection prevention protocols.
- Decommission or avoid central nitrous oxide piping.
- Portable E cylinders should be substituted where the use of nitrous oxide is essential, and tanks should be closed between uses.

4.1.3 Wastewater

Wastewater from General Operations

40. HCFs generate wastewater from medical wards, operating theaters, laboratories, pharmaceutical and chemical stores, cleaning activities, hemodialysis, dental departments, kitchens, and x-ray facilities, and treatment disposal technologies, including autoclaving, microwave irradiation, chemical disinfection, and incineration (e.g., flue gas scrubber).

41. Ineffective hazardous waste management can result in hazardous health care wastes, including microbiological pathogens (e.g., enteric pathogens such as bacteria, viruses, and helminths/parasitic worms), hazardous chemicals, pharmaceuticals (e.g., cytotoxic or antimicrobials), and radioactive isotopes, to enter the wastewater stream. Pollution prevention measures include:

- Segregate waste to prevent solid waste and hazardous liquids from entering the wastewater stream.
- Collect urine, feces, blood, and vomit from patients treated with genotoxic drugs separately.
- Collect large quantities of pharmaceuticals for separate treatment or return to manufacturer (see table 2).

Municipal Wastewater Treatment

42. If discharging wastewater to municipal sewage systems with a centralized wastewater treatment (WWT) facility, HCFs should confirm compliance with applicable permits and that the municipal WWT facility can handle the effluent, as discussed in the General EHS Guidelines. Establish a pretreatment facility, if needed.[35] Consider the following criteria for discharging HCF wastewater to sanitary sewage treatment systems without pretreatment:

- The municipal sewer is connected to WWT facilities with primary, secondary, and tertiary treatment.
- The municipal WWT facility achieves 95 percent or better bacteria removal.
- Sewage treatment sludge is further processed (e.g., anaerobic digestion to one helminth egg per liter of sludge or better).

[34] Agency for Health Care Research and Quality, *Patient Safety and Quality*.
[35] WHO, *Safe Management of Wastes*, 147-164. This source includes additional criteria for disposal to municipal systems.

- The HCF's HWMS minimizes discharges of chemical, pharmaceutical, radioactive, and cytotoxic wastes as much as practicable.

On-site Wastewater Treatment

43. Major HCFs or those with complex waste profiles may use on-site WWT facilities, while temporary HCFs may deploy portable WWT facilities if needed. Minor or Specialized HCFs should assess their wastewater profile to determine the need for on-site, portable, or off-site WWT. In cases where wastewater is not discharged to adequate sanitary sewage systems, three-stage treatment (primary, secondary, and tertiary) of wastewater streams is recommended.[36]

44. The primary stage removes or separates solids via sedimentation. The secondary stage converts dissolved organic matter into solids using waterborne bacteria and inorganic matter is eliminated by sorption to sludge particles, which is separated from water by sedimentation. The tertiary stage treats the remaining water to remove suspended solids, phosphates, and other contaminants, and may include disinfection (e.g., chlorination). Wastewater treatment techniques in this sector include those listed below. Additional controls may be needed for removing active ingredients (antibiotics, antimicrobials and miscellaneous pharmaceutical products, among other hazardous constituents), and containing volatile constituents and aerosols.

- Segregation at source and pretreatment for removal/recovery of specific contaminants (e.g., radioisotopes, mercury)
- Skimmers or oil water separators for floatable solids.
- Filtration for separation of filterable solids.
- Flow and load equalization.
- Sedimentation using clarifiers for suspended solids reduction.
- Biological treatment, typically aerobic treatment, for reduction of soluble organic matter (biochemical oxygen demand).
- Biological or chemical nutrient removal for nitrogen and phosphorus reduction.
- Effluent chlorination for disinfection.
- Dewatering and disposal of residuals as hazardous medical waste.

45. Wastewater from wet scrubbers should be treated through chemical neutralization, flocculation, and sludge settling. Sludge should be considered hazardous and may be treated off site in a hazardous waste facility or encapsulated in drums with mortar and landfilled. Sludge treatment options include anaerobic digestion or drying before incineration with solid infectious waste.

Other Wastewater Streams and Water Consumption

46. The General EHS Guidelines provide guidance on managing non-contaminated wastewater, stormwater, and sanitary sewage. Contaminated streams should go to the industrial wastewater treatment system. Recommendations for reducing water consumption, especially where it may be a limited natural resource, are also included.

[36] WHO, *Safe Management of Wastes, Chapter 9*.

4.2 Occupational Health and Safety

47. Major occupational health and safety risks and hazards at HCF include: [37]

- Biological: infectious materials, waste, body fluids, specimens, tissue
- Chemical: hazardous materials, cytotoxic and hazardous pharmaceuticals, waste anesthetic gas, surgical smoke
- Physical: extreme temperatures in boiler/freezer rooms, ionizing and non-ionizing radiation, musculoskeletal disorders
- Psychosocial: stress, burnout, fatigue, violence, harassment.

4.2.1 Biological Hazards

48. Health care personnel may be exposed to biological hazards, including air-, water- or blood-borne infections from patients, other workers, or infectious materials during specimen testing, patient care, or waste management.[38] The following measures reduce the risk of infectious disease transmission:[39]

- Implement engineering controls, including:
    - Design, construct, install, and maintain HVAC systems in patient areas and workspaces per local regulations or GIIP, whichever is more stringent, to achieve acceptable indoor air quality.[40] Consider room dimensions, building layout, contaminant type, climate, occupancy, and work activities.
    - Separate clean and dirty workflows.
    - Use easy-to-clean surface finishes.
- Establish and implement an Exposure Control Plan (ECP) for air- and blood-borne pathogens with universal precautions, including:[41]
    - Immunize staff members against vaccine-preventable infections based on occupational risk (e.g., hepatitis B), per national requirements.[42]
    - Use gloves, masks (fit tested as needed), and gowns, changing gloves between patient contact.[43]
    - Install biosafety hoods to minimize exposure to infectious aerosols in labs.
    - Handle dirty linen, contaminated clothing, and food preparation with proper procedures and facilities.
    - Follow cleaning, disinfection, and waste disposal practices (e.g., waste segregation, safe disposal of contaminated sharps).

[37] WHO, *Occupational Hazards eTool*; WHO, *Health Worker Safety Guide*. WHO has an extensive list of information sheets, tools, and guidance regarding the development and implementation of occupational health and safety management systems in HCF.
[38] According to the US Occupational Safety and Health Administration (OSHA), bloodborne pathogens are pathogenic microorganisms that are present in human blood and can cause disease in humans, including human immunodeficiency virus (HIV), hepatitis B virus (HIB), and hepatitis C virus (HCV). Other potentially infectious materials include: (1) The following human body fluids: semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, any body fluid that is visibly contaminated with blood, and all body fluids in situations where it is difficult or impossible to differentiate between body fluids; (2) Any unfixed tissue or organ (other than intact skin) from a human (living or dead); and (3) HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV.
[39] US CDC, *Guideline for Isolation Precautions;* AHIA, *Australasian Health Facilities Guidelines;* OSHA, *29 CFR 1910.1030–Bloodborne Pathogens*.
[40] ASHRAE, *Health Care Facilities Resources,* including *Standard 170 – Ventilation.*
[41] OSHA, *Model Plans Bloodborne Pathogens*. This OSHA resource includes a model ECP.
[42] WHO, *Immunizations for Healthcare Workers*.
[43] Health care workers may be latex sensitive, resulting in serious allergic reactions. Hypoallergenic gloves, glove liners, powderless gloves, or other similar alternatives should be available to those workers who are allergic.

- Provide adequate hand washing and sanitizing facilities[44]
- Enforce patient isolation protocols.
- Minimize patient transfers.
- Implement rigorous cleaning and sterilization for non-disposable equipment and use sterile disposable materials.
- Provide staff and visitors with information about infection control policies and procedures.
- Provide health care workers with specific infection control training.
- Implement policies to exclude animals unless risk assessments have been developed to protect patient safety.
- Provide adequate supplies of PPE for health care workers involved in direct patient contact and waste management, including overalls, aprons, leg protectors, boots, heavy duty gloves, helmets, visors/face masks and eye protection (especially for cleaning of hazardous spills), and respirators (for spills, highly infectious airborne diseases, e.g., COVID-19, or waste involving toxic dust or incinerator residue) as necessary.[45] PPE should be suitable for different genders and sizes.
- Use laboratory biological safety cabinets (e.g., Biosafety Cabinet Type II) and other containment devices in labs.[46]
- Provide blood-borne spill kits.

49. The HCF emergency response plan should address public health emergencies, such as infectious disease outbreaks (e.g., Ebola, Covid-19, Zika virus). Emergency response personnel, including medical staff and nurses, face various biological hazards when treating patients. Their protection, training, equipment should be planned for, including in the deployment of health care workers to the emergency areas, when establishing temporary HCF or the adaptation of existing HCF.[47]

4.2.2 Chemical Hazards

50. Health care workers may be exposed to carcinogenic and reproductive toxins, including glutaraldehyde (toxic chemical used to sterilize heat sensitive medical equipment), ethylene oxide gas (a sterilant for medical equipment), formaldehyde, mercury (exposure from broken thermometers), chemotherapy and antineoplastic chemicals, solvents, and photographic chemicals. They may also be exposed to waste anesthetic gases such as nitrous oxide, halothane (fluothane), enflurane (ethrane), and isoflurane (forane).

51. Implement a chemical hygiene plan to control exposure to hazardous chemicals, particularly in laboratories.[48] A chemical hygiene plan should consider the following mitigations:

- Eliminate unnecessary chemical use (e.g., no need to disinfect sharps if they are to be incinerated).
- Substitute less harmful chemicals where possible (e.g., use mercury-free substitutes).

[44] US CDC, "Guideline for Hand Hygiene"; WHO, *Guidelines on Hand Hygiene*.
[45] Health Care Without Harm. *Health Care Worker PPE;* US CDC, *Burn Rate Calculator.* US CDC provides a PPE burn rate calculator relating to COVID-19 PPE for health care staff. The tool may be used to estimate adequate space for emergency PPE stockpiles.
[46] WHO. *Laboratory Biosafety Manual*.
[47] WHO and ILO, *Occupational Safety Manual.*
[48] OSHA, *29 CFR 1910.1450—Occupational Exposure to Hazardous Chemicals in Laboratories*.

- Install exhaust ventilation systems for airborne chemical hazards and use active scrubber or scavenging systems in work areas with a high risk of exposure to waste anesthetic gas. Dispose of spent charcoal filters as hazardous waste. If no scavenging unit or filter is available, use vacuum lines to disperse and dilute waste anesthetic gases.
- Conduct occupational hygiene monitoring in high-risk airborne exposure work areas, such as in pathology and pharmacy laboratories, surgical and endoscopic suites, and operating rooms. Assess data against national industrial hygiene standards or reputable international standards such as the US Occupational Safety and Health Administration (OSHA) permissible exposure limits, whichever is more stringent. In the absence of these, use threshold limit values (TLV) from the American Conference of Governmental Industrial Hygienists (ACGIH) or recommended exposure limits from the US National Institute for Occupational Safety and Health (NIOSH). Further information on health monitoring is provided in Section 5.2.1 of these guidelines.
- Implement a hazard communication program with safety data sheets for all chemicals.
- Adopt an international labelling system for the classification and labeling of chemicals such as Global Harmonized System (GHS).[49]
- Train health care workers on hazardous chemicals handling upon employment and when new chemicals are introduced.
- Provide and train workers in the use and maintenance of appropriate PPE.
- Provide training in the use of emergency decontamination equipment (e.g., safety showers, eye-wash stations).
- Provide suitable chemical spill measures, including neutralizing agents, spill containment, and absorbents.

52. The HCF emergency response plan should address chemical emergencies (e.g., toxic gas releases, large scale oil spills). The protection of emergency response personnel, including medical staff, should be planned for, including in the deployment of health care workers to the emergency area, when establishing temporary HCF.

Physical Hazards

53. The main physical hazards in HCF include musculoskeletal risks, slips, trip and fall, sharps exposure, and radiation (ionizing and non-ionizing). Control measures include:

- Provide and use assistive devices to eliminate manual patient handling (e.g., lifts, sit-to-stand lifts, slide sheets, sling lifts, monkey bars, air transfer mattresses, transfer boards, slide boards, gait belts).
- Avoid using extension cords and multiple adaptors.
- Train health care workers to avoid excessive musculoskeletal strain and use assistive devices properly. Further information on musculoskeletal risks and ergonomics is provided in the General EHS Guidelines.
- Design facilities with anti-slip floors and safe layouts to prevent slips, trips, and falls.
- Provide adequately labelled, lead-lined, leak-proof containers for radioactive waste and train workers on handling it.
- Evaluate and select needleless devices or sharps with engineered protective systems.
- Use puncture-resistant, leak-proof, and appropriately labeled sharps containers. Dispose of contaminated sharps promptly as outlined in table 2.

[49] UNECE, *Classification of Chemicals.*

54. The use of radiation in HCFs for diagnostics and treatment, including handling of radioactive waste, poses significant risk to health care workers.[50] HCFs should therefore implement protocols, procedures, and training to prevent or minimize radiological hazards. A radiation safety program should be designed and implemented in consultation with the affected workforce and should:

- Minimize personnel exposure to radioactive materials.
- Maintain records of radionuclide acquisition, use and disposal.
- Individual dosimetry monitoring of personnel and environmental radiation monitoring, radioactive incidents, and emergencies;
- Provide radiation safety training on protection protocols and procedures.
- Implement measures for radioactive waste disposal including safety audit records and reports, and a radiation safety audit program.
- Appoint an accredited radiation protection officer (RPO) to manage the development and implementation of the radiation monitoring and compliance program, which should be tailored to factor in planned or emergency exposure situations and whether the monitoring relates to routine, special, confirmatory, or task-related activities. The program should always be kept current and be updated whenever there are changes in actual radiation exposure conditions.

55. The HCF emergency response plan should address public health emergencies, such as radiation emergencies (e.g., Fukushima, Chernobyl); and natural disasters (e.g., earthquakes, tsunamis). Emergency response personnel, including first responders, medical staff and nurses, face various health and safety hazards related to emergencies. Their protection should be planned for, including specialized PPE, training, resources and support, in the deployment of health care workers to the emergency area.

4.2.4 Psychosocial Hazards

56. Health care workers face psychosocial hazards including anxiety, post-traumatic stress, depression, sleep disorders, occupational violence, extended work hours, burnout, and fatigue.[51] These can lead to mental health and stress-related psychological and physical harm to health care workers, including predisposition to drug and substance use. Physical and psychologically sound health workers are less error-prone, which contributes to better patient and community health outcomes.[52] Physical harm may include musculoskeletal injuries, chronic disease, or fatigue related injuries. Management strategies for these hazards may include:

- Implement a worker fatigue risk assessment and management program. [53]
- Provide sleeping quarters.
- Enforce shift length limits.
- Implement appropriate staffing levels, including a mix of individuals to support safe, quality care, treatment, and services, as well as effective workload assignments.[54]

[50] IAEA, *Occupational Radiation Protection*; OSHA, *29 CFR 1910.1096--Ionizing Radiation*. These resources, plus WHO publications, contain comprehensive risk control measures.
[51] NIOSH, *Risk Factors for Stress.* This resource provides an extensive range of work stress and mental health tools, including training for health care workers.
[52] WHO, *Patient Safety Action Plan*.
[53] SafeWork Australia, *Risk of Fatigue.*
[54] WHO, *Workload Indicators.* This resource can help determine appropriate staffing levels.

- Implement ergonomic requirements for office and workstation spaces.[55]
- Provide recreational facilities.
- Implement management programs to prevent drug and substance abuse.
- Provide video/teleconferencing for staff to contact families during long/irregular shifts.
- Educate on the importance of nutritionally balanced meals.
- Implement a zero-tolerance policy on workplace violence.[56]

4.3 Community Health and Safety

57. HCF, as public access buildings, present health and safety risks to patients, visitors, and local communities. These risks include life and fire safety and exposure to disease.

4.3.1 Life and Fire Safety

58. HCFs are prone to considerable fire hazards due to presence of flammable gases and liquids, oxygen bottles and conveyancing networks, and bed linen, among others. High-risk areas should be segregated from the other hospital areas and/or protected by dedicated fire suppression systems. The consequences of fire and explosion in HCF is considered significant given that many patients cannot self-evacuate.

59. Recommendations applicable to buildings accessible to the public, including HCF, are presented under "Life and Fire Safety" in the General EHS Guidelines. The following summarizes additional, sector-specific recommendations for life and fire safety: [57]

- Maintain all fire safety systems in proper working order, including self-closing doors in escape routes and ventilation ducts with fire safety dampers.
- Develop a fire safety program that includes fire prevention, emergency response, early detection, suppression, containment of fire and smoke, and evacuation plans for workers, visitors, and patients, including those with low mobility and those who require additional support.
- Provide and maintain fire safety systems (e.g., extinguishers, sprinklers, fire alarms) and train health care workers in their use, especially in smaller or temporary facilities where facility size may limit more sophisticated fire control.
- Train staff on evacuation procedures, including defend-in-place, patient and visitor assistance, and full hospital evacuation.
- Display safety information prominently in relevant languages for effective communication. Maintain registers of patients, visitors, and staff for accounting of all HCF occupants during an evacuation.
- Limit smoking to designated non-patient care areas.

[55] AHIA, *Australasian Healthcare Facility Guidelines*. Reference should be made to the regularly updated sets of guidelines from the Australasian Healthcare Facility Guidelines, referred to as Parts.
[56] WHO and ILO, *Addressing Workplace Violence*.
[57] IFC, *Life and Fire Safety in Hospitals*; AHIA, *Australasian Health Facilities Guidelines*.

- Sufficient emergency and standby power systems connected to life safety systems and other special power circuits critical to patient care and clinical functions.
- Employ security personnel based on a security risk assessment to maintain safety and security of workers and patients. Provide adequate lighting and video surveillance, including parking areas and remotely backed-up footage.
- Special considerations for high rise HCF towers such as fire and smoke containment in lift wells and exit routes for vulnerable patients and maintaining functionally during alarms and evacuations.
- Implement a management of change (MOC) plan for changes that could impact life and fire safety systems whenever HCF undergoes renovations or expansion work. The MOC plan should include infection control risk assessment, temporary safety measures to mitigate fire risks during the renovation or expansion works, and training in new procedures.

4.3.2 Exposure to Disease

60. The interaction and impact of HCF on the community are crucial for disease prevention, especially when HCFs are near local communities that interact with patients, workers, and visitors.

61. The General EHS Guidelines provide guidance on the prevention of community disease transmission. Below are some unique considerations to minimize community exposure to disease from HCFs. These include:

- Spatial and structural architecture: Design and locate emission sources, especially from incinerators and laboratories, away from residential areas and other sensitive receptors to reduce exposure to toxins and pathogens (see Section 3).
- Biocontainment hygiene and biosecurity controls: Implement measures to prevent and minimize the spread of communicable diseases within the community, including health care workers' families and hospital visitors (see Section 4.2.1).
- Waste management practices: Implement proper siting, storage, segregation, and disposal of health care waste, including controlled outsourcing of collection and infection control during transportation and disposal (see Section 4.1.3).
- Antimicrobial stewardship. Promote appropriate use of antimicrobials (including antibiotics, antivirals, antifungals and antiparasitic) to reduce microbial resistance and the spread of multidrug-resistant infections.[58]

5 PERFORMANCE INDICATORS AND INDUSTRY BENCHMARKS

62. This section describes relevant EHS performance indicators and industry benchmarks of GIIP for this industry sector. Indicators that are applicable across industries are available in the General EHS Guidelines.

5.1 Environmental Performance

63. Environmental monitoring programs should encompass all activities with potentially significant impacts, during normal operations and upset conditions. Monitoring should use direct or indirect indicators of emissions, effluents, and resource, with sufficient frequency to

[58] WHO. *Antimicrobial Stewardship Programmes*.

provide representative data for the parameter being monitored. Monitoring methods including location, frequency and duration should provide representative data, follow GIIP, and include data verification processes.

64. Monitoring should be conducted by trained specialists using standard operating procedures for instrumentation deployment and retrieval, monitoring data collection and record-keeping, review, analysis and quality assurance and control (QA/QC). Monitoring equipment should be properly calibrated and maintained. Results should be analysed and reviewed regularly and compared to applicable standards to identify if corrective actions are necessary.

65. Exceedances of environmental limits should trigger a non-conformance review to identify causes and recommend changes to the operating procedures that prevent recurrence. The management plans should be updated accordingly.

5.1.1 Emissions Guidelines

66. Tables 3 and 4 provide emission and effluent guidelines for this sector, reflecting GIIP and standards from countries with recognized regulatory frameworks. These guidelines are achievable under normal conditions in appropriately designed and operated facilities using pollution prevention and control techniques as discussed throughout these guidelines. Incinerator emissions reflect the Stockholm Convention on Persistent Organic Pollutants, followed by signatory countries. Emissions guidelines for combustion sources up to 50 megawatts thermal (MWth) are in the General EHS Guideline. Ambient considerations based on total emissions are also in the General EHS Guidelines.

Table 3. Air emission levels for hospital waste incineration facilities

Pollutants	Units	Standard conditions	Guideline values for a 3-run average (1-hour minimum sample time per run) based on incinerator capacity[e]				Guideline values as daily average (>10 Tn/day)[a]
			Small rural incinerator (<2000 lb/wk)	Small capacity incinerator (<200 lb/hr)	Medium capacity incinerator (200-500 lb/hr)	Large capacity incinerator (>500 lb/hr)	
Total particulate matter (PM)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					10
		20^{o}C, 101.3 kPa, 7% O_2 dry	87	66	34	25	
Total organic carbon (TOC)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					10
		20^{o}C, 101.3 kPa, 7% O_2 dry					
Hydrogen chloride (HCl)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					10
	ppm(v)	20^{o}C, 101.3 kPa, 7% O_2 dry	810	15	7.7	6.6	

Table 3. Air emission levels for hospital waste incineration facilities

Pollutants	Units	Standard conditions	Guideline values for a 3-run average (1-hour minimum sample time per run) based on incinerator capacity[e]				Guideline values as daily average (>10 Tn/day)[a]
			Small rural incinerator (<2000 lb/wk)	Small capacity incinerator (<200 lb/hr)	Medium capacity incinerator (200-500 lb/hr)	Large capacity incinerator (>500 lb/hr)	
Hydrogen fluoride (HF)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					1
		20^{o}C, 101.3 kPa, 7% O_2 dry					
Sulfur dioxide (SO_2)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					50
	ppm(v)	20^{o}C, 101.3 kPa, 7% O_2 dry	55	4.2	4.2	9.0	
Carbon monoxide (CO)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O^2 dry					50
	ppm(v)	20^{o}C, 101.3 kPa, 7% O_2 dry	20	20	5.5	11	
Oxides of nitrogen (NO_X)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					200, 400[b]
	ppm(v)	20^{o}C, 101.3 kPa, 7% O_2 dry	130	190	190	140	
Mercury (Hg)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					0.05[c]
		20^{o}C, 101.3 kPa, 7% O_2 dry	0.051	0.014	0.025	0.018	
Cadmium + Thallium (Cd + Tl)	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					0.05[c]
		20^{o}C, 101.3 kPa, 7% O_2 dry	0.11[f]	0.017[f]	0.013[f]	0.0092[f]	
Sb, As, Pb, Cr, Co, Cu, Mn, Ni, and V	mg/Nm^3	273^{o}K, 101.3 kPa, 11% O_2 dry					0.5[c]
		20^{o}C, 101.3 kPa, 7% O_2 dry	0.50[g]	0.31[g]	0.018[g]	0.036[g]	
Polychlorinated dibenzodioxin and	ng/Nm^{3}TEQ	273^{o}K, 101.3 kPa, 11% O_2 dry					0.1[d]

Table 3. Air emission levels for hospital waste incineration facilities							
Pollutants	**Units**	**Standard conditions**	**Guideline values for a 3-run average (1-hour minimum sample time per run) based on incinerator capacity[e]**				**Guideline values as daily average (>10 Tn/day)[a]**
			Small rural incinerator (<2000 lb/wk)	Small capacity incinerator (<200 lb/hr)	Medium capacity incinerator (200-500 lb/hr)	Large capacity incinerator (>500 lb/hr)	
dibenzofuran (PCDD/F)		20°C, 101.3 kPa, 7% O_2 dry	5.1	0.013	0.020	0.054	

a EU, *Directive 2010/75/EU*. See Annex VI, Part 3 Air emission limit values for waste incineration plants as a daily average value (for continuous measurement of pollutants, except for heavy metals and dioxins and furans, which shall have two measurements per year or as otherwise specified given the specific project conditions or regulatory requirements). Applicable to hazardous waste incinerators with a capacity exceeding 10 tons per day.
b NOx values of 200 mg/Nm3 for incinerators with a nominal capacity exceeding 6 tons per hour and 400 mg/Nm3 for incinerators with a nominal capacity of 6 tons per hour or less.
c Average values over a sampling period of 0.5 to 8 hours. These average values cover gaseous and vapor forms of the relevant heavy metal emissions as well as their compounds.
d Average values over a sampling period of 6-8 hours. 3-run average (4-hour minimum sample time per run).
e US EPA, *40 CFR Parts 60, 62*. Rural small capacity is defined as >50 miles from boundary of nearest standard metropolitan statistical area, burning <2000 lb/wk (approximately 907 kg) of waste. Small capacity is defined as <200 lbs/hr (approximately 91 kg). Medium capacity is defined as >200 to 500 lbs/hr. Large capacity is defined as >500 lbs/hr (approximately 227 kg).
f Cadmium only.
g Lead only.

Key:
°C = Degrees Celsius
°K = degrees Kelvin
kPa = kilopascals
mg/Nm^3 = milligrams per normal cubic meter
ng/Nm^3 = nanograms per normal cubic meter
O_2 = oxygen molecule
PCDD/F = Polychlorinated dibenzodioxin and dibenzofuran
TEQ = Toxic Equivalency Factors

As = Arsenic
Co = Cobalt
Cr = Chromium
Cu = Copper
Mn = Manganese
Ni = Nickel
Sb = Antimony
Pb = Lead
V = Vanadium

5.1.2 Effluent Guidelines

67. Effluent guidelines apply to direct discharges of treated effluents from any HCF to surface waters. Site- specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the General EHS Guidelines. Table 4 lists guideline values for common HCF wastewater parameters, which should be met without dilution at least 95 percent of the time that the plant or unit is operating, calculated as a proportion of annual operating hours. Deviation from these levels in consideration of specific, local project conditions should be justified in the environmental assessment.

Table 4. Effluent levels for health care facilities		
Pollutants	**Guideline units**	**Guideline value**
pH	S.U.	6–9
Biochemical oxygen demand (BOD_5)	mg/L	50
Chemical oxygen demand (COD)	mg/L	250
Oil and grease	mg/L	10

Table 4. Effluent levels for health care facilities		
Pollutants	**Guideline units**	**Guideline value**
Total suspended solid (TSS)	mg/L	50
Cadmium (Cd)	mg/L	0.05
Chromium (Cr)	mg/L	0.5
Lead (Pb)	mg/L	0.1
Mercury (Hg)	mg/L	0.01
Chlorine, total residual	mg/L	0.2
Phenols	mg/L	0.5
Total coliform bacteria[a]	CFU or MPN/100 mL	400
PCDD/F[b]	ng/L TEQ	0.1
Temperature difference[c]	°C (degrees Celsius)	3

Notes:

a US EPA, *Microbial Methods Water Waste*. Approved methods and comparison for total coliform bacteria are available in table A1.

b Polychlorinated dibenzodioxin and dibenzofuran.

c Temperature change at the edge of a scientifically established mixing zone that considers ambient water quality, receiving water use, potential receptors, and assimilative capacity.

Key:

CFU = coliform forming units

mg/L = milligrams per liter

mL = milliliters

MPN = Most Probable Number

ng/L = nanograms per liter

S.U. = standard units

TEQ = Toxic Equivalency Factors

5.1.3 Resource Consumption, Energy Use, and Waste Generation

68. HCF environmental performance should be assessed using international protocols and against internationally published benchmarks for resource consumption, energy use, GHG emissions (direct and indirect), and waste generation where these are available. If inefficiencies are found, conduct an audit or survey to identify improvement opportunities, without compromising quality and safe health care.[59]

5.2 Occupational Health and Safety Performance

69. HCF should aim to reduce the risk of occupational incidents and injuries among health care workers, especially incidents that could result in lost work time, disability, illnesses, or fatalities. Benchmark facility-level health and safety performance against sector standards (e.g., US Bureau of Labor Statistics, UK Health and Safety Executive, US OSHA Hospitals e-Tool).[60] Use metrics like the

[59] US DOE EIA, *Energy Efficiency Healthcare Facilities*; Government of Canada, *Office of Energy Efficiency*; Healthcare Environmental Resource Center, *Pollution Prevention Compliance Assistance*.
[60] US BLS, *Injuries, Illnesses, and Fatalities*; Health and Safety Executive, *Health and Safety Statistics*; US OSHA, *Hospitals e-Tool*.

number of incidents, workplace inspections, resolved and unresolved findings, and training sessions to aid performance assessments. Refer to the General EHS Guidelines for more guidance.

5.2.1 Occupational Health and Safety Monitoring

70. Monitor the working environment for project-specific occupational health hazards. Monitoring, including auditing and reviews, should be designed and implemented by qualified and / or accredited professionals as part of an occupational health and safety monitoring program.[61] Facilities should maintain records of occupational accidents, injuries, diseases, and dangerous occurrences. Refer to the General EHS Guidelines for further guidance.

5.2.2 Occupational Health and Hygiene Guidelines

71. Occupational hygiene monitoring should be compared against internationally published chemical, biological, or physical hazard exposure standards and guidelines.[62]

[61] Accredited professionals may include Certified/Chartered or Registered Industrial or Occupational Hygienists, or Certified Safety Professionals or specialists or equivalent.
[62] US DOL OSHA, *Permissible Exposure Limits*; US DOL OSHA, *Table Z-1 Limits for Air Contaminants*; ACGIH, *TLV/BEI Guidelines*; NIOSH, *Pocket Guide Chemical Hazards*; European Agency for Safety and Health at Work, *Occupational Exposure Limit Values*; ILO, *Chemical Exposure Limits.*

6 REFERENCES

ACGIH, n.d. *TLV/BEI Guidlines.* https://www.acgih.org/science/tlv-bei-guidelines/.

Agency for Healthcare Research and Quality. 2008. *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Ed. Hughes RG. Chapter 28: The Impact of Facility Design on Patient Safety. https://www.ncbi.nlm.nih.gov/books/NBK2633/.

ASHE (American Society for Healthcare Engineering) of the AHA (American Hospital Association). https://www.ashe.org/tools?type=1145.

ASHE. 2020. *Infection Control Risk Assessment (ICRA) 2.0*. https://www.ashe.org/icra2.

ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). n.d. *Health Care Facilities Resources*. https://www.ashrae.org/technical-resources/bookstore/health-care-facilities-resources.

ASHRAE. 2021. *Standard 170-2021, Ventilation of Health Care Facilities*. https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/170_2021_c_20210730.pdf.

ASHRAE and US Army Corps of Engineers. 2021. *Alternate Care Site HVAC Guidebook*. https://www.ashrae.org/file%20library/technical%20resources/covid-19/usace-acs-guidebook---final-2020-11-08.pdf.

AHIA (Australasian Health Infrastructure Alliance). 2022. *Australasian Health Facilities Guidelines.* https://healthfacilityguidelines.com.au/aushfg-parts.

AHIA. 2021. *Australasian Health Facilities Guidelines Part C - Design for Access, Mobility, Safety and Security.* https://aushfg-prod-com-au.s3.amazonaws.com/Part%20C%2018%20Sept_4_Nov%202021%20Reference%20Edit.pdf.

Batterman et al. 2004. *Findings of an Assessment of Small-scale Incinerators for Health-care Waste*. https://iris.who.int/bitstream/handle/10665/68775/a85187.pdf?sequence=1&isAllowed=y.

European Agency for Safety and Health at Work. 2024. *Directive 2019/1831 - Indicative Occupational Exposure Limit Values.* *https://osha.europa.eu/en/legislation/directive/directive20191831-indicative-occupational-exposure-limit-values*.

EEA (European Environment Agency). 2019. *EMEP/CORINAIR Emission Inventory Guidebook*. Group 9: Waste Treatment and Disposal. Incineration of Hospital Wastes, Activity 090207. Emission Inventory Guidebook. Copenhagen: EEA. https://www.eea.europa.eu/publications/EMEPCORINAIR4/page018.html.

EU (European Parliament and Council of the European Union). 1999. *Council Directive 1999/31/EC on the Landfill of Waste*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31999L0031.

EU. 2010. *Council Directive 2010/75/EU on Industrial Emissions (Integrated Pollution Prevention and Control).* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32010L0075.

EU. 2024. *Council Directive 2024/1786 on Industrial Emissions and the Landfill of Waste*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32024L1785.

Exner et al. 2020. "Chemical Disinfection in Healthcare Settings: Critical Aspects for the Development of Global Strategies." National Library of Medicine. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7818848/.

FGI (Facility Guidelines Institute). 2022. *Guidelines for Design and Construction for Hospitals, Outpatient Facilities and Residential Healthcare and Support Facilities*. https://www.fgiguidelines.org/. [Available for purchase].

Healthcare. 2021. Kenny C, Priyadarshini A. "Review of Current Healthcare Waste Management Methods and Their Effect on Global Health." Mar 5;9(3):284: *9*(3), 284; https://doi.org/10.3390/healthcare9030284.

Healthcare Environmental Resource Center. n.d. *Pollution Prevention and Compliance Assistance Information for the Healthcare Industry.* https://www.hercenter.org/.

Health Care Without Harm. 2004. *Non-Incineration Medical Waste Treatment Technologies in Europe*. Prague, Czech Republic: Health Care Without Harm. https://www.env-health.org/IMG/pdf/altech_Europe_updated_version_10_12_2004.pdf.

Health Care Without Harm. 2007. *For Proper Disposal: A Global Inventory of Alternative Medical Waste Treatment Technologies. Washington, DC: Health Care Without Harm.* https://global.noharm.org/media/4090/download?inline=1.

Health Care Without Harm. 2010. *Non-Incineration Medical Waste Treatment Pilot Project at Bagamoyo District Hospital, Tanzania*. https://global.noharm.org/media/3883/download?inline=1.

Health Care Without Harm. 2024. *Health Care Waste Management Worker PPE – Guidance Document Number: 303*. https://noharm-global.org/documents/health-care-waste-management-worker-ppe-guidance.

Health Care Without Harm. 2024. *Waste Minimization and Recycling of Infectious Waste – Guidance Document Number: 501.* https://global.noharm.org/documents/waste-minimization-and-recycling-infectious-waste-guidance.

HSE (Irish Health Service Executive). 2018. *National Guidelines for the Prevention of Nosocomial Aspergillosis*. https://www.hpsc.ie/a-z/microbiologyantimicrobialresistance/infectioncontrolandhai/guidelines/Aspergillus%20Guidelines%202018.pdf.

IAEA (International Atomic Energy Association). 2018. *Occupational Radiation Protection*. https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1785_web.pdf.

IAEA. 2019. *Predisposal Management of Radioactive Waste from the Use of Radioactive Material in Medicine, Industry, Agriculture, Research, and Education.* No. SSG-45. https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1758_web.pdf.

IAHSS (International Association of Healthcare Security and Safety). 2020. *Design Guidelines for Healthcare Facilities – Alternate Care Sites – Medical Surge Capacity (draft)*. https://cdn.ymaws.com/www.iahss.org/resource/resmgr/iahss_alternate_care_site_me.pdf.

ICC (International Code Council). 2020. *Structures Used for Temporary Healthcare Use*. https://www.iccsafe.org/wp-content/uploads/20-18698_GR_Temp_Hospital_RPT_FINAL2_HIRES.pdf.

ICRC (International Committee for the Red Cross). 2011. *Medical Waste Management*. https://www.icrc.org/en/doc/assets/files/publications/icrc-002-4032.pdf.

IFC (International Finance Corporation). 2017. *Good Practice Note Life and Fire Safety: Hospitals*. https://www.ifc.org/en/insights-reports/2017/publications-gpn-lfs-hospitals.

IFC. 2024. *Excellence in Design for Greater Efficiencies (EDGE) – Hospitals.* https://edgebuildings.com/building-types/hospitals/.

ILO (International Labour Organization). 2011. *Chemical Exposure Limits.* https://www.ilo.org/resource/chemical-exposure-limits.

IMERT (Illinois Medical Emergency Response Team). 2020. *Temporary Medical Treatment Stations Guide*. http://alternatecaresiteplanning.com/wp-content/uploads/2020/03/final-revision-TMTS-GUIDE_V2020_adult_combined.pdf.

ISO (International Standard Organization). 2020. ISO 15190:2020 Medical Laboratories – Requirements for Safety. Edition 2, 2020. https://www.iso.org/standard/72191.html#lifecycle [Available for purchase].

JCI (Joint Commission International). 2019. *Planning, Design and Construction of Health Care Facilities, 5th Edition.* https://store.jointcommissioninternational.org/planning-design-and-construction-of-health-care-facilities-5th-edition/?_gl=1*idmvia*_ga*MTYzNjg4MzIwNi4xNzQzMzQ1NzE4*_ga_BVWBGLR37D*MTc0MzM0NTcxOC4xLjEuMTc0MzM0NTc0MS4zNy4wLjA.*_gcl_au*MjE0NTc1Mjk4Ny4xNzQzM [Available for purchase].

JRC (Joint Research Centre). 2018. *Best Environmental Management Practice for the Waste Management Sector*. https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/inline-files/WasteManagementBEMP.pdf.

MMIS (Making Medical Injections Safer). 2010. *The Incinerator Guidebook: A Practical Guide for Selecting, Purchasing, Installing, Operating and Maintaining Small-Scale Incinerators in Low-Resource Settings.* https://media.path.org/documents/TS_mmis_incin_guide.pdf.

Natural Resource Canada Office of Energy Efficiency. n.d. *Energy Consumption in Health Care Facilities*. https://www.nrcan.gc.ca/energy-efficiency/10832.

NHS (National Health Service). n.d. *Health Building Notes*. https://www.england.nhs.uk/estates/health-building-notes/.

Safe Work Australia. 2013. *Guide for Managing the Risk of Fatigue at Work*. https://www.safeworkaustralia.gov.au/system/files/documents/1702/managing-the-risk-of-fatigue.pdf.

Sampath B, Jensen M, Lenoci-Edwards J, Little K, Singh H, Sherman JD. "Reducing Healthcare Carbon Emissions: A Primer on Measures and Actions for Healthcare Organizations to Mitigate Climate Change." (Prepared by Institute for Healthcare Improvement under Contract No. 75Q80122P00007.) AHRQ Publication No. 22-M011. Rockville, MD: Agency for Healthcare Research and Quality; September 2022. https://www.ahrq.gov/sites/default/files/wysiwyg/healthsystemsresearch/decarbonization/decarbonization.pdf

The Global Fund. 2022. *Technical Brief Avoidance, Reduction and Safe Management of Health Care Waste*. https://www.theglobalfund.org/media/9356/core_healthcarewastemanagement_technicalbrief_en.pdf.

UK Health and Safety Executive. n.d. *Health and Safety Statistics*. https://www.hse.gov.uk/statistics/index.htm.

United Nations. 2001. Stockholm Convention on Persistent Organic Pollutants. United Nations Treaty Collection: CHAPTER XXVII – ENVIRONMENT – 15. https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-15&chapter=27.

United Nations. 2015. United Nations Framework Convention on Climate Change (Paris Agreement). United Nations Treaty Collection: CHAPTER XXVII – ENVIRONMENT – 7d. https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en.

UNECE (United Nations Economic Commission for Europe). *Globally Harmonized System of Classification and Labelling of Chemicals (GHS)*. https://unece.org/about-ghs.

UNEP (United Nations Environment Programme). 2007. *Guidelines on Best Available Techniques (BAT) and Guidance on Best Environmental Practices (BEP). Relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants.* Geneva, Secretariat of the Stockholm Convention. https://chm.pops.int/Portals/0/Repository/batbep_guideline08/UNEP-POPS-BATBEP-GUIDE-08-2.English.PDF.

UNEP-POPS-BATBEP- Section V Guidance/guidelines by source category: Source categories in Part II Category (a) of Annex C: Waste Incinerators (2021). https://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-BATBEP-GUID-GUIDELINES-02.En.docx

US BLS (US Bureau of Labor Statistics). n.d. *Injuries, Illnesses, and Fatalities.* https://www.bls.gov/iif/.

US CDC (United States Centers for Disease Control and Prevention). 2002. "Guideline for Hand Hygiene in Health-Care Settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force." Prepared by Boyce, J. and D. Pittet. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5116a1.htm.

US CDC. 2007. *Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings*. (2007, updated July 2023). https://www.cdc.gov/infectioncontrol/pdf/guidelines/isolation-guidelines-H.pdf.

US CDC. 2003. *Guidelines for Environmental Infection Control in Health-Care Facilities*. https://www.cdc.gov/infection-control/hcp/environmental-control/air.html?CDC_AAref_Val=https://www.cdc.gov/infectioncontrol/guidelines/environmental/background/air.html.

US CDC. 2019. *Infection Control in Healthcare Personnel: Infrastructure and Routine Practices.* https://www.cdc.gov/infection-control/hcp/healthcare-personnel-infrastructure-routine-practices/?CDC_AAref_Val=https://www.cdc.gov/infectioncontrol/guidelines/healthcare-personnel/infrastructure.html.

US CDC. 2020. *PPE Burn Rate Calculator*. https://www.cdc.gov/niosh/healthcare/hcp/pandemic/ppe-burn-rate-calculator.html?CDC_AAref_Val=https://www.cdc.gov/niosh/topics/pandemic/ppe.html.

US CDC. 2024. *Healthcare-Associated Infection (HAI) Prevention Toolkits.* https://www.cdc.gov/hai/prevent/prevention_tools.html.

US CDC. 2024. *Operational Considerations for Infection Prevention and Control in Outpatient Facilities: Non-U.S. Healthcare Settings.* https://www.cdc.gov/covid/hcp/non-us-

settings/outpatient.html?CDC_AAref_Val=https://www.cdc.gov/coronavirus/2019-ncov/hcp/non-us-settings/outpatient.html.

US CDC NIOSH (US Centers for Disease Control and Prevention National Institute for Occupational Safety and Health). 2024. *Healthcare Workers: Risk Factors for Stress and Burnout*. https://www.cdc.gov/niosh/healthcare/risk-factors/stress-burnout.html?CDC_AAref_Val=https://www.cdc.gov/niosh/topics/healthcare/workstress.html.

US CDC NIOSH. 2007. *Pocket Guide to Chemical Hazards.* Publication Number 2005-149. http://www.cdc.gov/niosh/npg/.

US DOE EIA (Department of Energy, Energy Information Administration). 2021. *Integrating Health and Energy Efficiency in Healthcare Facilities*. https://www.energy.gov/femp/articles/integrating-health-and-energy-efficiency-healthcare-facilities.

US DOL OSHA (Department of Labor Occupational Safety and Health Administration). n.d. *Hospitals e-Tool*. http://www.osha.gov/SLTC/etools/hospital/index.html.

US DOL OSHA. n.d. *Permissible Exposure Limits – Annotated Tables*. https://www.osha.gov/annotated-pels/table-z-1.

US DOL OSHA. n.d. *Table Z-1 Limits for Air Contaminants*, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992.

US DOL OSHA. 1989. *Ionizing Radiation. OSHA 29 CFR 1910.1096*. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1096.

US DOL OSHA. 1990. *Occupational Exposure to Hazardous Chemicals in Laboratories. 29 CFR 1910.1450.* https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1450.

US DOL OSHA. 1991, updated 2001. *Bloodborne Pathogens Standard, 29 CFR 1910.1030*. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1030.

US DOL OSHA. 2003. *Model Plans and Programs for the OSHA Bloodborne Pathogens and Hazard Communications Standards.* OSHA 3186-06N. https://www.osha.gov/sites/default/files/publications/osha3186.pdf.

US EPA (United States Environmental Protection Agency). 2013. *Federal Plan Requirements for Hospital/Medical/Infectious Waste Incinerators Constructed on or Before December 1, 2008, and Standards of Performance for New Stationary Sources: Hospital/Medical/Infectious Waste Incinerators*. Federal Register. https://www.govinfo.gov/content/pkg/FR-2013-05-13/pdf/2013-09427.pdf.

US EPA. 2011. *Handbook on the Operation and Maintenance of Medical Waste Incinerators.* EPA/625/6-89/024. Washington, DC: EPA. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=39372.

US EPA. 2005. *EPA Office of Compliance Sector Notebook Project. Profile of the Healthcare Industry*. EPA/310-R-05-002. Washington, DC: EPA. https://archive.epa.gov/compliance/resources/publications/assistance/sectors/web/pdf/health.pdf.

US EPA. 1978. Bordner, R. H.; Winter, J. A.; Scarpino, P., "Microbiological Methods for Monitoring the Environment. Water and Wastes." 40 CFR part 163.3. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=300014TD.TXT.

US EPA. 2013. *Standards of Performance for New Stationary Sources*. Federal Register 28052 Vol. 78, No. 92 40 CFR Part 60. https://www.ecfr.gov/current/title-40/part-60.

US EPA. 2013. *Approval and Promulgation of State Plans for Designated Facilities and Pollutants*. Federal Register 28052 Vol. 78, No. 92 40 CFR Part 62. https://www.ecfr.gov/current/title-40/part-62.

WHO. 2005. *Mercury in Health Care*. Policy Paper. Geneva: WHO. https://www.who.int/publications/i/item/WHO-SDE-WSH-05.08.

WHO. 2009. *WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care is Safer Care*. https://iris.who.int/handle/10665/44102?search-result=true&query=hand+hygiene+in+health&scope=&rpp=10&sort_by=score&order=desc.

WHO. 2010. *Workload Indicators of Staffing Need (WISN). User's Manual.* https://www.who.int/publications/i/item/9789241500197.

WHO. 2011. *Health-care Waste Management Rapid Assessment Tool*. https://www.who.int/publications/m/item/health-care-waste-management-rapid-assessment-tool.

WHO. 2014. *Safe Management of Wastes from Healthcare Activities. Eds.* Prüss, A. Giroult, and P. Rushbrook. Geneva: WHO. https://www.who.int/publications/i/item/9789241548564.

WHO. 2019. *Antimicrobial Stewardship Programmes in Health-Care Facilities in Low- and Middle-Income Countries. A WHO Practical Toolkit.* https://iris.who.int/bitstream/handle/10665/329404/9789241515481-eng.pdf.

WHO. 2020. *Laboratory Biosafety Manual, 4th Edition: Risk Assessment*. https://www.who.int/publications/i/item/9789240011458.

WHO. 2021. *Global Patient Safety Action Plan 2021–2030: Towards Eliminating Avoidable Harm in Health Care.* License: CC BY-NC-SA 3.0 IGO. https://www.who.int/teams/integrated-health-services/patient-safety/policy/global-patient-safety-action-plan.

WHO n.d. *Incineration of Healthcare Waste and the Stockholm Convention Guidelines*. https://cdn.who.int/media/docs/default-source/wash-documents/wash-in-hcf/training-modules-in-health-care-waste-management/module-16---incineration-of-health-care-waste-and-the-stockholm-convention-guidelines.pdf?sfvrsn=9e98d5c2_2.

WHO. 2022. *Implementation Guide for Vaccination of Health Workers.* https://iris.who.int/bitstream/handle/10665/360603/9789240052154-eng.pdf?sequence=1.

WHO. 2023. *Occupational Hazards in the Health Sector eTool.* https://www.who.int/tools/occupational-hazards-in-health-sector/.

WHO and ILO (International Labour Organization). 2018. *Occupational Safety and Health in Public Health Emergencies: A Manual for Protecting Health Workers and Responders: Geneva*. https://www.ilo.org/publications/occupational-safety-and-health-public-health-emergencies-manual-protecting.

WHO and ILO. 2002. *Framework Guidelines for Addressing Workplace Violence in the Health Sector*. Geneva: WHO. https://www.who.int/publications/i/item/9221134466.

WHO and ILO. 2022. *Caring for Those Who Care - A Guide for the Development and Implementation of Occupational Health and Safety Programmes for Health Workers.* https://iris.who.int/bitstream/handle/10665/351436/9789240040779-eng.pdf?sequence=1.

Zilberberg MD, Nathanson BH, Harrington R, Spalding JR, Shorr AF. "Epidemiology and Outcomes of Hospitalizations with Invasive Aspergillosis in the United States, 2009-2013." *Clinical Infectious Diseases*, Volume 67, Issue 5, 1 September 2018, Pages 727–735, https://doi.org/10.1093/cid/ciy181.

ANNEX A: GENERAL DESCRIPTION OF INDUSTRY ACTIVITIES

72. The HCF sector includes diverse facilities varying in complexity, size, purpose, and permanence, which influence their environmental, health and safety impacts. These Guidelines categorize HCFs based on these variables to aid discussion, not to prescribe characteristics, as definitions may vary by jurisdiction. Table A1 lists HCF categories and examples.[63]

Table A1. Examples of health care facility types

Major HCF	Minor/Specialized HCF	Temporary HCF

• General-purpose or multifunction hospitals or clinics with high patient capacity (>100 beds), multiple specialists, and a complex waste profile
• Research institutes with a complex waste profile
	• Single-function hospitals, or clinics or centers with small patient capacities (<100 beds) and simple waste profile
	• Rural health centers or posts
	• Radiology clinics
	• Pregnancy and birth centers
	• Blood banks
	• Stand-alone Medical Laboratories
	• Hospice homes
	• Mental health clinics
	• Ambulant facilities
	• Alternative medicine clinics (e.g. accupuncture)
	• Research institutes with a simple waste profile
		• Modular or field HCF, commonly referred to as Alternate Care Sites (ACS), including:
		  ○ Pop-up vaccination facilities
		  ○ Field hospitals or clinics
		  ○ Facilities housed in temporary structures, generally with a single function and simple waste profile

73. The HCF sector involves close contact among patients, health care providers, and staff; extensive use of sharps and diagnostic instruments; and the use of pharmaceutical, chemical, radiological, and other agents for diagnosis, treatment, cleaning, and disinfection.

74. HCF facilities aim to improve patient health, prevent transmission of infections, and control environment, health, and safety impacts. Key activities include maintaining sanitary conditions, using proper disinfection and sterilization; providing potable water and clean air, and controlling nosocomial infection control.

75. The medical technology area (MTA) is central to hospitals and clinics but is not typically found outpatient, assisted living, or hospice facilities. Patient and services areas (P&SA) are crucial in hospitals and clinics, assisted living, and hospice facilities. Where present, each patient bed typically requires 60 to 100 square meters (m^2) per bed, plus a similarly sized area for parking and facility access. HCF electricity consumption is influenced by its design and service needs, with general hospitals consuming nearly double the energy of other buildings due to MTA energy needs.

76. HCF generate various wastes, including air emissions, wastewater, health care waste (e.g., infectious, radioactive, and chemical), and municipal solid waste (e.g., plastic packaging and single-use products). These waste streams can harm the environment and

[63] WHO, *Waste Management Assessment Tool*. HCF categories referred to in these guidelines are adapted from those defined in the WHO rapid assessment tool, which is designed to develop performance profiles of participants and encourage good health care waste management practices. In view of the intent of these EHS Guidelines, the adaptations of the definitions from WHO (2011) generally account for requirements related to the variety of services, patient numbers, and scale of an HCF.

human health. Waste control processes, specific to the health care sector, may be conducted on- or offsite. Figure A1 shows some treatment methods for managing health care waste hazards figure A1.

Figure A1. Illustration of health care waste treatment methods