4 Environmental Management Practices

A clean environment plays an important role in the prevention of hospital-associated infections (HAI). Many factors, including the design of patient care areas, operating rooms, air quality, water supply and the laundry, can significantly influence the transmission of HAI.

Premises/buildings

Facility design and planning should ensure:

- adequate safe water supply;
- appropriate cleaning practices;
- adequate floor space for beds;
- adequate interbed space;
- adequate handwashing facilities;
- adequate ventilation for isolation rooms and high-risk areas like operation theatres, transplant units, intensive care areas, etc.
- adequate isolation facilities for airborne, droplet, contact isolation and protective environment;
- regulation of traffic flow to minimize exposure of high-risk patients and facilitate patient transport;
- measures to prevent exposure of patients to fungal spores during renovations;
- precautions to control rodents, pests and other vectors; and
- appropriate waste management facilities and practices.

Air

Ventilation

Ventilation systems should be designed and maintained to minimize microbial contamination. The air conditioning filters should be cleaned periodically and fans that can spread airborne pathogens should be avoided in high-risk areas.

High-risk areas such as operating rooms, critical care units and transplant units require special ventilation systems. Filtration systems (air handling units) designed to provide clean air should have high efficiency particulate air (HEPA) filters in high-risk areas. Unidirectional laminar airflow systems should be available in appropriate areas in the hospital construction. Ultra clean air is valuable in some types of cardiac surgery/neurosurgery/implant surgery theatres and transplant units.

For the operating room, the critical parameters for air quality include:

- frequent maintenance/validation of efficacy of filters (in accordance with manufacturer's requirements);
- pressure gradient across the filter bed and in the operation theatre;
- air changes per hour (minimum 15 air changes per hour);
- temperature should be maintained between 20°C and 22°C and humidity between 30% and 60% to inhibit bacterial multiplication;
- general areas should be well ventilated if they are not air-conditioned.

Special air handling for airborne precautions

Negative air pressure vented to the air is recommended for contaminated areas and is required also for isolation of patients with infections spread by the airborne route. An air-handling system providing 6–12 air changes per hour with the air being discharged outside through a filtration mechanism is recommended. Systems must be checked by engineering services to ensure they are in fact offering negative pressure rooms.

An air-conditioned single room with an exhaust or a well-ventilated room are adequate options for health care facilities without "negative pressure" rooms. (See also "Negative Pressure Room" in the glossary.)

If an air-conditioned single room is not available as in many resource poor settings, a fan can be placed in the room to direct airflow towards an

outside window. The door/s to the aisle or other rooms should be kept closed at all times.

Protective environment

A protective environment may be required for some neutropenic patients. Ultra clean unidirectional air may be required in some units such as haematology or intensive care due to the level of immunosuppression of the patients. To minimize airborne particles, air must be circulated into the room with a velocity of at least 0.25m/sec through a high efficiency particulate air (HEPA) filter. The HEPA filter removes particles to a certain defined size. If particles 0.3 microns in diameter are removed, the air entering the room can be classified as being clean and free of bacterial contamination. [2]

Other important ways of protecting patients with severely lowered immune systems include:

- Health care workers and visitors should avoid contact with the patient if they have any infections (for example, upper respiratory tract infections or herpes simplex blisters).
- Where appropriate, staff and visitors should wear personal protective equipment to protect the patient from micro-organisms.
- Do not put flowers or plants in the room.
- Ensure a tidy environment.
- Environmental cleaning should be done twice daily and should consist of damp dusting only – do not create aerosols.
- Use strict aseptic techniques for all clinical procedures.

Water

The health care facility should provide safe water. If it has water storage tanks, they should be cleaned regularly and the quality of water should be sampled periodically to check for bacterial contamination.

Safe drinking water

Where safe water is not available, boil water for 5 minutes to render it safe. Alternatively, use water purification units.

Store water in a hygienic environment. Do not allow hands to enter the storage container.

Dispense water from storage container by an outlet fitted with a closure device or tap.

Clean the storage containers and water coolers regularly.

Cleaning of the hospital environment

Routine cleaning is important to ensure a clean and dust-free hospital environment. There are usually many micro-organisms present in "visible dirt", and routine cleaning helps to eliminate this dirt. Administrative and office areas with no patient contact require normal domestic cleaning. Most patient care areas should be cleaned by wet mopping. Dry sweeping is not recommended. The use of a neutral detergent solution improves the quality of cleaning. Hot water (80°C) is a useful and effective environmental cleaner. Bacteriological testing of the environment is not recommended unless seeking a potential source of an outbreak.

Any areas visibly contaminated with blood or body fluids should be cleaned immediately with detergent and water.

Isolation rooms and other areas that have patients with known transmissible infectious diseases should be cleaned with a detergent/disinfectant solution at least daily.

All horizontal surfaces and all toilet areas should be cleaned daily.

Waste management

Hospital waste is a potential reservoir of pathogenic micro-organisms and requires appropriate, safe and reliable handling. The main risk associated with infection is sharps contaminated with blood.[2] There should be a person or persons responsible for the organization and management of waste collection, handling, storage and disposal. Waste management should be conducted in coordination with the infection control team.

Steps in the management of hospital waste include:

- generation,
- segregation/separation,
- collection,
- transportation,

- storage,
- treatment,
- final disposal.

Waste management practices must meet national and local requirements; the following principles are recommended as a general guide:

Principles of waste management

Develop a waste management plan that is based on an assessment of the current situation and which minimizes the amount of waste generated.

Segregate clinical (infectious) waste from non-clinical waste in dedicated containers.

Transport waste in a dedicated trolley.

Store waste in specified areas with restricted access.

Collect and store sharps in sharps containers. Sharps containers should be made of plastic or metal and have a lid that can be closed. They should be marked with the appropriate label or logo, e.g. a biohazard symbol for clinical (infectious) waste (see picture below).

Biohazard Symbol

Mark the storage areas with a biohazard symbol.

Ensure that the carts or trolleys used for the transport of segregated waste collection are not used for any other purpose – they should be cleaned regularly.

Identify a storage area for waste prior to treatment or being taken to final disposal area.

Treatment of hazardous and clinical/infectious waste

Each health care facility should identify a method for the treatment of clinical/infectious waste. This may consist of transportation of infectious waste to a centralized waste treatment facility or on-site treatment of waste.

Methods of disposal

Sharps:

- autoclave, shred and land-fill or microwave, shred and land-fill or treat by plasma pyrolysis of puncture-proof containers storing discarded sharps ;
- deep burial in a secure area. Burial should be 2 to 3 meters deep and at least 1.5 meters above the groundwater table.

Waste requiring incineration:

- anatomical parts and animal carcasses;
- cytotoxic drugs (residues or outdated);
- toxic laboratory chemicals other than mercury.

Waste that may be incinerated:

- patient-contaminated non-plastics and non-chlorinated plastics.

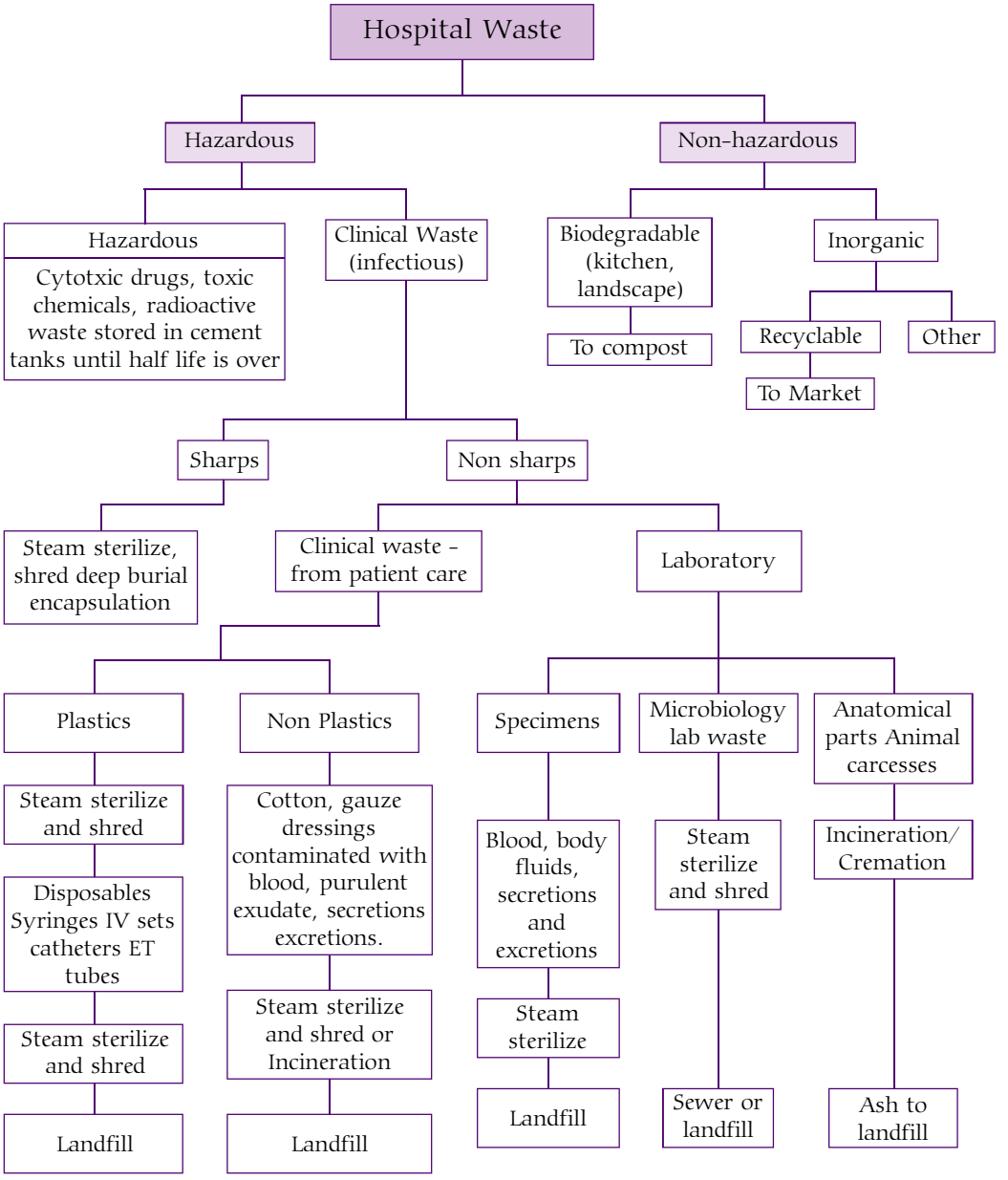
Waste that should not be incinerated:

- chlorinated plastics;
- volatile toxic wastes such as mercury;
- plastics, non-plastics contaminated with blood, body fluids, secretions and excretions and infectious laboratory wastes. (Such wastes should be treated by steam sterilization in autoclavable bags or microwave treatment. Shredding may follow both these methods. If neither method is available, chemical treatment with 1% hypochlorite or a similar disinfectant is recommended. However, excessive use of chemical disinfectants should be avoided as it may be a health and environmental hazard).

Radioactive waste (should be dealt with according to national laws).

For further details please refer to WHO's Safe *management of wastes from health-care activities* (1999) at: http://www.who.int/water_sanitation_health/medicalwaste/wastemanag/en/

Figure 1. Practical classification of hospital waste and methods of treatment



Source: Prüss A, Giroult E and Rushbrook P, eds. *Safe Management of Wastes from Health-care Activities*. Geneva, World Health Organization, 1999, page 168. Electronic access: http://whqlibdoc.who.int/publiations/9241545259.pdf

Laundry

General instructions

Linen

The basic principles of linen management are as follows:

- Place used linen in appropriate bags at the point of generation.
- Contain linen soiled with body substances or other fluids within suitable impermeable bags and close the bags securely for transportation to avoid any spills or drips of blood, body fluids, secretions or excretions.
- Do not rinse or sort linen in patient care areas (sort in appropriate areas).
- Handle all linen with minimum agitation to avoid aerosolisation of pathogenic micro-organisms.
- Separate clean from soiled linen and transport/store separately.
- Wash used linen (sheets, cotton blankets) in hot water (70°C to 80°C) and detergent, rinse and dry preferably in a dryer or in the sun. (Heavy-duty washers/dryers are recommended for the hospital laundry.) See table 7 for details.
- Autoclave linen before being supplied to the operating rooms/theatres.
- Wash woollen blankets in warm water and dry in the sun, in dryers at cool temperatures or dry-clean.

Bedding

- Mattresses and pillows with plastic covers should be wiped over with a neutral detergent.
- Mattresses without plastic covers should be steam cleaned if they have been contaminated with body fluids. If this is not possible, contaminations should be removed by manual washing, ensuring adequate personnel and environmental protection.
- Wash pillows either by using the standard laundering procedure described above, or dry clean if contaminated with body fluids.

Reprocessing of instruments and equipment[3]

The risk of transferring infection from instruments and equipment is dependent on the following factors:

(1) The presence of micro-organisms, the number and virulence of these organisms;

(2) The type of procedure that is going to be performed (invasive or non-invasive), and

(3) The body site where the instrument/and or equipment will be used (penetrating the mucosal or skin tissue or used on intact skin).

The classification of risk of transmission of infection by instruments and equipment has been called the "Spaulding Classification"[8]. The risk of transmission is classified according to the site where the instrument is to be used. Contact sites for instruments may be classified as critical, semi-critical or non-critical. Table 1 shows these classifications. The level of reprocessing required is based on the classification and level of risk. Any instrument or equipment entering into a sterile part of the body must be sterilized. Where the instrument or equipment will be in contact with mucous membranes or non-intact skin, it must have undergone disinfection, and where there will be contact with intact skin, disinfection or cleaning should be used.[3]

Reprocessing of instruments and equipment in an effective way includes:

(1) cleaning instruments and equipment immediately after use to remove all organic matter, chemicals and

(2) disinfection (by heat and water or chemical disinfectants) or

(3) sterilization.

For more information on the selection and use of disinfectants see APIC Guideline for selection and use of disinfectants (1996.) [9]

Reprocessing Principles[3]

There are certain principles that must be applied to ensure instruments and equipment have been appropriately reprocessed.

Table 1. *Level of disinfection/cleaning required for patient care equipment*[2,3,8]

Application	Spaulding-Classi-fication	Level of risk	Level of reprocessing required	Examples	Storage of reprocessed instrument
Entry or penetration into sterile tissue, cavity or bloodstream E.g. Into vascular system Into sterile cavity Into sterile tissue	Critical	High	Sterile Sterilization by steam under pressure or an automated low-temp chemical sterilant system, other liquid chemical sterilant or ethylene oxide sterilization.	Surgical procedure, entry into sterile tissue, arthroscopy, biopsies, intravascular cannulation	Sterility must be maintained. - packaged items must be allowed to dry before removal from the sterilizer - the integrity of the wrap must be maintained - wraps should act as effective bio- barrier during storage - store away from potential environmental contaminants - unpackaged sterile items must be used immediately
Contact with intact non-sterile mucosa or non-intact skin,	Semi-Critical	Medium	Disinfection Heat tolerant items - steam sterilize where possible - if unable to steam sterilize – use thermal disinfection Heat-sensitive items - low temperature automated chemical sterilant systems - chemical disinfectant	Respiratory therapy, gastroscopy	Store to protect from environmental contaminants.
Intact skin, no contact with the patient	Non-critical	Low	Items must be cleaned - Clean after each use with detergent and water. - if disinfection is required follow with appropriate disinfectant e.g. 70% alcohol.	Beds, sinks, etc.	Store in a clean dry place

1. Staff Training

Staff who work in the sterilizing service department and are responsible for the reprocessing of instruments and equipment must have undergone formal training in how to clean, disinfect and sterilize instruments and equipment. The level of training must be appropriate for the level of responsibility that the staff member is expected to undertake.

2. Appropriate Level of Reprocessing

As described above it is essential that the correct level of reprocessing of an instrument/equipment is chosen according to its intended use. This decision is made not according to what the instrument or equipment is, but rather what it is intended use is.

Steam sterilization is recommended as the most effective method to achieve sterility. However, this may not always be possible as some instruments may not be able to withstand the temperature or moisture required for sterilization using steam. Other methods may be used to achieve sterility such as ethylene oxide or automated low temperature chemical sterilant systems, provided the manufacturer of the instrument / equipment agrees that this is an effective means to sterilize them.

3. Servicing of instruments and equipment

Prior to sending medical devices for service they should be reprocessed appropriately. If however they are unable to be reprocessed before being repaired, they should be placed in a fluid resistant plastic bag or container and labelled appropriately before being sent for repair.

4. Selected items that require special reprocessing.

Items that require special treatment include:

- Endoscopes,
- Respiratory and anaesthetic apparatus,
- Diagnostic ultrasonic transducers.

Instruments and equipment like these may not be able to withstand the heat or the moisture of steam or thermal disinfection or even some chemical agents. They therefore may require very delicate measures to reprocess them. It is essential that equipment that will not withstand the regular types of

reprocessing must only be reprocessed in a department that has the proper facilities. The manufacturers' instructions must be followed.

5. Storage

Storage of instruments and equipment is an essential component in ensuring the product maintains its level of sterilization or disinfection. Most instruments and equipment are dry and packaged once they have been sterilized. They should be stored in a clean, dry environment and protected from any damage. Correct storage of sterile instruments and equipment is a critical component in keeping them sterile.[3]

6. Patient care equipment

Any equipment that is used for a patient, and touches only their intact skin, such as bedpans, urinals, commode chairs, blood pressure cuffs etc. should be cleaned or cleaned and disinfected – usually in hot water (at least 70^{0}C).

Cleaning, disinfection and sterilization

Cleaning

Prior to any reprocessing to achieve disinfection or sterility all instruments and equipment MUST be cleaned. If not cleaned properly, organic matter may prevent the disinfectant or sterilant from having contact with the instrument/equipment and may also bind and inactivate the chemical activity of the disinfectant.[10] If an instrument/equipment is unable to be cleaned then it is unable to be sterilized or disinfected.

After an instrument has been used, prior to it drying, it should be washed to remove any gross soiling. At this stage, detergent and water is appropriate to use.

There are four main methods used for cleaning of instruments and equipment:

1. Manual cleaning

All surfaces of the instrument/equipment must be cleaned taking care to reach all channels and bores of the instrument. If instruments are being washed manually the following procedure should be followed:

- wear personal protective equipment (plastic apron, thick rubber gloves, eye protection, surgical mask and/or face shield),
- remove any gross soiling on the instrument by rinsing in tepid water (15–18 degrees),
- take instrument apart – fully and immerse all parts in warm water with a biodegradable, non-corrosive, nonabrasive, low foaming and free rinsing detergent or use an enzymatic cleaner if necessary,
- ensure all visible soil is removed from the instrument – follow manufacturers' instructions,
- rinse in hot water (unless contraindicated),
- dry the instrument either in a drying cabinet, or hand dry with clean lint-free cloth,
- inspect to ensure the instrument is clean.

2. Enzymatic cleaners

Used for fibreoptic instruments and accessories, and other items that are difficult to clean. These products are hazardous and care should be taken when in contact with them.

3. Ultrasonic cleaners and automated washers

Ultrasonic cleaners and automated washers are recommended for cleaning basic instruments that can withstand this process. Using a machine to wash the instruments will cut down on the handling of the instruments. These cleaners must be compliant with national guidelines and standards, and must be used according to the manufacturers' instructions. Ultrasonic cleaners do not disinfect the instruments. By causing high frequency, high-energy sound waves to hit the instrument/equipment, the soiling matter drops off the instrument, or becomes easy to remove during the rinsing process.

These cleaners are not appropriate for use on cannulated instruments (they cannot clean inside the instrument), plastic materials, two or more different metals, or some glass instruments, syringes and lenses. Daily efficiency tests should be done.[3]

4. Disinfection

Disinfection removes micro-organisms without complete sterilization. Disinfection is used to destroy organisms present on delicate or heat-sensitive

instruments which cannot be sterilized or when single use items are not available. Disinfection is not a sterilizing process and must not be used as a convenient substitute for sterilization. Thermal disinfection is not appropriate for instruments that will be used in critical sites (see Table 1) as these instruments must be sterile.

Certain products and processes will provide different levels of disinfection. These levels are classified as:[2,3]

(a) *High-level disinfection*: Destroys all micro-organisms except some bacterial spores (especially if there is heavy contamination).

(b) *Intermediate disinfection*: Inactivates *Mycobacterium tuberculosis* vegetative bacteria, most viruses and most fungi, but does not always kill bacterial spores.

(c) *Low-level disinfection*: Can kill most bacteria, some viruses and some fungi, but cannot be relied on to kill more resistant bacteria such as *M. tuberculosis* or bacterial spores.

The two methods of achieving disinfection are thermal and chemical disinfection.

1. Thermal disinfection (pasteurization)

If an instrument is able to withstand the process of heat and moisture and is not required to be sterile, then thermal disinfection is appropriate. By using heat and water at temperatures that destroy pathogenic, vegetative agents, this is a very efficient method of disinfection.

The level of disinfection depends on the water temperature and the duration the instrument is exposed to that temperature.

Table 2. *Minimum surface temperature and time required for thermal disinfection*[3]

Surface Temperature (°C)	Minimum disinfection time required (minutes)
90	1
80	10
75	30
70	100

2. Chemical disinfection

The performance of chemical disinfectants is dependent on a number of factors including: temperature, contact time, concentration, pH, presence of organic or inorganic matter and the numbers and resistance of the initial bioburden on a surface.[3]

Instrument grade disinfectants are classified as high, intermediate or low level. When used according to the manufacturers' guidelines, disinfectants will fall into one of these levels – see Table 3.

Table 3. *Chemical Disinfectant – level of disinfection achieved*[3]

Level of Disinfection	Activity against microbes
High level chemical disinfectant	Inactivates all microbial pathogens except where there are large numbers of bacterial spores
Intermediate level disinfectant	Inactivates all microbial pathogens except bacterial spores
Low level disinfectant	Rapidly inactivate most vegetative bacteria as well as medium sized lipid-containing viruses, but may not destroy bacterial spores, mycobacteria, fungi or small non-lipid viruses

Selection of disinfectant

There is no single ideal disinfectant. Different grades of disinfectants are used for different purposes. Only instrument grade disinfectants are suitable to use on medical instruments and equipment. Hospital grade or household grade disinfectants must not be used on instruments, they are only suitable for environmental purposes.

Monitoring of the disinfectant is important if it is a multi-use solution. It is important that it is stored correctly and according to the manufacturers instructions. Be sure not to contaminate the solution when pouring out for use.

Glutaraldehyde is generally the most appropriate chemical disinfectant that will provide high-level disinfection. This chemical must be used under very strict controlled conditions and in a safe working environment.

Glutaraldehyde 2% is an appropriate high level disinfectant for endoscopes, respiratory therapy equipment and for material that is destroyed by heat. An immersion time of $\geq$ 20 min is required. Flexible endoscopes are very easy to damage and particularly difficult to disinfect. It is extremely important that meticulous mechanical cleaning must always precede sterilization or disinfection procedures. For the selection of disinfectants see APIC Guideline for selection and use of disinfectants (1996.)[9]

Sterilization

Sterilization is the destruction of all micro-organisms and can be achieved by either physical or chemical methods.[2] Sterilization is necessary for medical devices penetrating sterile body sites. (see Table 1) Cleaning to remove visible soiling in reusable equipment should always precede sterilization. All materials must be wrapped before sterilization. Only wrapped/packed sterilized materials should be described as sterile. Before any instrument or equipment goes under the process of steam sterilization, the following should be checked:

(1) Ensure that the instrument can withstand the process (e.g. steam under pressure),

(2) Ensure that the instrument has been adequately cleaned,

(3) Ensure that the instrument does not require any special treatment,

(4) Ensure that records of the sterilisation process and for the traceability of instruments are kept.

Instruments and equipment will only be sterile if one of the following sterilizing processes is used:

(1) Steam under pressure (moist heat),

(2) Dry heat,

(3) Ethylene oxide,

(4) Automated environmentally sealed low-temperature peracetic acid, hydrogen peroxide plasma and other chemical sterilant systems or sterilants, or

(5) Irradiation.

The above sterilizing methods are designed to give a sterility assurance level of at least one in a million or 10^{-6} (see glossary) as long as the process is validated and is according to the manufacturers' guidelines.

Ultraviolet light units, incubators, microwave ovens and domestic ovens must not be used for sterilizing.

1. Steam under pressure (moist heat) sterilization[3]

This is the most efficient and reliable method to achieve sterility of instruments and equipment. This method sterilizes and dries the sterile package as part of the cycle. This is recommended in office-based practice. There are several types of steam under pressure sterilizers (also called autoclaves):

Downward (gravity) displacement sterilizers (jacketed and non-jacketed) - these are designed for the sterilisation of waste, solutions and instruments.

Self-contained (benchtop) sterilizers – these are recommended for office-based practice as they are able to do small quantities or fairly simple items. Benchtop sterilizers do not take wrapped items and therefore items must be used immediately after they are removed from the sterilizer. There will be differences in the models and types of features that are offered may vary. These variations may include: drying stage, ability to take packaged and unwrapped items, systems to monitor temperature, pressure and holding time.

Prevacuum (porous load) sterilizers – these are not suited for liquid sterilisation but are optimised for sterilisation of clean instruments, gowns, drapes, towelling and other dry materials required for surgery.

2. Dry heat sterilization[3]

Dry heat sterilisation is caused by hot air that destroys pathogens by the process of oxidation. Dry heat sterilizes have had limited value because it is difficult to maintain the same temperature throughout the load, while the high temperatures and long time required to achieve sterility makes this method undesirable for many situations. The manufacturers' instructions must be followed, the door to the unit must not be opened while in sterilizing cycle.

3. Ethylene Oxide (EO)[3]

Ethylene oxide gas is appropriate to use for sterilization of instruments/ equipment made from heat labile materials or those devices that contain electronic components. The time required to process the instrument is

dependent on the temperature, humidity and concentration level of the gas. The gas must penetrate the packaging and reach all surfaces of the instrument/equipment requiring sterilization. The time for such a process is between 12 hours to over 24 hours. Because EO is toxic, this gas is restricted in health care facilities and must be used according to strict guidelines to ensure staff safety. The manufacturer's instructions must be followed for the packaging, sterilization process, validation and aeration process.

4. Automated chemical (low temperature) systems[3]

Hydrogen peroxide plasma in a fully automated cycle can achieve low temperature, low moisture sterilization within a 45-80 minute cycle depending on the model of sterilizer used. The packaging used must be non-woven/non-cellulose polypropylene wraps.

Peracetic acid is a low-temperature sterilization method. Peracetic acid 0.2% is placed in an environmentally sealed chamber and fully automated processing system. The process achieves moist, low temperature sterilization within 25-30 minutes.

5. Irradiation

Gamma radiation is available from some commercial gamma irradiation facilities. However, it is not readily available for use in health care facilities.

Only those instruments and equipment that have undergone the entire sterilizing process can be regarded as sterile. Items must be wrapped or packaged appropriately to be considered sterile.[2]

Materials for packaging include:

- Paper - this prevents contamination if it remains intact. It maintains sterility for a long period, can act as a sterile field and can also be used to wrap dirty devices after the procedure.
- Non-woven disposable textiles.
- Containers - these can be used only if they contain material intended for a single treatment procedure for a single patient.
- The end-user must check the physical integrity of the package before use.

Quality control parameters for the sterilization process which also serve as a check list for the Sterilization Department include:

- Load number,
- Load content,
- Temperature and time exposure record chart,
- Physical/chemical testing,
- Biological testing, e.g. using *Bacillus subtilis*.

Regular engineering maintenance on sterilization equipment must be performed and documented.

For details refer to Young, Jack H. and Reichert, Marimargaret. *Sterilization Technology for the Health Care Facility*, 2 ed. New York, USA, Aspen Publishers, 1997.

Boiling of medical devices for reuse is not recommended since it does not guarantee sterility.

However, in certain resource-poor situations where steam sterilization is not possible, these items should be thoroughly cleaned and subjected to a cycle in a pressure cooker for 30 minutes.

Special consideration – Creutzfeldt-Jacob disease [3]

The only infectious agent that requires special treatment in order to ensure disinfection is the Creutzfeldt-Jacob disease (CJD)-prion. Historically, CJD has been transmitted through implanted brain electrodes that were disinfected with ethanol and formaldehyde after use on a patient known to have CJD. Iatrogenic transmission has been observed in some patients who have been recipients of contaminated human growth hormone, gonadotropin and corneal, pericardial and dura mater grafts.[9] These prions resist normal inactivation methods.

If material has been contaminated with prions or contamination is suspected the preferred method is steam sterilization for at least 30 minutes at a temperature of 132°C in a gravity displacement sterilizer. If a prevacuum sterilizer is used, 18 minutes at 134°C has been found to be effective. Semi critical and non-critical items may be immersed in 1N sodium hydroxide, a caustic solution, for 1 hour at room temperature and then steam sterilized for 30 minutes at a temperature of 121 °C.