ARAB REPUBLIC OF EGYPT

MINISTRY OF HEALTH AND POPULATION

NATIONAL GUIDELINES FOR TB INFECTION CONTROL

NATIONAL TUBERCULOSIS CONTROL PROGRAMME

2015

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These guideline were developed by the National Tuberculosis Program(NTP) in collaboration with Infection Control Program(ICP) , Ministry of Health of Egypt

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Abbreviations

ACH	Air change per hour
AIIR	Airborne infection isolation room
ART	Antiretrovirus treatment
BAL	Bronchoalveolar lavage
BCG	Bacillus Calmette - Gue´rin
BSC	Biological safety cabinet
DST	Drug sensitivity test
ER	Emergency room
ESRD	End stage renal disease
HCW	Health care worker
HEPA	High efficient particulate air filter
HLD	High level disinfectant
HIV	Human immune deficiency virus
ICC	Infection control committee
ICP	Infection control program
ICT	Infection control team
ICU	Intensive care unit
LTBI	Latent TB infection
MDR	Multiple drug resistance
PPE	Personal protective equipment
SSD	sterilization service department
TB	Tuberculosis disease
UVGI	Ultra violet germicidal lamp
VAP	Ventilator associated pneumonia

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Introduction

Presently, disease caused by *Mycobacterium tuberculosis (M. tuberculosis)* is the leading cause of mortality among adults in the world. Populations in resource limited settings account for nearly 95% of *M. tuberculosis* infections, with the global burden due to infection of *M. tuberculosis* being approximately 1.1 billion people. In 1998, WHO reported an estimated two million deaths due to tuberculosis(TB), In 2008, an estimated 390 000- 510 000 cases of MDR-TB emerged globally(best estimate 440 000) . In 2013 ,WHO global tuberculosis reported an estimated number for all TB forms 8.6(8.3-9.0) million, estimated number of deaths 1.3(1.0-1.6)million ,and estimated MDR-TB cases 450.000 and 170.000 estimated number of deaths

This guideline provide recommendations for the district and referral level based upon three levels of infection control: Administrative, Environmental, and personal Respiratory protection. The first priority in infection control is ***Administrative control measures to reduce the risk of exposure of the HCWs and patients to M.tuberculosis.*** Measures at the referral and district level include development of an Infection Control Plan, HCW training, patient education, sputum collection, triage and evaluation of suspect TB patients in outpatient settings, and reduction of exposure in the laboratory. Additional measures such as isolation of patients with multidrug-resistant TB (MDR-TB) and other isolation policies apply specifically to referral level facilities.

The second priority is ***Environmental control measures that are used to reduce the concentration of droplet nuclei in air in high-risk areas***. Environmental control methods range from inexpensive methods such as maximizing natural ventilation to more costly methods such as ultraviolet germicidal irradiation and HEPA filtration. Environmental control methods should not be used in absence of, or as a replacement for, administrative control measures.

The third priority is to ***protect HCWs, via personal Respiratory protection, from inhaling infectious droplets.*** Surgical masks *prevent the spread of* microorganisms from the wearer but *do not provide protection to* the wearer. Respirators provide protection to the wearer from inhaling infectious droplet nuclei.
Personal respiratory protection alone will not provide adequate protection for the HCW from infection of *M. tuberculosis*.

HCWs are vital resources in the fight against TB. Efforts should be made to execute such control strategies to prevent health care associated transmission of *M. tuberculosis*.

1-Administrative control

Administrative controls include:.

1.1 Assigning responsibility for the TB ICP
1.2 Conducting a TB risk assessment of the setting
1.3 Training, educating, and counseling employees about TB
1.4 Screening employees for TB infection and disease
1.5 Monitoring and evaluation to ensure prompt TB control policies and procedures implementation

1.1 Assigning responsibility for TB-ICP

Implementation of the plan and procedures, follow up, surveillance and renewing of the plan to overcome the default.

1.1.1 INFECTION CONTROL COMMITTEE (ICC):

The committee should include :

- The setting manager *(as chairman of the ICC)*
- Infection control doctor (ICT leader).
- Infection control nurse .
- Chest physician.
- Representative of any other department (pharmacy, central supply, maintenance, housekeeping, etc)
- Microbiologist

The infection control committee must have a reporting relationship directly either to the administration or the medical staff to promote program visibility and effectiveness. Regular meeting should be held (monthly) and according to the local need.

ROLE OF ICC:

1. Reviewing and approving the annual plan for infection control.
2. Reviewing and approving the infection control policies.
3. Supporting the infection control team and to direct resources to solve problems as identified.
4. Ensuring availability of the appropriate supplies needed for infection control.
5. Reviewing epidemiological surveillance data and identify areas for intervention.

6. Ensuring appropriate staff training in infection control and safety.
7. Reviewing and providing input into an outbreak investigation.
8. Communicating and cooperating with other committees of the settings with common interest as antibiotic committee, occupational health committee.

1.1.2 INFECTION CONTROL TEAM (ICT)

It comprises:

- *the infection control doctor* who serves as a specialist advisor and takes a leading role in the effective functioning of the infection control team, an active member of the hospital ICC, drawing up annual plans, policies and long term programs.
- *Infection control nurse is a registered nurse with academic education and practical training which enable him / her to act as a specialist advisor in all aspects of infection control. He / she takes the key role in day to day infection control activities with the infection control doctor providing the leading role.*
- *May include link nurses in charge in specific wards (e.g. MDR)*

The team should meet regularly to discuss relevant issues, any regulation, rules or recommendation should be distributed throughout the facility . Feedback from the ward staff should be encouraged.

ROLE OF ICT:

1. To develop an annual infection control plan with clearly defined objective
2. To develop written policies and procedures including regular evaluation and update.
3. To prepare an action plan for implementation of the infection control program and get approval from the infection control committee.
4. To supervise and to monitor daily practices of patient care designed to prevent infection.
5. To identify problems in the implementation of the infection control activities which need to be solved or transferred to the hospital infection control committee
6. To organize an epidemiological surveillance program for health care associated infections particularly in high risk areas to detect outbreaks early.
7. To report outbreaks to infection control committee and to investigate outbreak and provide data that should be evaluated to allow for any changes in practice or allocation of the resources

8. to educate all grades of the staff in infection control policy , practice and procedure relevant to their own area of practice

9. To provide advice to all grades of the staff on all aspects of infection control on day to day basis

10. To develop an annual training plan for the health care workers and to get an approval from the ICC

11. To implement the infection control training activities within the facility

12. To ensure availability of the supplies and equipment needed for the infection control.

13. To have a scientific and technical advice in purchasing, monitoring of the equipment and supplies, and in evaluation and checking the efficacy of sterilization and disinfection measures

14. To participate with the pharmacy and antibiotic committee in developing a program for supervising use of antibiotic

15. To submit monthly reports on activities to ICC.

1.2 TB risk assessment of the setting

At the District Level:

- Number of infectious TB patient seen /year in: the entire facility and each specific areas.
- The amount of time that infectious TB patient spends in the area.
- Special procedures (e.g. Sputum collection) that increase the number of infectious particles performed in the area.

At the Referral level:

- In addition to the previously mentioned items ,assessment of the Health Care Workers (HCWs) risk of exposure to M. tuberculosis should be conducted in both inpatient and outpatient settings.
- Evaluation of the entire hospital and specific areas within the facility where TB patient might receive care or HCWs may be at risk.

1.2.1 Administrative control for outpatient areas:

Aim:

1. Reduce the total time period that patient spend in the health care facility
2. Reduce airborne transmission to other patients and health care workers

Implementation :

1- Screening for respiratory symptoms, by asking patient about their symptoms
2- Education on cough etiquette and respiratory hygiene, through posters or by discussion with volunteers
3- Patient segregation within separate well ventilated waiting rooms
4- The outpatient area should be well ventilated to reduce the risk of airborne transmission
5- Fast identification of the TB patient, by rapid sputum smear examination.
6- The other important area where these patients are given priority is while waiting to perform chest radiology.
7- If separate waiting room is not available, priority service should be performed

1.2.2 Administrative control in the inpatient areas:

1- Minimize hospitalization of TB patient
2- Establish separate rooms ,wards, or areas within wards
3- The rooms and wards should be well ventilated
4- The rooms should be away from immune-compromised patients
5- Educate inpatients on cough hygiene and provide adequate sputum disposal,
6- Establish safe radiology procedures for TB patients either confirmed or suspect, by scheduling the radiograph for TB patient at the end of the day, patient should put-on his surgical mask

1.3 Training, educating, and counseling employees about TB

Training is offered to employees upon employment, during regular work hours and annually.

The following topics are included in employee TB education:

- Where to get a copy of the TB ICP if desired
- Groups at risk for occupational TB, especially immune compromised workers
- Modes of *M. tuberculosis* transmission
- Symptoms of TB

- TB screening and treatment for LTBI
- MDR TB
- Procedure for isolating persons with suspected or known infectious TB
- Use and limitations of methods that will prevent TB transmission, including administrative and work-practice controls, environmental controls, and respiratory protection
- Reuse and disposal of respirators

1.4 Screening employees for TB infection

The TB ICP must contain information about how that facility:

- Defines employees who are at risk of occupational TB exposure
- Identify suspected or confirmed TB cases among employees.
- Isolate or control exposure when a suspected or confirmed infectious TB patient is identified
- Screen employees for TB annually
- Conduct follow-up of employees exposed to TB

(Annex 2)

1.5 Monitoring and evaluation

Goal: the goal of M&E in airborne infection control is to ensure that the facility level policy and procedures are in place to minimize the risk of infection

- Baseline facility risk assessment by specific check list .
- Regular evaluation of the facility
- Assessment of TB among HCWs .
- Assessment of HCW training needs .
- Area specific infection control standards.
- Evaluation on airborne infection control activities should be done monthly.
- Policies and procedures should be revised every 2 years.

2-Environmental control

Environmental control measures are the second line of defense for preventing the spread of TB

Health care facility should seek to achieve maximum standard for air exchange.

As natural ventilation is the preferred method for ensuring adequate air exchange, effective ventilation at all times and in all climatic condition should be ensured, it may be maximized through mixed ventilation (propeller fans – exhaust fans – UVGI – and HEPA filters), if air conditions are used (preferred avoided in inpatient areas) an exhaust fan should be installed at the opposite side of the air condition to achieve adequate air exchange, and by keeping larger gap under the door to allow more air entering the room.

In high risk areas where it is not possible to achieve adequate air exchange by natural ventilation a complementary option should be added as upper room UVGI devices with ceiling fans for air mixing .

Directional air flow is recommended especially where MDR-TB patient are likely to be managed.

Optimal arrangement of patient and staff, in which air passes from staff area (clean air) to patient area

Architectural Considerations

- Ideally, infectious TB patients should be isolated from other patients so that others are not exposed to the infectious droplet nuclei that they generate.
- Limit the number of areas in the facility where exposure to potentially infectious TB patients may occur
- Whatever arrangement is used, patients with and without TB should be physically separated from each other and the wards should be well-ventilated.
- Patient with MDR-TB require special management at a referral center. Because of the prolonged period that such patients are infectious and the consequent increased risk of health care associated transmission,
- Patients suspected of having MDR-TB should be placed in a separate area or building in the facility, preferably in well-ventilated individual patient rooms where the possibility of contact with other patients who do not have TB or do not have MDR-TB is nil.

Upper room germicidal Ultra Violet Lamps (UVGI)

Ultraviolet germicidal irradiation (UVGI) is a type of radiation that has been shown to kill or inactivate M. tuberculosis in air. UVGI is maximally germicidal at a wavelength of 254nm (UVC,or short-wavelength UV). This sort of UV radiation differs from the longer wavelength UV in sunlight (UV-A and UV-B), in that UV-C penetrates poorly.

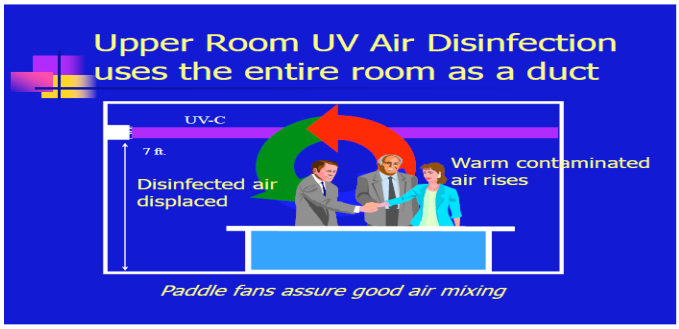


Fig 1 : showing Upper UVGI with ceiling fan

UV-C UVGI devices may be sometimes less expensive than structural alteration of the facility for ventilation purposes. Several studies have shown that a well-designed and maintained UVGI upper room system can disinfect Mycobacterium (surrogate test organisms), with an efficiency of 10–20 equivalent air changes per hour. It has been estimated that when an average UVGI intensity of 10 µW/cm2 is present, 63% of airborne tuberculosis germs that arrive in that “kill zone” will be killed in 24 seconds, and 99% will be killed in 2 minutes.

- UV-c lamps of wave length 254 nm may be used to increase the purification of air.
- The upper-air UV beam passes in one direction and kept always open
- Using ceiling fans with low speed to ensure the germicidal effect of UV rays as hot air rises upwards due to its low density and replaced by cold air.
- The room ceiling should be more then 2.4m high
- The lamp should be installed at 2.10 m high so people cannot look into the lamp.
- The lamp should be of 30w / 18-20m. square or /7 patients
- Cleaning of the lamp should be done every week by 70% alcohol and annual maintenance is needed or replacement as the lamp works up to 8000hours
- Efficacy of UV lamp decrease if humidity is around 70% , this should be put in consideration

fig 2 : showing HEPA filter unit

High Efficient Particulate Air (HEPA) Filters

- Used in settings that may have inadequate ventilation .
- It provides clean air to dilute infectious particles and also remove airborne particles
- *Engineering consideration* :
    - Its size and effect depends on the amount of air they deliver
    - small units are used on site clinic rooms or small areas but they do not meet the precise requirement for HEPA filters, place the unit next to staff so that purified air generated is delivered close to the staff face
    - large units is expensive and used for large areas as waiting areas
- Routine maintenance is required with changing the filter annually

Checking of Natural ventilation

People can usually feel the presence or absence of air movement in a space. Use the following checklist to assess natural ventilation in your facility:

- Check that all occupied rooms have a source of natural ventilation
- Check that windows are easy to open and is kept open
- Check doors are kept closed
- Check air mixing and determine directional air movement in all parts of occupied rooms. An inexpensive way to visualize air movement is to use incense sticks (smoke test):

1. Hold two incense sticks together and light them.
2. As soon as the incense starts to burn, blow out the flame. Now the incense should produce a continuous stream of smoke.
3. Observe the direction of the smoke.
4. Observe how quickly the smoke dissipates. This is a subjective test that may require some practice. It does not give a definite result but is useful for comparing rooms

to each other. For example, it may take 5 seconds for smoke to dissipate in one room but 10 seconds in another.

5. Repeat smoke tests for different common conditions at your facility. For example, if doors are kept open during the day but closed at night, the tests should be done under both conditions.
   - Check that all room fans are working and clean
   - Check that exhaust fans are working and clean. To check exhaust fans that have agrille, hold a tissue or a piece of paper against the grille. If the fan is working, the tissue or paper should be pulled against the grille

Airborne infection isolation room(AIIR)

1- Administrative control:

- The location of the proposed AIIR should be away from areas prone to strong drafts, such as those near elevator banks or doorways. AIIR should be separated from other wards or rooms especially high risk patient, e.g. immunocompromised.
- The AIIR should have an anteroom to the specific room or ward, bathroom inside the room if possible or dedicate one next to the room.
- AIIR doors should be equipped with self-closing devices, and should be kept closed
- Standard precaution should be applied at the AIIR :

AIIR with Anteroom

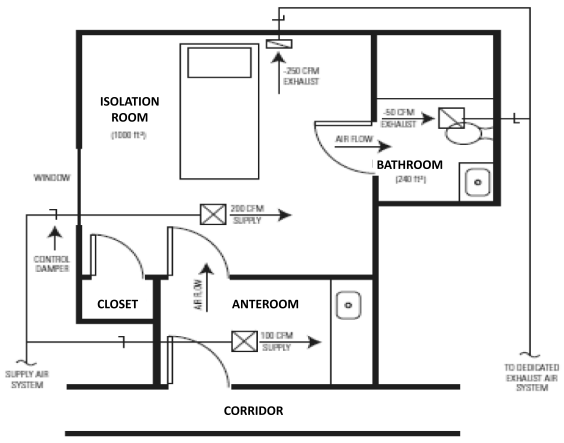


Fig 3 : showing Upper UVGI with ceiling fan

- Hand washing before and after every patient contact
- The use of gloves, respirators (N95 or FFP2), gowns and eye protection in situations in which exposure to body secretions or blood is possible.

- Safe injection practices
- The safe disposal of sharp instrument and needles in impervious container
- The placement of soiled linens in impervious bags

2- Environmental control:

- Doors should be kept closed and elevated from the floor about 5-7 cm to help drawing air inside the room.
- Windows should be kept open, unless the direction of air is changed inwards, in this case mixed ventilation is needed as exhaust fans to direct air outwards.
- The air change per hour (ACH) should be from 12-18 ACH
- Anteroom is preferred to control the direction of air where air should pass from the corridor to anteroom to patient room

- The direction of airflow should be well assessed as it may be the cause of cross infection, air should be directed outside the building, this is achieved by smoke test or tissue strip to identify the direction of air
- To increase the ventilation and achieve unidirectional airflow, ceiling fans may be used with exhaust fans.
- **UVGI**: may be placed to increase the purification of air.
- **HEPA filter** may be used, if the size of the room is big it will not be cost effective as it will need a big HEPA filter.

3- Respiratory control

- The respirator N95 or FFP2 should be worn before entering the AIIR, also gowns ,and gloves, eye protection (goggle) or shield according to the procedure performed
- Extra PPE(personal protective equipment) package should be placed inside AIIR for emergency or any accident.
- Hand wash facility should be found at the anteroom or beside the isolation room for HCWs use only.
- Respiratory hygiene or etiquette in which all HCWs , patient and visitors who have any sign of respiratory illness should cover their nose or mouth when coughing and practice hand hygiene after contact with respiratory secretion

3- Respiratory control

The third level of the TB control hierarchy is the use of personal respiratory protection equipment (PPE).

Types of masks :

1- Surgical mask: used for patients and HCW used for large particles, TB patients should wear surgical mask whenever leaving the isolation room, suspect patient at the emergency department, radiology department.

2- High efficient particulate mask : used for airborne infections , in which particles less than 3 µ as TB are trapped . N95 OR FFP2 (CEN Respirators FFP2- FFP3) ; are generally acceptable for TB situation, Sputum induction, Bronchoscopy and operation room, during suction of TB patient at ICU, At MDR- TB and TB department.

Respiratory control program within facility should include: (instruction for respirators)

• Employee training.
• Respiratory tests:
  - Conducting respirator fit tests
  - Conducting respirator fit checks
• Storing and disposing of respirators :

Respirators should be stored in dry area ,not left in bare in the coats pocket should be packed by tissue not in plastic bags as it increase the humidity and temperature making good environment for microorganism replication ,should be disposed in dangerous waste bag (red bag)

• Respirator limitations:

- The respirator should be changed every shift, whenever soiled, or discomfort breathing
- Routine Hand washing should be performed before and after donning of the respirator

Fit testing : used to ensure fitness of the respirator , you must choose the appropriate size to decrease the leakage of the respirators and ensure its effectiveness.

The fit test kit contains:

– Face hood ,
– Solution pump ,
– Test agents (saccharine and bitter solution for challenge and sensitivity test

SENSITIVITY TEST : done without wearing the respirator to determine whether the individual being tested can detect the taste , the subject should be instructed to breath normally with mouth slightly opened with the tongue extended, also instructed to report when he or she detect the bitter taste , counting 10 squeezes of the pump, if not detected increase more 10 and if not detected increase more 10 if not detected so this solution should not be used .

CHALLENGE TEST : done when wearing the respirator and fitting the hood , number of squeezing according to number of sensitivity test

- Normal breathing
- Deep breathing
- Move head side to side
- Move head up and down
- Talk non stop

- Walking in place
- Normal breathing

Elapsed time	# of "Squirts"	Exercise
0:00	10/20/30	Normal breathing
0:30	5/10/15	
1:00	5/10/15	Deep breathing
1:30	5/10/15	
2:00	5/10/15	Head side to side
2:30	5/10/15	
3:00	5/10/15	Head up and down
3:30	5/10/15	
4:00	5/10/15	Talk non-stop
4:30	5/10/15	
5:00	5/10/15	Walk/jog in place
5:30	5/10/15	
6:00	5/10/15	Normal breathing
6:30	5/10/15	
7:00	Stop	Complete paperwork

Table 1 : showing performance (time and positions) of fit test

RESULT OF THE FIT TEST

The tested subject shall inform the test conductor if at any time during the fit test the taste is indicated.
If not reported tasting the test passed.
If the taste is detected the test fail and should try different respirators and entire test procedure is repeated.

Respirator fit check (seal check):

- The user seal check can be either positive or negative pressure
- Positive pressure user fit check : the person wearing the respirator exhales gently while blocking the paths for exhaled breath to exit the face piece.
- A successful check is when the face piece is slightly pressurized before increased pressure causes outward leakage
- The negative pressure user fit check: the person wearing the respirator inhales sharply while blocking the paths for inhaled breath to enter the face piece
- A successful check is when the face piece collapses slightly under the negative pressure that is created with this procedures
- Fit check should be completed each time the respirators is put on

Infection control standard precaution

1- Hand Hygiene (Annex 3)

According to the standard precaution in the national guideline hand hygiene is either :

a- routine hand wash :

- Before the start of work
- When visibly soiled
- Before contact with patient
- After removal of the gloves
- After contact with patient and surroundings
- If get in contact with patient secretions
- Before serving meals or drinks
- Before leaving work.

Washing with soap and water for 30 seconds, in which all parts of the hand should be well scraped as palm, back, fingers and its sides, nail beds and the thumb

b- Aseptic Hand wash :

- Washing with antiseptic solution as povidone iodine, no effect of chlorhexidine gluconate on *Mycobacterium* tuberculosis
- Is performed before the performance of invasive procedures, contact with non-intact skin or mucous membrane, before contact with immune compromised patients.

c- Surgical hand wash:

- Is performed for surgical procedures, indwelling central line catheters ,urinary tract catheter.

2- Personal Protective Equipment

A- gloves

1. Sterile gloves: Mostly used for surgery. They are disposable, sterile, and individually wrapped items. They are used whenever there will be a percutaneous or permucosal contact with tissues (e.g. surgical procedures, insertion of central venous catheter and urinary catheter).

Fig. 7: Sterile Gloves

2. Non-sterile gloves: Non-sterile disposable, single use gloves (e.g. latex gloves) are usually not individually wrapped. They are used to protect against direct skin exposure to blood or other body fluids or for anticipated contact with mucous membranes and prior to contact with contaminated equipment or surfaces. Examples of application include putting on gloves prior to insertion of a peripheral IV catheter (except in high risk areas). These types of gloves should be discarded after one use followed by hand hygiene.

Fig. 8: Non-sterile Gloves

3. Utility or heavy-duty household gloves: Utility gloves are used for handling contaminated items and waste and for performing environmental cleaning activities. They can be reused after decontamination, but they should be discarded when punctured or torn.

Fig. 9: Utility Gloves

B- Face mask and Respirators :

1- High efficient respirators (N95 or FFP2) :should be worn at entering to the airborne isolation room, during contact with TB patient at ward or clinic, during operation, suction of ICU patient, bronchoscopy, dental care for TB patient

2- Surgical masks is worn by the patient during transportation within the facility

C- Aprons and Gowns **:** Single use plastic aprons or gowns should be used during procedures that are likely to generate splashes of blood or body fluids or during activities that may contaminate clothing or uniforms with microorganisms or infectious material. Most often, aprons can be used to minimize potential for contamination of HCWs uniforms or personal clothing.

D- Eye protection (goggle): used during splash generating procedures

E- Foot wear :closed foot wears or boots are recommended to protect personnel from skin exposure to blood and other body fluids

Fig10: showing suitable PPE for operation room

3- Aseptic Techniques: Aseptic techniques include practices performed just before, during, or after any invasive procedures.

Procedures with the highest risk for causing infection include :

The placement of medications or devices into sterile body spaces such as:

- The placement of intravenous lines.
- The placement of indwelling urinary catheters.
- wound care
- preparation and administration of intravenous fluids
- intravenous and intramuscular injections of medication ,especially vials

Key processes for performing medical (non-surgical) procedures with aseptic techniques include:

- Aseptic hand wash
- wear suitable personal
- Wear suitable personal protective equipments.
- Skin antisepsis of the site of insertion of invasive devices, e.g., IVs
- Using and maintaining sterile patient care equipment, e.g., multi-dose medication vials, IV fluids and devices, by minimizing contact with non-sterile

surfaces or reuse of equipment and devices intended for single patient use.

- The introduction of a sterile item into a patient should always be performed with a no-touch-technique. This means that the skin in the area of insertion should not be touched after skin antisepsis. Similarly, IV administration tubing should be kept sterile and tops of vials of medication should be disinfected prior to entry.

4- Disinfection :

Decontamination is the process by which microorganisms and spores are removed or destroyed in order to render safe object. It includes:

- Cleaning,
- Disinfection, and
- Sterilization.

All hospitals and health care facilities should have a decontamination policy and help staff to decide what decontamination process should be used for which item of equipment. (risk assessment of equipments)

Processing Instruments

Definition of Terms

Antimicrobial agent: Any agent that kills or suppresses the growth of microorganisms.

Biocide: A chemical or physical agent that kills all living organisms, pathogenic and nonpathogenic.

Biologic indicator (BI): A standardized preparation of bacterial spores on or in a carrier serving to demonstrate whether sterilizing conditions have been met. The type of spore varies by type of sterilization.

Cleaning: Cleaning is a process, usually involving detergent or enzymatic pre-soak that removes foreign material (e.g. dirt or microorganisms) from an object. Cleaning is the most essential step in reprocessing instruments and equipment.

Decontamination: The use of physical or chemical means to remove, inactivate, or destroy pathogens on a surface or item to the point where they are no longer capable of transmitting infectious particles and the surface or item is rendered safe for handling, use, or disposal. Decontamination could comprise cleaning, disinfection or sterilization as appropriate.

Disinfection: Any process, chemical or physical, that destroys pathogens such that an item is safe to handle for its intended use.

Disinfectant: A disinfectant is a chemical agent that destroys most pathogens but may not kill bacterial spores. Chemical disinfection should only be used if heat treatment is impractical or if it may cause damage to the equipment. Disinfectants are used on inanimate objects only and not on living tissue. Chemicals used to kill microorganisms on skin or living tissue are known as antiseptics.

The broad category of disinfection may be subdivided into low -level, intermediate-level, and high -level disinfection according to the anti-microbial activity of the disinfectant.

Low level disinfectant (LLD): LLD is an agent that destroys all vegetative bacteria (except tubercle bacilli), lipid viruses, some non-lipid viruses, and some fungus, but not bacterial spores.

Intermediate-level disinfectant (ILD): ILD is an agent that destroys all vegetative bacteria, including tubercle bacilli, lipid enveloped and some non-lipid enveloped viruses, and fungus spores, but not bacterial spores.

High-level disinfectant (HLD): A high-level disinfectant is a chemical or physical agent or process that is capable of killing some bacterial spores when used in sufficient concentration, temperature, and under suitable conditions. It is therefore expected to be effective against vegetative bacteria, fungi, viruses and other microorganisms. It does not kill high numbers of bacterial spores.

Spaulding classification: A strategy developed by Dr. Earle H. Spaulding for reprocessing contaminated medical devices. The system classifies devices as critical, semicritical, or non-critical based on the risk of contamination of a device to a patient. Three different levels of disinfection are applied based on this risk scheme. For example a needle used for entry into tissue is critical and needs to be sterile. A speculum (endoscopes) has contact with mucous membranes and therefore needs to be cleaned and then undergo high-level disinfection. A blood pressure cuff has contact with intact skin and only needs cleaning.

Table 2: Decreasing order of resistance of microorganisms to disinfection and sterilization and the level of disinfection or sterilization.

Types of organisms		Level
Resistant ↓ **Susceptible**	Prions (e.g., Creutzfeldt-Jakob Disease)	- Sodium Hydroxide soap for one hour - 18 min prevacuum steam sterilization (134-137C)
	Bacterial spores (e.g. Clostridium teteni, Clostridium difficile)	Sterilization
	Coccidia (Cryptosporidium)	
	Some spores generated by spore forming bacteria	High Disinfection
	Mycobacterium tuberculosis	Intermediate Disinfection
	Nonlipid or small viruses (polio, coxsackie)	
	Fungi (e.g., Aspergillus, Candida)	Low Disinfection
	Vegetative bacteria (S. aureus, P. aeruginosa)	
	Lipid viruses (HIV, HBV, HCV, herpes, myxoviruses)	

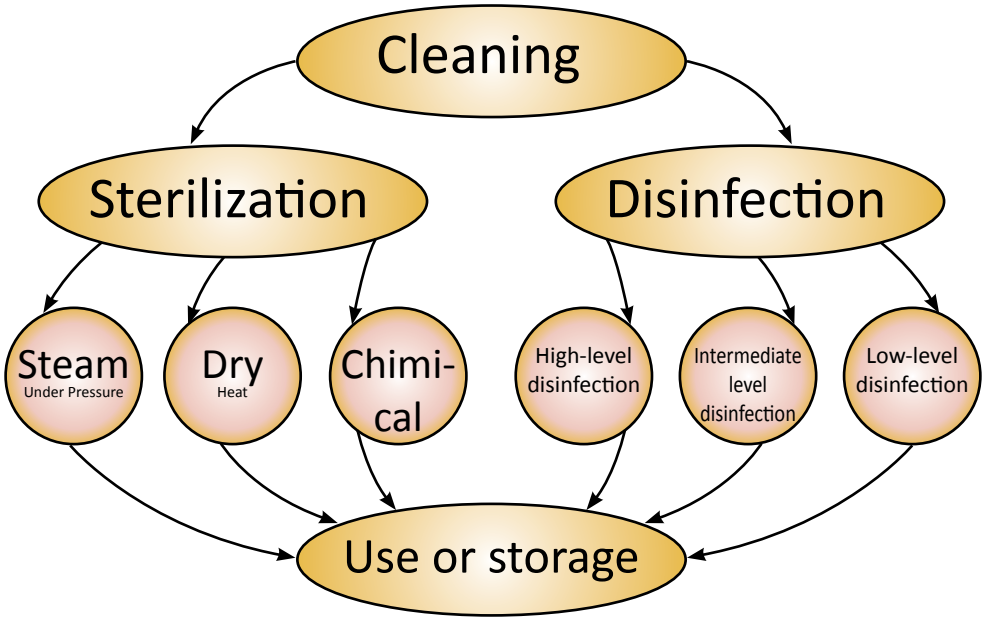


Fig 11 : showing disinfection steps

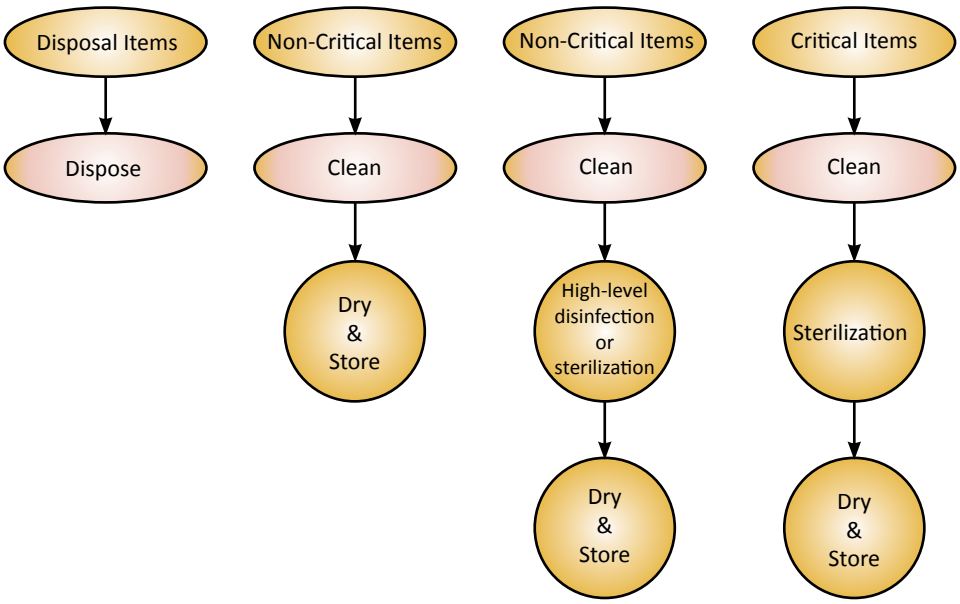


Fig 12: showing disinfection according to Spaulding classification

Cleaning

Cleaning is the removal of all foreign material (dirt and organic matter) from the object being reprocessed. Two key components of cleaning are friction to remove foreign matter and fluids to remove or rinse away contamination.

Cleaning is normally accomplished by the use of water, detergents and mechanical actions. Detergent is essential to dissolve proteins and oil that can reside on instruments and equipment after use.

Cleaning may be manual or mechanical. Mechanical cleaning includes ultrasonic cleaners or washer/disinfectors that may facilitate cleaning and decontamination of some items and may reduce the need for handling.

The solution used most often to clean is an enzymatic presoak (protease formula that dissolves protein). Alternatively a detergent can be used. Detergents lower surface tension and lift dirt or oil away from the device. Studies have shown that thorough cleaning alone can provide a 10 000 fold reduction in contaminant microbes from endoscopes. Cleaning can be very effective in removing microbial contaminants from surgical devices.

Mechanical Cleaning

Most modern cleaning units are automated and there is minimal handling of dirty equipment by staff. The equipment is placed in trays ready for washing:

- Washing machine. The washing machine gives a cold rinse followed by a hot wash

at 71 °C for 2 minutes. This is followed by a 10-second hot water rinse at 80-90 °C and then by drying by a heater or a fan at 50-75 °C.

- Washer/disinfector is used for some equipments. It runs a 45-minute cycle of washing and cleaning plus a 2 minutes cycle with water at 80-100 °C and with a detergent solution.
- Ultrasonicator. The ultrasonicator is a sophisticated and expensive but extremely efficient piece of equipment. It uses high-power output of 0.44 W/cm^3 and dislodges all organic matter

Manual cleaning

Steps for manual cleaning

1. Wear heavy-duty rubber gloves, a plastic apron, eye protection, and mask during cleaning.
2. Soak the instruments in normal tab water containing a detergent for 3 – 5 minutes.
3. Scrub instruments and other items vigorously to completely remove all foreign material using a soft brush or toothbrush, detergent, and water. Hold items under the surface of the water while scrubbing and cleaning to avoid splashing. Disassemble instruments and other items with multiple parts, and be sure to brush in the grooves, teeth, and joints to items where organic material can collect and stick.
4. Flush through lumens with an adapted water jet.
5. Rinse items thoroughly with clean water to remove all detergent. Any detergent left on the items can reduce the effectiveness of further processing.
6. Inspect items to confirm that they are clean.
7. Allow items to air dry or dry them with a clean towel if chemical disinfection is going to be used. This is to avoid diluting the chemical solutions used after cleaning. Items that will be high-level disinfected by boiling or steaming do not need to be dried.

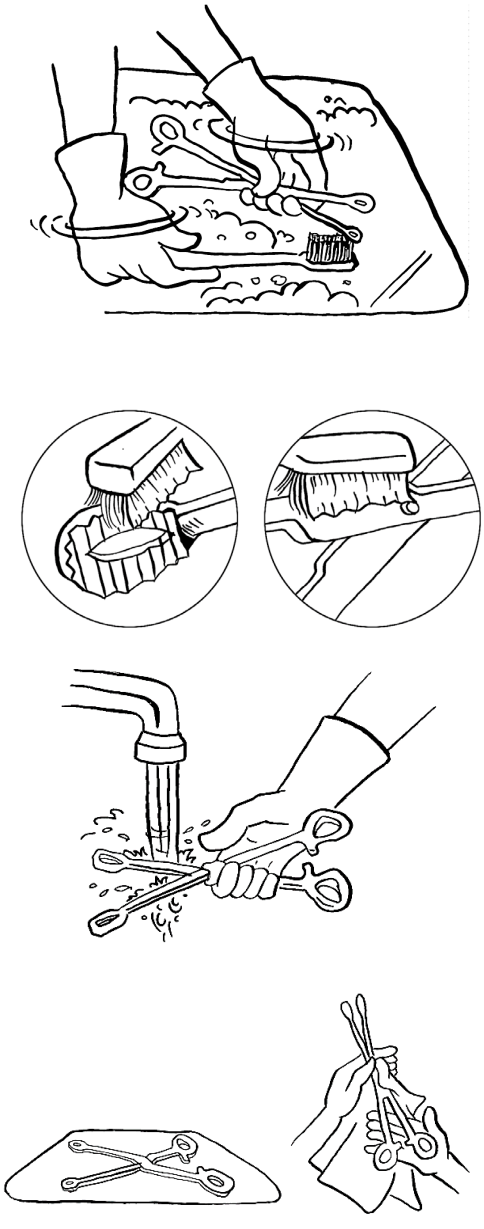


Fig. 13: Steps for cleaning

Disinfection

Disinfection can be carried out either by thermal or chemical processes. Thermal disinfection is preferred whenever possible. It is generally more reliable than chemical processes, leaves no residues, is more easily controlled, and is non-toxic. Heat sensitive items have to be reprocessed with a chemical disinfectant**.**

High Level Disinfection (HLD) - Semi-critical Item

There are three types of HLD:

- Disinfection by boiling
- Moist heat at 70-100°C
- Chemical disinfection

HLD by Boiling

High-level disinfection is best achieved by moist heat such as boiling in water (100°C for 10 minutes holding time), which kills all organisms except for a few bacterial spores. It is important to note that boiling equipment items in water will not achieve sterilization

Tips for HLD by boiling:
Instruments and other items must be completely covered with water. Open all hinged instruments and other items and disassemble those with sliding or multiple parts. Always boil for 10 minutes. Start counting the ten minutes when the water reaches a rolling boil. If you forget to start timing the HLD procedure, start timing at the point at which you realize that you did not begin timing. Do not add anything to or remove anything from the pot/boiler once boiling begins. A white, scaly deposit may be left on instruments and other items that have been boiled frequently and on the pot/boiler itself. These are lime deposits caused by lime salts in the water. To minimize lime deposits: Add some vinegar to the water to remove deposits from instruments, other items, and the inside of the pot/boiler. Boil the water for 10 minutes at the beginning of each day that the pot/boiler is used; this will precipitate the lime (make it come out of the water and settle on the bottom or sides of the pot/boiler instead of on the instruments or other items) before the instruments or other items are added. Use the same water throughout the day, adding only enough to keep the instruments and other items below the surface. Drain and clean out the pot/boiler at the end of each day that it is used. A high-level disinfected tray or container can be prepared by: Boiling for 10 minutes and drying thoroughly

HLD by mechanical or thermal disinfection

Disinfection by hot water can also be performed in specially constructed washing machines (e.g., for linen, dishes and cutlery). In these machines the processes of cleaning, of hot water disinfection, and of drying are combined in a very effective procedure, providing some items ready for use (e.g., respiratory circuits) or safe to handle (e.g. surgical instruments). The thorough initial rinsing and washing removes most of the microorganisms and shorter disinfection times. If machines are used they should be regularly maintained and checked for efficacy.

Low to high-level disinfection is achieved depending on type of machine and complexity of the items.

Chemical HLD

Before deciding to use a chemical disinfectant, consider whether a more appropriate method is available. Chemical disinfection is used most commonly for heat-labile equipment (e.g. endoscopes) where single use is not cost effective.

A limited number of disinfectants can be used for this purpose. e.g.:

- Glutaraldehyde **>** 2% for 20 - 45 minutes
- Hydrogen peroxide 7.5% for 20 – 30 minutes
- Peracetic acid 0.2-0.35% for 10 minutes.
- Ortho-phthalaldehyde (OPA) for 5 -12 minutes.
- Hydrogen peroxide and Peracetic acid (7.35% 0.23%) for 15 minutes

The object must be thoroughly rinsed with sterile water after disinfection. If sterile water is not available, freshly boiled water for 5 – 10 minutes can be used. After rinsing, items must be kept dry and stored properly.

Table 3: Comparison of the characteristics of chemical sterilant used primarily as high–level disinfectants.

	HP (7.5%)	PA (0.2%)	Glut (>2.0%)	OPA (0.55%)	HP/PA (7.35%- 0.23%)
HLD Claim	20-30minutes	10minutes	20 – 45 minutes	12minutes	15minutes
Sterilization Claim (sporicidal effect)	6 hours	50 minutes	10 hours	None	3hours
Activation	No	No	Yes (alkaline glut)	No	No
Reuse Life	21 days	one day or single cycle	14 days or 28 cycles	14 days	14 days
Shelf Life Stability	2 years	6 months	2 years	2 years	2 years
Disposal Restrictions	None	None	Local	Local	None
Materials Compatibility	Good	Fair	Excellent	Excellent	No data
Monitor MEC	Yes (6%)	No	Yes 2% or more	Yes 03%	No
Safety	Serious eye damage (safely glasses)	Serious eye & skin damage (conc soln)	Respiratory, eye & skin	Eye irritant, stains skin	Eye damage
Processing	Manual or automated	Manual or automated	Manual or automated	Manual or automated	Manual
Organic material resistance	Yes	Yes	Yes	Yes	Yes

Table 4: Disinfectant properties (High level disinfection)

	Properties *				Antimicrobial activity				
Disinfectant	**Stability**	**Inactivation Organic matter**	**Corrosive/ Damaging**	**Irritant/ Sen-sitizing**	**Spores**	**Myco-bacterial**	**Other Bacteria**	**Viruses**	
								E	NE
Glutaraldehyde>2% (20 – 45 minutes)	Moderately (14days)	No (fixative) **	No	Yes ***	Good 3- 10 hours	Good ****** 20-45 minutes	Good 10 minutes	Good 10 minutes.	Good 10 minutes
Peracetic acid 0.2-0.35% (10 minutes)	No (< 1 day)	No	Slight	Slight	Good 50 minutes	Good	Good	Good	Good
Alcohol ** 60-90% (ethanol or isopropa-nol) (10 minutes)**	Yes (in closed container)	Yes (fixa-tive) **	Slight	No	None	Good	Good	Good	Moder-ate
Peroxygen compounds 7.5% (20-30 minutes)	Moderately (7 days)	Yes	Slight	No	Variable	Variable	Good	Good	Variable
Chlorine releasing agents 200-1000 PPM	No (< 1 day)	Yes	Yes	Yes *****	Good	Good	Good	Good	Good
Clear soluble 1-2% phenolics ***** **	Yes	No	Slight	Yes	None	Good to moderate	Good	Moderate	Poor
Quaternary ****** ammonia compounds 0.1%-0.5%**	Yes	Yes	No	No	None	Variable	Moderate	Moderate	Poor

* Use protective clothing when handling disinfectants
** Poor penetration
*** Should only be used in a well ventilated room
**** Flammable
***** In high concentration
****** Less active against M. avium intracellulare
******* Potentially toxic
******** Diluted solutions may allow the growth of Gram-negative bacilli
E = enveloped
NE = non enveloped Sterilization

Sterilization is a process which achieves the complete destruction or killing of all microorganisms, including bacterial spores.

Sterilization is principally accomplished by:

- Steam under pressure (Autoclaving)
- Dry heat (Hot Air Oven)
- The use of chemicals such as ethylene oxide gas (which is mainly used in industry) or other low temperature methods (e.g. hydrogen peroxide gas plasma).

Pressure Steam Sterilization (Autoclaving)

The steam must be applied for a specified time so that the items reach a specified temperature. For unwrapped items:

- 121 °C for 20 min. at 1.036 Bar (15.03 psi) above atmospheric pressure.
- 134 °C for 3-4 minutes at 2.026 Bar (29.41 psi) above atmospheric pressure.

Types of steam sterilizers

1. Small table-top sterilizers

- Sometimes used in physicians' and dentists' offices and clinics.
- Are essentially horizontal pressure cookers.
- Holding temperature for unwrapped items:

  121ºC for 20 minutes or 134 °C for 3-4 minutes.

2. Gravity downward-displacement sterilizers

- Larger than tabletop sterilizers with addition of more automatic controls.
- The chamber fills with steam, displacing the air downward and forcing it out of the drain valve.
- Holding temperature for unwrapped items: 121ºC for 20 minutes or 134 °C for 3-4 minutes.

Fig 14:Flash sterilizer

3. Emergency (flash) sterilizers (these are a form of gravity-displacement sterilizer):

- Normally located in operating room suite.

  Quick sterilization cycle at 134ºC for 3-4 minutes.
- Should be used only when there is insufficient time to sterilize an item by the

preferred prepackaged method.

- Only for unwrapped items.

4. High-speed pre-vacuum vacuum sterilizers (Porous load autoclaves)

- Similar to downward-displacement sterilizers, with the addition of a vacuum pump system.
- Vacuum pump removes the air from the chamber before the steam is admitted, reducing the penetration time and total cycle time.
- Holding temperature 134ºC for 3-4 minutes for wrapped items or unwrapped items.
- Ideally used for wrapped items and porous loads (fabrics, swabs, instruments with lumens).

Table 5: Sterilization times

Type of instruments to be sterilized	Sterilization Time
Gravity sterilizer:	
Unwrapped 121 ºC (1.036 Bar)	15 - 20 minutes
Unwrapped: 134 ºC (2.026 Bar) (metal and glass only)	3 – 5 minutes
Unwrapped: 134 ºC (2.026 Bar) (e.g., rubber)	10 – 20 minutes
Wrapped 121 ºC (1.036 Bar)	30 minutes
Wrapped 134 ºC (2.026 Bar)	15 minutes
High-speed vacuum sterilizer	
Wrapped or unwrapped items: 134 ºC (2.026 Bar)	3 - 4 minutes

Dry-heat Sterilization

Dry heat sterilization (Hot Air Oven):

For dry heat-sterilization to be achieved, a constant supply of electricity is necessary. Dry heat is preferred for reusable glass, metal instruments, oil, ointments and powders. Do not use this method of sterilization for other items, which may melt or burn.

Dry heat ovens should have fans to give even temperature distribution and faster equilibrium of load to sterilization temperatures.

Steps of dry-heat sterilization:

1. Clean and dry all items to be sterilized.
2. Either (1) wrap with foil or (2) place unwrapped items on a tray or shelf, or (3) put them in a closed metal container.
3. Place items in the oven and heat to the holding temperature.

Table 6: Dry heat sterilization temperatures & times

Holding Temperature	Sterilization Time (After reaching the holding temperature) at hot air ovens without fans	Sterilization Time (After reaching the holding temperature) at hot air ovens with fans
180 ºC	1 hour	30 minutes
170ºC	2 hours	1 hour
160ºC	----------	2 hours

4. Leave items in the oven to cool to room temperature before removing. When items are cool, remove instruments and other items (using sterile pickups for unwrapped items) and use immediately or store.
5. Proper storage is as important as the sterilization process itself.

Store items using the following guidelines:

- Wrapped items – store in a closed, dry, cabinet with moderate temperature and low humidity in an area that is not heavily trafficked.
- Unwrapped items – use immediately after removal from the autoclave or hot oven, keep them in a covered, dry, and sterile container for up to 24 hours.

Low Temperature Sterilization

- Low temperature sterilization is used for heat- and moisture- sensitive medical devices.
- Ethylene oxide has been the most common method of low temperature gas sterilization.
- Other methods have emerged that include hydrogen peroxide + gas plasma and immersion in a dilute liquid Peracetic acid.

Hydrogen peroxide gas plasma

Uses: Gas plasma is generated in a chamber under deep vacuum and acted on by radiofrequency radiation wherein free radical particles which disrupt microbial cellular components. The plasma is combined with hydrogen peroxide. The cycle time is approximately 75 minutes. Diffusion of the vapor and plasma into long, narrow lumens can be enhance with use of additional devices to assure flow of gas through the device's lumen. Diffusion into long lumens even with H_2O_2 injection is of poor quality assurance.

Chemical Sterilization

Chemical sterilant are primarily used for *heat- labile equipment* where single use is not cost effective.

- Instruments and other items can be sterilized by soaking in a chemical solution

followed by rinsing in sterile water.

- The immersion time to achieve sterilization or sporicidal activity is specific for each type of chemical sterilant, a biological indicator is not available for most chemical sterilant.
- Given these limitations most liquid chemical sterilant are instead used for high-level disinfection. If an item is sterilized chemically, it should be used immediately after sterilization.

Types of chemical sterilant

- Glutaraldehyde >2% is a commonly available solution that can be used for sterilization. Other chemical sterilant may be locally available, such as Peracetic acid 0.2%-0.35%, 7.5% hydrogen peroxide, or hydrogen peroxide (7.35%) plus Peracetic acid (0.23%).

Glutaraldehyde

Uses: A >2% glutaraldehyde solution for at least 10 hours that can be used to sterilize heat labile items. Glutaraldehyde solution is irritating to the skin, to the eyes, and to the respiratory tract. There are two types of glutaraldehyde, One alkaline solution that requires activation (e.g., Cidex®) and one acidic solution that is stable and does not require activation but is slower in activity than the activated alkaline buffered solution.

Precautions:

– Glutaraldehyde is an eye and nasal irritant and may cause respiratory illness (asthma) and allergic dermatitis.

– Glutaraldehyde should not be used in an area with little or no ventilation.

– Eye protection, a plastic apron, and gloves must be worn when glutaraldehyde liquid is used. Latex gloves may be worn and discarded after use if the duration of contact with glutaraldehyde is brief, e.g. less than 5 minutes. For longer duration, nitrile gloves must be worn.

– Glutaraldehyde should be stored away from heat sources and in containers with close-fitting lids. The length of time that glutaraldehyde solutions can be used varies but they are usually good for up to 14 days. Solutions should be replaced any time they become cloudy.

Peracetic acid

Uses: A 0.2 – 0.35% Peracetic solution for 50 minutes can be used to sterilize heat-labile items (e.g. arthroscopes, dental instruments).

- A special advantage of Peracetic acid is that it has harmless decomposition products and leaves little residue on sterilized items. It remains effective in the presence of organic matter and is sporicidal even at low temperatures.
- Peracetic acid can corrode copper, brass, bronze, plain steel, and galvanized iron, but additives and pH modification can reduce these effects.
- It is considered unstable, particularly when diluted.
- It is more effective than glutaraldehyde at penetrating organic matter, e.g. biofilms.
- It is known to be highly corrosive and its use as a disinfectant in its natural state is therefore limited unless there is a corrosion inhibitor in the formulation.
- Sterilization using Peracetic acid can be done through an automated reprocesses that dilutes the 35% Peracetic acid to a use concentration of 0.2%. This system can only be used if the device being reprocessed is immersible as endoscopes. Filtered water is used to rinse the device. Connectors to assure free flow of the liquid chemical sterilant are important and the connectors are very specific to each model of device being reprocessed. This system is used to chemically sterilize both flexible and rigid endoscopes.

Monitoring the Effectiveness of Sterilization

To ensure that sterilization has been successful the process of sterilization (and not the end product) is tested. Indicators have been developed to monitor the effectiveness of sterilization by measuring various aspects of the process through different indicators

Mechanical indicators

These indicators, which are part of the autoclave or dry-heat oven itself, record and allow you to observe time, temperature, and/or pressure readings during the sterilization cycle.

Chemical indicators

- Tape with lines that change color when the intended temperature has been reached.
- Pellets in glass tubes that melt, indicating that the intended temperature and time have been reached.
- Indicator strips that show that the intended combination of temperature, time, and pressure has been achieved.

- Indicator strips that show that the chemicals and/or gas are still effective.
- Chemical indicators are available for testing ethylene oxide, dry heat, and steam processes. These indicators are used internally, placed where steam or temperature take longest to reach, or put on the outside of the wrapped packs to distinguish processed from nonprocessed packages.

Biological indicators

These indicators use heat-resistant bacterial endospores to demonstrate whether or not sterilization has been achieved. If the bacterial endospores have been killed after sterilization, you can assume that all microorganisms have been killed as well. After the sterilization process the strips are placed in a broth that supports aerobic growth and incubated for 3 days. The advantage of this method is that it directly measures the effectiveness of sterilization. The disadvantage is that this indicator is not immediate, as are mechanical and chemical indicators. Bacterial culture results are needed before sterilization effectiveness can be determined.

Recommended ideal monitoring system

Perform the following monitoring activities whenever possible.

For steam sterilization

- If the autoclave has recording chart, review it after each load. If not, record the temperature, time and pressure information in a log book that is reviewed after each load.
- Place heat-and steam-sensitive chemical indicators on the outside of each pack.
- Perform testing with biological indicators weekly (or monthly, if testing weekly is not possible).
- Indicators should be in the middle of the item reprocessed (the most difficult part of the load).
- A thermometer could be put in the most difficult part of the load.

For dry-heat sterilization

- If the oven has a recording chart, review it after each load. If not, record the temperature and time information in a log that is reviewed after each load.

- Place heat-sensitive chemical indicators, if available, on the outside of each pack.
- Perform testing with biological indicators weekly (or monthly, if testing weekly is not possible).
- A thermometer could be put in the most difficult part of the load.

For chemical sterilization

- Record the time information in a log that is reviewed after each load.
- Use an indicator strip, if available, to determine if the solution is still effective.

Correcting sterilization failure
If monitoring indicates a failure in sterilization, attempt to determine the cause of the failure and arrange for corrective steps, as follows: - Immediately check that the autoclave or dry-heat oven is being used correctly or replace the chemical solution. - If correct use of the unit has been documented and monitoring still indicates a failure in sterilization, discontinue using the unit and have it serviced. - Any instruments or other items that have been processed in the faulty autoclave or dry-heat oven must be considered non sterile and must be processed again with the unit is functioning properly.

Storage in the sterilization service department (SSD)

After items have been reprocessed, the sterile packs should be stored in well-ventilated, clean stores ready for dispatch to the wards. Collection should be regular and there should be a written record of receipt and delivery. This helps to monitor the use and the loss of instruments.

Note!
Do not store instruments or other items such as scalpel blades and suture needles in solutions-always store them in a dry container. Microorganisms can live and multiply in both antiseptic and disinfectant solutions which can contaminate instruments and other items and which can lead to infections.

SSD staff facilities

All SSD staff should be provided with adequate protective clothing (e.g. heavy duty gloves, plastic aprons, and eye protection if manual cleaning is undertaken). Overshoes are not necessary.

SSD staff should be immunized against hepatitis B.

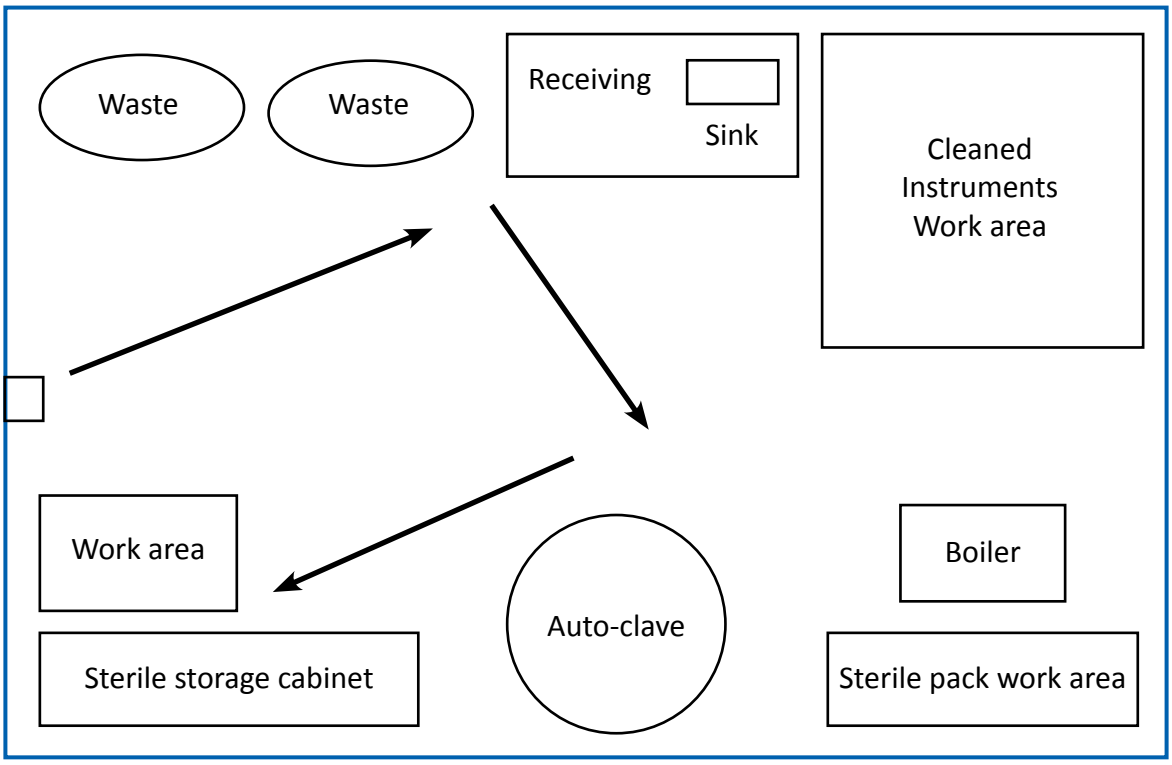


Fig. 15: Single room for processing instruments and other items

The flow of work in a single room for reprocessing of instruments should be designed to minimize the likelihood of contamination. Activity patterns should be established in which soiled objects never cross paths with clean, sterilized, or high-level disinfected instruments and other items

5-Environmental cleaning:

The term “environmental cleaning” refers to the general cleaning of environmental surfaces and to the maintenance of cleanliness in a health care facility. It is the physical removal of organic materials such as soil and dirt, which removes a large proportion of microorganisms, followed by complete drying

General Guidelines for Cleaning

Cleaning Schedules

Cleaning schedules should be developed by the head nurse in accordance with hospital policies and should be posted to where all staff that responsible for housekeeping can see and follow them closely. Regular supervision of their performance is important and is provided by the “Worker Supervisor”. Routine cleaning is necessary to maintain a standard of cleanliness.

Protective Clothing for Cleaning

During cleaning, workers should always wear gloves (preferably heavy utility gloves) and shoes that cover the toes. If there is a potential for splashing or for splattering (e.g., during the cleaning of toilets), they may need additional protection such as an impermeable apron, mask, and protective eyewear.

Cleaning Principles

Warm water and detergent removes 80% of microorganisms. The majority of these microorganisms are skin flora and spores.

- Cleaning should be done in a way that minimizes the scattering of dust and dirt. A damp cloth or wet mop should be used for walls, floors, and surfaces
- Cleaning should begin from the least soiled area to the most soiled area, which is usually the toilets and soiled storage areas. Surfaces should be washed from top to bottom so that debris falls to the floor and is cleaned up last. The highest fixtures should be cleaned first, working downward to the floor (e.g. ceiling lamps, shelves, tables, and lastly, the floor).
- The use of friction or scrubbing action is the most effective way to remove dirt and microorganisms in every cleaning procedure.
- The floors should be mopped with warm water and detergent and dried. Cleaning

solutions should be changed frequently. If a disinfectant is used, the disinfectant solution is less likely to kill infectious microorganisms if it is heavily soiled.

- Cleaning of environmental surfaces should be performed by using separate buckets. One container should contain detergent and the other one should contain plain water. The procedure starts by wiping or scrubbing with detergent, followed by rinsing with water, and drying at the end.
- Cleaning procedures for environmental surfaces must not be applied to patient care equipment/instruments (e.g., dental instruments, thermometer). The cleaning methods and products may differ significantly. Reusable equipment (e.g., bed, chairs) is not used for the care of another patient until it has been cleaned appropriately.
- Buckets should be washed and rinsed out after use and stored dry.
- Mops should be laundered daily in very hot water and detergent or in a washing machine (if available) and dried thoroughly. Wet mops should not be left standing in a bucket.
- Ward surfaces, rails, bedsteads, etc. should be damp-dusted with a detergent cleaner.
- Bathtubs should be washed with warm water and detergent and then should be dried.
- Toilets must be cleaned regularly and surfaces dried. Toilet floors must be dried thoroughly.

Sweeping

The use of dry brooms, dry mops and dry dusters should be avoided in patient treatment and food preparation areas as it is not efficient and it is potentially hazardous. It leads to the dissemination of bacteria carrying particles and increases the air-borne bacterial count nearly tenfold.

fig 16

Wet Cleaning Method

Wet cleaning is accomplished manually by a damp cloth, damp mop, or deck scrubber using water with or without detergent and with or without disinfectant. In addition to water, mechanical action (i.e., scrubbing) is used. Routine use of chemical disinfectants is not necessary.

If a detergent cleaner is used, rinsing is recommended, since detergents become concentrated, leading to a build-up of a detergent film.

Drying is essential. Moist surfaces are considered potentially contaminated because moisture encourages bacterial growth. Direct patient care and food preparation areas should not be used until completely dry.

Disinfectant

Disinfectants rapidly kill or inactivate infectious microorganisms during the cleaning process. In most settings a chlorine solution made from locally available bleach is the cheapest and most accessible disinfectant.

Disinfectants are also used to clean up spills of blood or other body fluids and body fluids and to decontaminate items of infected patients.

Disinfectants rapidly kill or inactivate infectious microorganisms during the cleaning process while detergents remove dirt and organic material. Removal of dirt and organic material cannot be done by water or disinfectants alone.

Note:
Chlorine (bleach) solutions should never be mixed with cleaning products that contain ammonia or phosphoric acid. Combining these chemicals will result in the release of a chlorine gas, which can cause nausea, eye irritation, tearing, headache, and shortness of breath. These symptoms may last for several hours. If you are exposed to an unpleasantly strong odor following the mixing of a chlorine solution with a cleaning product, leave the room or area immediately until the fumes have cleared completely. Accidents can be avoided by ensuring all solutions are clearly labeled and only one type of disinfectant solution is available in the cleaning supplies storage

Rules for Disinfectants

- Read the label and follow the manufacturer's instructions.
- Check the expiration date of the solution.
- Ensure that the correct dilution is used– more is not more effective.
- Always wash and clean articles before disinfection.
- Do not refill disinfectant containers without cleaning and drying the container between each use – topping off a partially filled container is not permitted.
- Disinfectants should be supplied in a ready-for-use dilution from the pharmacy.
- Empty containers should be returned to the pharmacy. Do not use empty containers

to store any other solutions – this is dangerous as the wrong solution might be used in the wrong situation.

- Open containers of disinfectant should not be tolerated in any hospital environment as there is a serious risk of contamination with multiply-antimicrobial-resistant bacteria, such as Pseudomonas species and spores.
- Where disinfectants are indicated for use on surfaces allow the disinfectant to remain on the surface for a sufficient amount of time to inactivate microbes. The instructions for use on the label of the disinfectant usually specify the contact time.

Table 7: Commonly Used Disinfectants

	Alcohol	Chlorine-based disinfectants	Hydrogen peroxide
Antimicrobial activity	Alcohol does not penetrate well into organic matter, especially protein-based (e.g., blood), and should therefore be used only on physically clean surfaces.	They are fast acting and have a broad spectrum of antimicrobial activity. Diluted solutions are unstable and should be freshly prepared daily unless prepared in an opaque container, in which case the solution remains stable for >1 week. They are inactivated by organic matter e.g., blood particularly if used in low concentrations. They are incompatible with cationic detergents.	Hydrogen peroxide and peroxygen compounds have a broad spectrum of antimicrobial activity. This activity depends on use concentration; for hydrogen peroxide, this needs to be >6% for semicritical devices. At lower concentrations this chemical has limited capabilities for surface disinfection.
Uses	Mainly as an antiseptic: Can also be used for disinfecting physically clean equipment or hard surfaces such as stethoscopes.	It is very active against viruses and is the disinfectant of choice for environmental decontamination of blood and body fluids. It can also be used for environmental disinfection on hard surfaces, e.g. baths or sinks.	Can be used for semicritical items such as endoscopes; Peroxygens are effective in penetration of organic matter but can cause damage to devices.
Precautions	Alcohol should be stored in cool places as it is flammable. Bottles should always be capped.	They should not be used in the presence of formaldehyde as some of the reaction products are carcinogenic. Skin and eyes should be protected when using undiluted hypochlorite solutions. Do not mix with ammonium.	Manufacturer's approval should be obtained before using on equipment where corrosion may present problems. Wear eye protection when pouring high concentration hydrogen peroxide (>6%); splash into the eye can cause irreversible damage.

Cleaning Up Spills

Clean up spills of potentially infectious fluids immediately. Besides preventing the spread of infection, prompt removal also prevents accidents.

When cleaning up spills:

- Always wear disposable gloves.
- If the spill is small, wipe it with a disposable cloth and then disinfect the surface area of the spill with another disposable cloth that has been saturated with a disinfectant (1000 PPM chlorine solution)) .
- If the spill is large, place a disposable paper or cloth towel over the spill to soak up the fluid. Still wearing gloves, pick up the towel, dispose into a bag to be disposed as biological waste and then soak the area with(5000 PPM chlorine solution). Leave it for considerable time then dry the surface.
- Do not simply place a cloth over the spill for cleaning up later; someone could easily slip and fall on it and be injured.

Cleaning of equipments and patient care articles

Table 8: Cleaning of Equipment and Patient-Care Articles

Equipment, patient-care articles	Routine or preferred method	Acceptable alternative or additional recommendations	Cleaning schedule
Bathtub Bath water usually contaminates the inner bath surface with large numbers of microorganisms including potential pathogens that can be transferred to the next patient using the bath.	Non-infected patients: Scrub with detergent solution. Rinse and dry after cleaning.	Infected patients: Disinfect after cleaning with a chlorine solution. Patients with open wounds: Disinfection after cleaning with a 200 PPM chlorine solution is recommended in all departments where patients have open wounds and/or are immunocompromised.	After each use
Beds and bed frames	Wash with detergent solution, rinse, and dry.	Infected patients: Disinfect after cleaning with a 200 PPM hypochlorite solution.	Daily and after discharge
Bedpans and urinals A bedpan or urinal should be specified for each patient	Wearing gloves, wash thoroughly with warm water using a brush and detergent to remove all visible signs of organic contamination. Dry or leave them to dry and store them in a special place away from patient care areas and clean areas.	They should be disinfected after patient discharge. - After each use, low level disinfection should be performed for high risk patients (200 PPM chlorine solution)	After each use.

Equipment, patient-care articles	Routine or preferred method	Acceptable alternative or additional recommendations	Cleaning schedule
Bowls (washing) **An individual washbowl should be available for each patient.**	Wash with detergent solution, rinse, and dry. Store inverted and tilted forward to avoid trapping of water, which may harbormicroorganisms	Infected patients: Disinfect after cleaning with a 200 PPM hypochlorite solution.	After each use
Bowls **(surgical, sterile)**	Clean with detergent and autoclave.		After each use
Bowls **(emesis)**	Wearing gloves, empty, rinse and wash with detergent and hot water, rinse and dry.	Infected patients: Disinfect after cleaning with a 200 PPM hypochlorite solution.	After each use
Ceilings	Wash with detergent solution	Keep in good repair. Physical integrity of ceiling is important because fungi and mold can grow on moist/water-damaged surfaces.	Clean if visibly soiled
Commodes	Using heavy-duty utility gloves, wash seats with a hot detergent solution and dry with a disposable paper towel. After each use the seat of the commode should be cleaned with a large alcohol soaked wipe or chlorine solution and dried.	If fecal contamination has occurred, remove soil with tissue, wash with a hot detergent solution, then wipe with disinfectant, (200 PPM Chlorine or alcohol soaked wipe; rinse and dry).	Daily and the seats after each use
Crockery and cutlery	1. Machine wash with rinse temperature above 80° C and dry. 2. Hand washings are preferably performed in two sinks, the first for washing with a hot detergent solution (as hot as possible: approx. 60° C) and the second for rinse with hot water (77-82° C or higher) for at least one minute and allow drying. Heavy utility gloves will be required at this temperature.	Each patient should have an individual set, either provided by the hospital or brought from home.	After each meal.
Drains	Wearing heavy utility gloves, clean the area around the drain. Wash hands after removal of gloves. Chemical disinfection is not required.	Regular maintenance is a must. Cover with insect screen. When blockage occurs, contact Maintenance Department.	On a regular basis.
Floors	Wash with a hot detergent solution. Disinfection is not routinely required except in high-risk areas.	If contaminated, clean and disinfect using a chlorine solution.	At the beginning of the day, and whenever necessary.
Furnishings	Clean cloths are used for each room, soaked with detergent or disinfectant-detergent solutions contained in a basin. Double-basin system minimizes the recontamination inherent in a single-basin technique. Alternatively, spray the surface with the disinfectant-detergent solution. Vigorously wipe the sprayed surface with a clean cloth saturated with the solution.		Each day, and whenever necessary

Equipment, patient-care articles	Routine or preferred method	Acceptable alternative or additional recommendations	Cleaning schedule
Mattresses and pillows	Wash water impermeable cover with a hot detergent solution, rinse and dry.	They should have plastic water-proof covers that can be easily cleaned and dried. Damaged pillows must be replaced immediately. Infected patients: Disinfect cover with a disinfectant solution. Allow a two-minute contact time then rinse and dry. Do not disinfect unnecessarily as this damages mattress cover.	After each patient and if soiled.
Patient partition	Clean partitions with a detergent solution.	- Should be disinfected if contaminated with blood or body fluids.	Each week and if dirty
Thermometers (Always separate rectal from orally used thermometers at all stages)	Wash in warm water (not hot!) and detergent and dry. Soak in 70% alcohol for 10 min.	Never leave soaking in disinfectants for long time or till been reused. Thermometers should be stored dry in a clean place till reused.	
Toilet bowl and seat	Using heavy-duty utility gloves, wash bowl and seat with a hot detergent solution and dry the seat with a disposable paper towel. Wash your hands after removal of gloves.	Infected patients or if grossly contaminated: After cleaning, disinfect with 200 PPM chlorine solution, rinse and dry. This is important in an area where soiling is more likely, e.g. Gynecology, Maternity, Urology Department, etc. This area should not be cleaned with the same supplies used for cleaning patient care areas!	Daily, and whenever necessary
Trolleys	Wipe with warm water and detergent to remove dust. Dry.	- Disinfect if contaminated with blood or body fluids.	Daily. Trolley tops before and after use.
Wash basins/sinks	Scrub with detergent; use cleaner for stains, etc. Disinfection is normally not required.	Disinfection may be required if contaminated.	Each day, and whenever necessary
Waste container	Wash waste container with a disinfectant cleaning solution, rinse, and dry with a disposable paper towel.		At the end of the day, and whenever necessary
Walls	Walls must be spot cleaned of spills and splashes and completely cleaned when they are soiled.	- Disinfect if contaminated with blood or body fluids.	In high-risk areas , and whenever necessary.
Working surfaces	Clean with a detergent solution, rinse and dry.	If there is visible spillage of blood or organic material, first remove spill and disinfect using a chlorine solution.	Several times during the day, and whenever they are soiled.

6-Waste management :

General Principles of Waste Management

- A clear facility policy for waste management should be available for proper implementation of a waste management system. The policy should describe in detail the methods of waste segregation, collection, storage, and disposal, according to the resources available in each health facility.
- Roles and responsibilities of the different team members responsible for waste management should be clarified. One main person should be assigned to be responsible for waste management in each facility.
- All used sharps must be discarded without re-sheathing in a puncture-resistant container that is readily accessible.
- All clinical waste, e.g., waste contaminated with blood and/or bloody fluids, should be discarded into a colored bag (e.g. red or yellow). Segregation of waste should take place at its source of origin
- Types of waste materials :
  1. Non medical waste
  2. Medical waste
  3. Sharp waste
  4. Chemical waste
  5. Pharmaceutical waste
  6. Radioactive waste
  7. Anatomic waste
  8. Genetoxic waste

Sorting, Handling, Interim Storage, and Disposal of Medical Waste

- **Sorting:** Sorting is separating waste by type (e.g., infectious waste, pharmaceutical waste) into color coded bags at the place where it is generated.
- **Handling:** Handling is collecting and transporting waste within the facility.
- **Interim storage:** Interim storage is storing waste within the facility until it can be transported for final disposal.

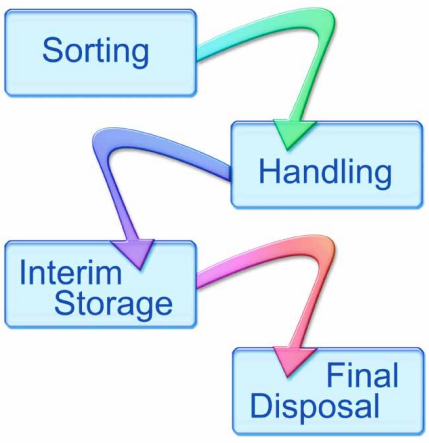


Fig. 17: Steps of Medical-Waste Mana

- **Final disposal:** Final disposal is the elimination of solid medical waste, liquid medical waste, sharps, and hazardous chemical waste from the health facility.

Sorting

- Red bags are used for infectious and pathologic waste that needs to be incinerated.
- Black bags are for general waste that is to be disposed with the normal general waste and is to be transferred by the municipals.
- Sorte waste at the point where it is generated
- Always keep waste containers at convinient places where ever both general and medical wastes are generated
- Use colored waste bage to distinguish between general and medical wastes containers
- Place sharp containers in a convinient places to minimize the distance that staff carry the sharp object
- The sharp containers should be puncture resistant and leak proof

Medical waste containers should be cleaned with a disinfectant solution at least once per day. Housekeepers should wear heavy utility gloves and eye protection during cleaning of the containers.

Handling

- Handle medical waste as little as possible
- Medical waste and sharps containers should be discarded when they are three quarters full or at least once per day
- Never put hands into the container that holds medical waste

Do not empty medical waste into open carts because this increases the risk of injury to staff, patients, and visitors, and may lead to spills and to environmental contamination.

Interim Storage

- Waste should be transported at the end of every shift.
- To reduce the risk of infection and of injury, minimize the amount of time waste is

stored at the health care facility. Waste should be stored in an area of controlled access that is minimally trafficked by staff, clients, and visitors. Interim storage time should not exceed two days. It is preferable to have a room to store waste in on each floor of the facility, but, if this is difficult, one central storage room should be designated.

- The storage area should be included in a cleaning schedule.

Final Disposal of Solid Medical and General Waste

There are two different ways of final disposal at a facility: Burn and non-burn techniques.

1. Non-burn techniques:

- Community waste collecting system.
- Disposal of general or non-hazardous waste.
- Burying solid medical waste

Transporting solid medical waste

Transporting solid medical waste is an option for final disposal if a facility is unable to use burn or non-burn techniques. It is the least desirable option for disposal because it is likely that non-medical personnel will put themselves at risk by being involved in the disposal process. If this option is used, facility staff must educate the waste transport and disposal personnel to the risks involved in the disposal process and must teach them how to dispose of solid medical waste safely.

2. Burn technique

Incineration of solid medical waste

Incinerating is the best option for solid waste disposal, since the high temperature (1300 ˚C) destroys microorganisms and reduces the amount of waste. Burning in an incinerator or oil drum is recommended.

Final Disposal of Liquid Medical Waste

Liquid medical waste can be poured down a sink, drain, and flushable toilet. If none of these are available, liquid medical waste should be buried in a pit. Points to remember when disposing of liquid medical waste:

- Always wear heavy utility gloves and shoes when handling or transporting liquid medical waste. Afterwards, wash both gloves and shoes.
- Consider where the sink, drain or toilet empties. It is hazardous to have medical waste flowing through open gutters or emptying onto the grounds of the facility.
- When carrying or disposing of liquid medical waste, avoid splashing the waste on yourself, on others or on surfaces.
- After disposal rinse the sink, drain, or toilet to remove residual waste, being careful to avoid splashing. Clean the fixture with a disinfectant solution at the end of each day or more often if heavily soiled.
- Decontaminate the container that held the liquid medical waste by filling it with a 0.5% chlorine solution and letting it sit for 10 minutes before washing.

7- Lenin management :

Although soiled linen can be contaminated with pathogenic microorganisms, actual disease transmission from linen has been demonstrated to be negligible if it is handled, transported and laundered in a manner that avoids dispersal.

Note:

- There is no evidence that linen used by patients who are under isolation precautions carries any greater microbial load or risk of disease transmission than patients who are not in isolation.
- Wet or linen saturated with body fluids should be folded with the wet areas inside in order to minimize contamination of the health care facility environment.

General Principles to Prevent Infection:

- All personnel involved in collection, transport, sorting, and washing of used linens should be adequately trained, should wear appropriate protective clothing, and should have access to hand-washing facilities.
- Dirty linen should be carefully removed with a minimum of agitation in order to minimize dispersion of the microorganisms into the air. Linen should then be placed in strong and appropriate bags or into a container at the bedside. Never place linen on chairs or on other surfaces.
- After removal of linen, soiled linen must be handled with care at all times. It should be placed into fluid resistant bags at the point of generation as soon as possible. Dirty linen bags should not exceed the weight of 20 kgs and should be be securely tied or otherwise closed to prevent leakage. Rinsing soiled laundry at the point of generation should not be done.
- Assume all used linen is contaminated. No need for color coding.
- Laundry bags: Single bags of sufficient tensile strength are adequate for containing laundry; leak-proof containment is needed as the laundry maybe wet and can soak through a cloth bag.
- Transport of soiled linen: Soiled linen in bags or containers should not be transported manually to the laundry processing area. If available, carts or containers with lids should be used for this task.
- Unnecessary handling of linen should be avoided.

Note:
Be sure that no miscellaneous items (e.g. needles) are collected with linen. Such items constitute a special hazard to laundry staff.

Changing linen:
Change bed linens daily and whenever soiled.

Laundry
Linen, surgical drapes, window curtains, rags, mups, uniforms, gowns, lab coats and others could be laundered. Sorting in the laundry area is essential. Sorting should be done separate from clean areas with limited traffic. Work surfaces are at or above the waist height. The sorting area needs to be equipped with sink, disposable gloves, soap and towels. The area should be provided by sharps containers.

The sorting system in the laundry:
Sorting of laundry should be done either before or after washing. Large health facilities usually sort laundry before washing due to existence of high volumes of laundry.

Sorting before washing:
- Remove objects that might be attached before washing.
- Sort same textile, same fiber or sort by products needed or by those who are packed together (gowns, curtains, etc.).

Sorting after washing:
Benefits of sorting after washing includes fewer microbial exposure by the workers, however, it shortens the life of fabrics and causes more lint on surgical materials.

Washing, drying and storing linen:
- Linen is washed in washing machines. It is important not to overload the washing machine. A temperature 71°C for at least 25 minutes is generally recommended. A preheating period for at least 5 minutes should be allowed. These temperatures along with these times are capable of killing most vegetative bacteria and viruses. However, addition of chemicals assists in adjusting the pH of the water- plus additional chemicals such as bleach facilitate inactivation of pathogens that might be present in the linen.
- Addition of bleach: Bleaches provide bactericidal action and disinfect heat labile materials when added to rinse water.

- An acidic agent (sour; e.g. vinegar) may also be added. These agents are added to prevent yellowing of fabrics but also produce a rapid shift in pH that aids bactericidal action.
- Facilities for manual washing of linen may be available and may offer a temporary alternative where is there is any lack of access to or a problem with mechanical washing processes.
- Spreading linen to dry in sunlight and open air (if away from any source of contamination or pollution) may be possible in some situations. In addition to cost reduction this allows exposure to ultraviolet sunrays, which produces natural disinfection.
- Dryer heat is also effective in ensuring total bacterial kill. Ironing has the same effect but linen need not be sterilized.
- Store clean linen and supplies in a separate place away from the soiled linens. Three clean sets of linen per bed should be available.

Mattresses and pillows

- May be a major source of contamination if not properly protected.
- Wet mattresses must be changed.
- Must be covered with an impervious layer (plastic, rubber) so that they can be cleaned thoroughly between patients.
- Covers must be cleaned with warm water and detergent.
- Never admit new patients onto soiled, stained, or contaminated mattresses.
- Rubber covers can be uncomfortable in hot countries. It may be possible to cover the mattress cover with absorbable paper, which should be changed frequently.

TB INFECTION CONTROL IN SPECIFIC AREAS

1- Laboratory
2-ICU
3-Operation room
4- Bronchoscopy unit
5- Emergency and Ambulatory units
6- TB ward
7- MDR-TB wards
8- Radiology areas
9- Dialysis
10- Dentistry

1- Lab infection control

Safe working in TB lab should start by risk assessment of infection. This manual contains the minimal requirements for infection control in TB lab according to its level .

-Risk assessment:

Labs dealing with drug resistant strains carry higher risk and should consider establishing higher levels of precaution.

Assessment should go through the following steps:

1. Decide who might be harmed and how:

– Procedural risk related to the generation of aerosols that could be inhaled by lab workers,

– Workload

– Susceptibility of lab workers, with reduced immunity, caused by medication, underlying disease as diabetes, pregnancy may at higher risk becoming infected.

2. Evaluate the risk and decide on precautions

– Determine the suitability of the physical structure, and design

– Evaluate the staff's proficiency safe practices.

– Evaluate the integrity of safe equipment.

Table 9: evaluate risk and precaution

Evaluate the risk	Precaution
Suitability of lab physical structure and design	- separate contaminated and clean area - airflow from clean to dirty away from technician - re-locate equipment to achieve safety to technician and environment
Evaluate the staff's proficiency practice	- pre-work training of staff - supervision & on job training - continuous evaluation of the staff
Evaluate the integrity of the equipment	Regular maintenance of the equipment should be performed - BSC should be cleaned daily before and after work by appropriate disinfectant, annual decontamination and certification. - UV lamps used in moderate and high risk TB labs should be cleaned by 70% alcohol each 3 months ,assessed annually by the imported company to achieve 254 nm. - Centrifuges used should be examined for lid closure , cleaned by disinfectant - Any other equipment should be maintained according to manufacture regulation as BECTEC, shakers ,vortex, microscope,.....

3- Record findings and implement them, the findings of risk assessment and precautions that need to be taken should be documented as part of standard operating procedure

4- Review your assessment and update it if necessary, risk procedures and practices should be reviewed annually.

Classification of TB Labs:

- **Low risk:** direct sputum smear microscopy, preparation of specimens for use in an automated nuclei acid amplification test.
- **Moderate risk:** processing and concentration of specimen for insulation on primary culture media, DST.
- **High risk:** culture manipulation for identification.

Primary Barriers (Essential safety measures for TB labs

1. Laboratory access: biohazard warning symbol and sign must be displayed on the lab door.
2. Only authorized persons should be allowed enter the lab working area.
3. Children should not be allowed to enter the lab working area.
4. Eating, drinking, smoking ,are prohibited in the lab.

Fig18: showing anteroom in DST Lab, only authorized persons

5. Training on procedures done in the lab, hazards facing the lab worker are the responsibility of lab manager.

6. Personal protective equipment (PPE):

- PPE must be worn at all time while worker in the lab
- Must be stored separately from personal clothing.
- Closed footwear must be worn in the lab.

For high risk labs gowns should be worn preferred the disposable ones that have long sleeves and elastic cuff at least 30mm long
- High efficient respirators (N95 or FFP2) should be worn - Gloves
For moderate risk, long sleeves up to elbow, and gloves should be worn; disposable aprons may be worn over the lab coat,
For low risk labs, gloves ,disposable aprons may be worn over the lab coat,
- Routine Hand washing should be performed after removal of the gloves and other PPE.

7. Safe procedures:

A- Primary barrier

For all laboratories

- When preparing smears, wooden sticks or disposable loops are preferable rather than reusable loops, which need to be heat sterilized.
- If a reusable loop is used, it should be heat sterilized in an enclosed micro incinerator or a Bunsen burner. Reusable loops should be cleaned using a sand-alcohol jar before sterilization.
- When preparing a smear using a stick or loop, move it slowly and smoothly to avoid creating an aerosol.
- Do not move or heat-fix smears until they have been completely air-dried.
- The lab request is considered contaminated and should be collected in the red bag
- Before starting work ,prepare instrument needed , disinfectant used for emergencies as spillage, wipe the cup lid before opening
- Strict adherence to hand hygiene or rub by alcohol 70%

For moderate and high-risk TB laboratories

- Do not forcibly expel infectious liquids from a pipette.
- Do not forcibly expel air from a pipette into potentially infectious liquids.
- When using a pipette to add a reagent to a potentially infectious liquid, place the pipette against the inner wall of the container and gently expel the fluid.
- Always avoid disrupting a bubble or film in an open culture tube. This may be avoided by replacing the cap, gently tapping the top of the tube, setting the tube aside and allowing any generated aerosols to settle before reopening.
- When centrifuging a specimen or culture, do so in a sealed safety cup or sealed rotor to avoid releasing an aerosol into the centrifuge and laboratory. Always open safety cups or sealed rotors inside a BSC.
- Following centrifuging, vortexing, or shaking specimens or cultures, place containers inside the BSC and leave them undisturbed for at least 10 minutes to allow aerosols to settle before opening.
- Never vortex an open tube; always ensure that screw caps are securely fastened to tubes before vortexing or shaking. Do not vortex tubes with cotton plugs or rubber stoppers.
- Do not mix or suspend infectious materials by repeatedly filling and fully emptying a pipette.
- Allow vortexed tubes to stand for 10–15 minutes to minimize the spread of aerosols, especially if the tubes contain high concentrations of TB bacilli.
- Ensure that when decanting liquids, tubes are held on an angle so that the liquid runs down the side of the tube or discard container to minimize any splashes.
- Only insert the disposable tip of a micropipette into a tube or container, NEVER insert the barrel of a micro-pipette.
- All contaminated materials, specimens and cultures must be decontaminated before disposal or cleaning using phenol, sodium hypochloride.
- All accidents, spills and potential exposures to infectious materials must be reported to the lab manager.
- Packing and transportation of samples should in a tight closed container.

Design and facilities

- Proper design of the lab protects the workers and the surrounding environment from any aerosols liberated from lab procedures.
- Internal lab design should be :
  - Specimen receiving area
  - Smear and staining area.
  - Microscopic and reporting area
- Bench tops should be impervious to water, chemicals and disinfectants.
- Hand washing facilities and supplies (towels, soap) should be provided preferably near the door.
- Good sewage of the facility.
- Illumination should be adequate
- Precaution should be made during movement within the lab
- Separation of contaminated(area dealing with specimen and its processing) and clean areas (dealing with clean equipment ,storage area, reporting area) is the main idea of the design which is the primary barrier and the secondary barriers

Basic design features for TB labs :

- Adequate ventilation, and directional airflow from clean to dirty (generating aerosols area), the outgoing air should be safely discharged to open un-crowded area.
- Natural Ventilation in low risk TB lab can be ensured by opening windows to provide clean air to dilute any potentially contaminated air, it depends on the lab design, climate and work practice of the staff if not available mechanical ventilation should be provided, as exhaust fans, the number should be calculated by a professional before installing.

For moderate and high risk TB lab: all processing and digestion of sputum samples, manipulation of liquefied sputum specimen should be conducted in biological safety cabinet (BSC)

- Centrifuges should be provided by sealed safety cups
- Loading and unloading of the buckets should be held within the BSC

– Adequate space for safe working, cleaning and maintenance.

– Close BSC sash after decontamination and light on UV lamp for 30min .

B- Secondary barriers:

Low risk TB labs:

1. separate the working area from the public
2. ensure proper waste disposal
3. provide hand wash facilities

Moderate and high risk labs

1. Anteroom separating the lab from the public
2. Biological safety cabinet (BSC) class II should be used

- Should be placed away from door opening .
- Assess daily for air direction using tissue strip, and annually maintenance of the HEPA filters as decontamination and certification .
- Do not over crowd the cabinet by the equipment.
- Do not use flam loop incinerator inside the BSC as it affect the airflow.
- Decontaminate the cabinet before and after working
- Be aware of sudden movement during working as airflow may be disturbed, wait 10 min before opening the cups or culture.
- The interior surface of the cabinet must be decontaminated before and after each use with reliable disinfectant a second wipe by sterilized water if the disinfectant is corrosive .

Fig19: Biological safety cabinet class II

3. Waste management:

To minimize the risk from waste, all infectious materials should be decontaminated, incinerated, or autoclaved.

Discard bags should be used to segregate waste, broken glasses and sharps should be discarded in safety boxes up to two third.

Decontamination by proper disinfectant for TB :

Phenol:

- Used in concentration of 5% in water
- Used for decontamination of equipment and single use items prior to disposal.
- Disadvantage: highly irritant to skin, mucous membrane and eyes , because of its toxicity and odor phenol derivatives are used.

Chlorine :

- Sodium hypochlorite (domestic bleach) contains 50g/l.
- diluted to 1: 50 or 1: 10 in water, **should be prepared daily**
- Stored in well ventilated, dark area.
- used as general disinfectants, soaking of contaminated materials
- Because it is highly alkaline it can corrode metals.

Alcohols:

- Ethanol or isopropyl alcohol are used at 70% solution
- Used for routine decontamination of BSC
- Used as hand rub when hand is decontaminated followed by thorough hand wash with soap and water.
- Disadvantage: alcohol is volatile; flammable should not be used near flames, and well labeled

Per acetic acid :

- Used at 2% conc. Solution stable for 48 hours
- It has a rapid action against all microorganisms.
- It lacks harmful decomposition product, enhance removal of organic materials and leaves no residue.

Disposal of potentially infectious materials:

All positive TB cultures should be autoclaved before disposal.

Discard container should be placed at working place, with appropriate disinfectant effective against TB, waste materials should remain in contact with disinfectant for the

appropriate time.

Plastic sputum container, wooden sticks, should be removed in sealed disposal bags.

8- Emergency response procedures for TB labs

Infectious spills (outside BSC)

1. Evacuation of the lab.
2. Staff must be prevented from re-entering the lab for at least 1 hr. .
3. Lab manager must be informed
4. Sign should be posted indicating that entry is not allowed during cleaning procedures:

– Put on personal protective equipment: gloves, gown and N95 or FFP2 respirators

– cover the spill by cloth or paper towels to contain it.

– pour an appropriate disinfectant (5% sodium hypochlorite) over the paper towel and surrounding area, apply it at the outer margin inwards

– Allow sufficient time (contact time) mainly 10- 15 min. before cleaning

– If broken glass and other sharps are involved, collect by stiff cardboard and place it in safety box.

– Place the contaminated paper towels in a *(red)* sealed bag for disposal.

– clean and disinfect the area of the spill.

Infectious spills inside the BSC

1. The BSC should be kept operating.
2. Cleaning process should begin immediately.

– place absorbent tissue over the spill and apply disinfectant solution

– If the cabinet wall has been splashed clean by absorbent towel soaked in disinfectant solution

– leave affected area covered by disinfectant for 30min to 1 hr.

– Any sharps should be collected and placed in safety box.

- Any equipment splashed should be cleaned by the same disinfectant
- Electrical equipment should be checked carefully
- Collect other contaminated materials in a sealed *(red)* bag for disposal.

Breakage of tubes inside sealed bucket:

- Discard the tubes in safety box
- Decontaminate the bucket by disinfectant other than bleach as it is corrosive
- Alternatively it may be decontaminated by autoclaving.

If spillage on the skin:

- wash skin with soap and water
- Hand rub with alcohol 70%

Stick injury:

- remove gloves and wash with soap and water.
- Hand rub with alcohol 70%

Eye spillage :

- wash eyes with running water for 15 minutes.
- Open eyes during washing
- consult specialist.

Sputum collection area :

- It should be collected in open area away from traffic
- airflow direction should not enter the building
- observation of the patient while giving the specimen through glass window
- sputum collection area may be shaded for privacy, by a way that good ventilation is provided

Specimen transportation :

- specimen may be sputum, broncho- alveolar -lavage (BAL) , body fluids as urine, CSF, ascetic fluid , pleural effusion , pericardial effusion and processed specimens as cultures

- Specimens should be transported in a tight closed metallic or cardboard container, patient name written over the lid and body of the cup, then transported in an ice – box.

- Processed specimen as culture it needs more precaution , every specimen should be caught by absorbable material and separated from each other. The specimen should be placed upright in a closed container with tight lid .

Slide transportation :

- Slides should be fixed, before transportation and placed in a slide box.

- For quality control slides should be placed in a slide box after cleaning from oil by zylol.

Transportation of Positive cultures:

- The bottle should be placed in a plastic rack and transported in an ice – box.

Maintenance :

1. **BSC:**

- Daily cleaning of the internal surface by phenol 10% ,(if sodium hypochloride is used wipe with sterile water as it is corrosive to metals)

- Then dry by clean towels.

- BSC tray should be removed and cleaned with soap and water, then wiped with alcohol 70% every 6 months

- Annual assessment and decontamination of HEPA filter and UV lamp

2. **Centrifuge :**

- Clean every day

- If spills occur it should be cleaned with soap and water then wiped with alcohol 70%

- Maintenance should be performed every 6 months

3. **Incubator :**

- Clean every day

- If spills occur it should be cleaned with soap and water then wiped with alcohol 70%

- Maintenance should be performed by imported company

4. Autoclave

- Daily cleaning of the interior chamber.
- Inspect water level
- Monthly, wash with soap and water, filter cleaning
- Annual maintenance by imported company.

Sterilization :

1. All specimen and culture should be decontaminated and autoclaved at 121ºc for 20 min.
2. Dedicate an autoclave for decontamination and other for sterilization of the media and equipment
3. Use chemical and biological indicators to ensure the efficiency of the autoclave.
4. Do not overload the autoclave
5. Sterilization time is considered when the temperature reaches 121 ºc or 134 ºc
6. Glass equipment is sterilized in hot air oven with circulating fan at 180 ºc for ½ an hour, for those without fan 1 hour.

TB infection control in Intensive care units

Intensive care units are dealing with highly sick patient where, sometimes, invasive interventions are performed with either TB or non-TB patients .

TB patient should be isolated from other non-TB patient in AII as shown above (Environmental control p. 13) .

ICU patient may need to be ventilated where being a TB or non-TB patients .

The ventilator is a devise that assists or control respiration through endotracheal or tracheostomy intubation

- It is preferred to use endotracheal tube rather than nasotracheal as the later cause sinusitis.
- The cuff should be adjusted at 20 mmHg
- It has an inspiratory and , expiratory tubes that should be provided by biological filters at the end entering the devise, especially the expiratory one , to protect the entire of the devise . Single use tubes are preferred , if reusable ones are used, they should be made of silicon, cleaned and decontaminated by appropriate disinfectant(high level disinfectant) or autoclaved by ethylene oxide or steam autoclaved at 121ºc after complete drying of the tubes.
- The ventilator tubes and the filters are changed not less than 48 hours. If not soiled check at day 7, 14, 30 for patient secretions, as excessive manipulation of the tubes causes increase of secretions that may be the cause of ventilator associated pneumonia.
- Water trap is added to the expiratory tube in which water vapor is collected. It should be evacuated daily or whenever filled.
- The ventilator humidifier should be supplied by sterile water (not distilled water as distilled water is condensed water with no mineral salts and not sterile) . Sterile water should be changed daily.
- Some ventilators have built in filter (HEPA) that should be changed after each patient. Others have reusable filters that are sterilized by autoclaving at 121ºc according to the manufacturer recommendations.
- The internal machine needs no cleaning while its outer body should be cleaned daily and whenever soiled by appropriate disinfectant.

Ventilator associated pneumonia (VAP):

VAP : pneumonia associated with mechanical ventilation that develops after 48 hours

or more of mechanical ventilation and which was not present at the time of admission, it has been considered to be the most serious healthcare associated infection, as it lengthens period of stay and the patient is exposed to resistant bacteria leading to more complication .

To prevent or decrease the incidence of VAP, the following steps should be strictly followed:

1- Avoid ventilation of the patient as far as possible.

2- In case of tracheostomy perform intubation aseptically in which :
   - Aseptic hand hygiene is performed using suitable antiseptics.
   - Sterile PPE; gloves, gown, respirator N95 OR FFP2 for HCWs.
   - Sterile equipment are used.

3- Apply VAP bundle:
   - prevent aspiration of secretion by maintaining the patient in a semi-recumbent position at 30-45 ºelevation of the head of bed (unless medically contraindicated), avoid gastric over distention.
   - maintain comprehensive oral hygiene by brushing using antiseptic solution (chlorhexidine 0.12%) twice daily
   - Management of oropharyngeal and tracheal secretion, by suction of the oral cavity every 12 hours ,or more according to the rate of accumulation
   - Suction of the endotracheal tube every 6 hours
   - Change the ventilator circuit when visibly soiled or malfunctioning.
   - In addition to:
   - Daily vacation of sedation and reassessment to extubate.
   - Peptic ulcer prophylaxis
   - Deep venous thrombosis prophylaxis.

4- Disinfect respiratory therapy equipment by high level disinfection using appropriate disinfectant or autoclaving.

Central venous catheter (CVC):

1- CVC bundle:
   - surgical hand hygiene
   - sterile PPE gloves, gowns , and mask N95 or FFP2
   - Cover the patient by sterile drapes exposing only site of insertion
   - Use appropriate skin antiseptics as (Betadine 10%) keep for contact time 2 min.
   - Subclavian approach is preferred than femoral and jugular

2- Use minimum number of ports or lumen.
3- Antibiotic impregnated CVC for patients suspected to indwell CVC for more than 5 days.
4- Use sterile gauze, preferred to be transparent, if not available observe the site of insertion every day.
5- Change dressing daily:
   - Washing hand routinely,
   - Apply clean gloves,
   - Removal of dressing
   - Apply skin antiseptics leave for contact time (e.g povidone iodine for at least 3 min, leave to dry)
   - Wash hands surgically;
   - Apply sterile gloves, sterile gown, and respirator N95or FFP2
   - Apply sterile dressing
6- If catheter is inserted in emergency department, it must be changed within 48 hours.
7- Disinfect the hub with alcohol swab before each connection to administration set
8- Reduce number of hubs (3 way) as possible

Peripheral venous catheter:

- Upper extremities are preferred than lower ones for insertion.
- Hand wash aseptically
- Non sterile gloves are accepted
- Do not touch access site after wiping by alcohol70%
- Replace catheter every 72-96 hours to prevent phlebitis

Administrative set

- wash hand routinely, wear clean gloves
- hand wash aseptically
- wipe the access by 70% alcohol
- The set is replaced every 72 hours except for:
- Blood transfusion to be completed within 4 hours and change the administrative set,
- Lipid emulsion within 12hrs,
- Lipid containing solution within 24 hrs

Nasal prongs or masks:

- Change between patient, if reused for the same patient wash thoroughly, dry and wipe by 70% alcohol.
- If reusable masks are used:
  - The masks are cleaned by water and soap,
  - Rinsed thoroughly,
  - And soaked in high level disinfectant for suitable time, as chlorine 500 ppm for 10 min
  - rinsed by sterile water, either boiled water or commercial sterile water
  - dried, and placed in a clean dry place

Humidifiers and Nebulizers

- Use only sterile water and fluids and dispense them aseptically
- If multidose medication vials are used , opening date is written on the vial , if possible dedicate the vial for one person and write his name on the vial, and store correctly.
- Between settings of the same patient: disinfect, rinse with sterile water and air dry.
- Nebulizers are sputum inducing device so while using for TB patient should be separated from other non TB ones. Environmental control measures should be achieved as mentioned before. Disinfect between patients by the appropriate disinfectant, then wipe with sterile water to decrease the irritant odor of the disinfectant .

Respiratory suction devices:

- Use sterile, single use if possible, or reuse suction tubes per shift (6 hours for the same patient).
- Use sterile water to wash the tubes

Change the tubes if soiled with patient secretion which is sticky and not easily washed.

Spirometers and pulmonary function test instrument

- The internal part of the instrument will not be infected
- The part in contact with the mucous membrane of the mouth should be cleaned and disinfected better to use single use mouth piece
- A filter is added beyond the mouth piece and changed after each patient .

Ambubag:

- Dedicate an ambubag for each patient
- Clean with soap and water, then immerse in the appropriate disinfectant for suitable time as intermediate level of disinfection .
- Rinse with sterile water ,pack and store in dry place

Suction and drainage bottles

These are usually disposable, with a self-sealing inner container held in a clear plastic outer container.

- Before buying a system, ensure that the outer container can be heat-disinfected or autoclaved.

***Non-disposable bottles*:**

- Must be changed every 24 hours (or sooner if full).
- The contents may be emptied down the toilet.
- Must be cleaned and disinfected or autoclaved.
- If sterilizing facilities are not available, wash thoroughly, dry and perform high level disinfection.
- Recyclable connector tubing should be cleaned thoroughly and disinfected or sterilized. The system must be closed and risk to staff from body fluids should be minimal.
- Do not leave fluids standing in suction bottles

Indwelling urinary catheter:

- Clean the perineum.
- Apply appropriate skin antiseptic as povidone iodine (Betadine 10%), in a circular manner, keep for contact time 2 min..
- Wash hands after removal of the clean gloves
- surgical hand hygiene
- Sterile PPE gloves, gowns, and respirator N95 or FFP2 if urinary or pulmonary TB is suspected
- Cover the patient by sterile drapes exposing only site of insertion.
- Insure that the balloon of the Foley catheter is functioning well by inflating 7-9cc sterile water, deflate and leave the syringe attached to Foley port.
- Insert lubricated catheter into the meatus until urine appear
- Inflate the balloon by 7-9cc sterile water Check catheter in place in the bladder

A sterile continuous closed system should be maintained during emptying the Drainage Bag

1. This should be done wearing non-sterile gloves and via the drainage tap at the bottom of the bag. When the bag is empty, the tap should be closed securely and wiped with a tissue. If the bag does not have a tap, then replace it when full. Do not reuse the bag.
2. Wash and dry hands thoroughly after touching the drainage bag.
3. With proper handling, drainage bags with taps can be left in situ for long periods and are more cost-effective on the long run.
4. A separate urine bag-collecting receptacle must be used for each patient and each bag should be emptied separately as required. For purposes of measuring urinary output, an integral measuring device is necessary.
5. The urine receptacle should be heat disinfected if possible and should be stored dry after each use. If heat labile, chemical disinfection could be used. Single-use disposable receptacles may be used. After emptying the receptacle, the gloves should be discarded and hands washed and dried thoroughly.

Collecting Urine Samples

Do not disconnect the drainage bag to obtain a urine sample as this causes an interruption in the closed drainage system and may pose a risk of infection to the patient. If a sample of urine is required for bacteriological examination, it should be obtained from a sampling port or sleeve. This must first be disinfected by wiping with a 60-90% ethyl or isopropyl alcohol impregnated swab. The sample may then be aspirated using a sterile needle and syringe and transferred into a sterile container. Do not obtain a sample for bacteriological culture from the drainage bag. If there is no port or sleeve for collecting urine samples, aseptic hand wash and wearing non sterile gloves should be attempted, wipe the connection between the urinary bag and the catheter, with alcohol, do not disconnect the drainage bag, collect a urine sample by sterile syringe from the catheter just above the connection in a sterile container

Irrigate Bladder

Routine irrigation of the bladder (bladder washout) with chlorhexidine or other antiseptics is not effective in prevention of infection and should not be performed. Irrigations rarely eradicate organisms but may introduce infection and can cause inflammation of the bladder wall, and, therefore, can increase the likelihood of

systemic invasion. They may also cause damage to the catheter.

If the catheter becomes obstructed and can be kept open only by frequent irrigation, the catheter should be changed, as it is likely that the catheter itself is contributing to obstruction.

Operational room

Surgical suites require special infection control measures for preventing transmission of TB :

Administrative control

- Postpone non urgent operation for suspect or confirmed TB up till proved to be non infectious.
- **If the operation is obligatory:**
  - It should be done at the end of the day to maximize the time available for removal of airborne contamination
  - Minimum number of HCWs should be present in operation room
  - The door should be closed, minimize traffic in and out the room and in the corridor.

Environmental control

- Normally the operation room should be positive pressure in which direction of air from the operation room outward to the hallway with ACH of 25-30 is recommended but in case of TB the reverse direction should be achieved in which air flow to the operation room from the hallway.
- Additional environmental support as UVGI and air cleaning system with HEPA filters can be placed in the room or in the surrounding areas to minimize contamination of the surrounding.
- A bacterial filter should be placed on the patient's endotracheal tube or at the expiratory side of the breathing circuit of the ventilator or the anesthesia machine
- The bacterial filter should be selected to filter 0.3µm.
- The anesthetic mask and tubes should be disinfected as at least intermediate level of disinfection (single use tubes is preferred)

Respiratory control: The surgical staff should adhere to the N95 or FFP2 respirator., (with sterile gown ,gloves and clean footwear)

Bronchoscopic suites:

Bronchoscopy is a cough inducing procedure that might transmit the TB infection either through the airborne route or contaminated bronchoscope

Administrative control

- Avoid bronchoscopy on patient with suspect or confirmed TB or postpone the

procedure until patient proves to be noninfectious

- Use a dedicated room to perform the bronchoscope
- It should be done at the end of the day to maximize the time available for removal of airborne contamination
- Minimum number of HCWs should be present in Bronchoscopic room
- The door should be closed, minimize traffic in and out the room and in the corridor
- The anesthetic mask and tubes should be disinfected at least intermediate level of disinfection (single use tubes are preferred)

Environmental control:

- A special room is dedicated for the bronchoscope which should be negative pressure of 10-12 ACH.
- Additional environmental support as exhaust fan, UVGI and air cleaning system with HEPA filters can be placed in the room or in the surrounding areas to minimize contamination of the surrounding.
- It should be supplied by a hand hygiene facility, central suction equipment .
- Keep the patient in the bronchoscopy room until cough subside after ending the bronchoscope

Respiratory control

HCWs should wear at least N95orFFP2 respirator and may wear full face shield

The patient with TB should wear surgical mask before and after the procedure.

Sterilization of the bronchoscope :

Sterilization of the bronchoscope should be done in a separate room with a sink or basin for cleaning the bronchoscope, hand wash facility for workers .

- The workers should wear N95 or FFP2 mask, apron, and heavy duty gloves.

The bronchoscope is a semi critical instrument in which it get in contact with mucous membrane .

1- At the beginning of the day the bronchoscope should be cleaned and disinfected (high level disinfection) with a suitable disinfectant (Glutraldehyde for 20 min). then rinsed by tap water, and dried. if automated machine is used it should be compatible with the instrument.

2- once used by the patient it should be rinsed by tap water or endozyme for quick removal of the protein secretion, never use hot water as it leads to coagulation of the protein secretion

3- All accessories are removed
4- Thorough rinsing with endozyme and tap water through all ports by using bronchoscope brush.
5- Leak testing of the bronchoscope should be performed by leak test instrument, or by immersing the bronchoscope in a sink full of water and wait until air bubble is removed and start to inject air in the different pores of the bronchoscope. If bubbles leak from the lumen of the bronchoscope, this bronchoscope should be subsided to maintenance and not used until full maintenance is performed and checked after, if the leak test passed successfully, you can go through the next step.
6- Immerse in a suitable disinfectant which should be compatible with the bronchoscope according to the manufacturer recommendation for the suitable contact time according to the disinfectant used.
7- Thorough rinsing by tap water which is accepted, then drying by the passage of air through the pores of the bronchoscope, then inject alcohol 70% at the last step as it helps drying of the bronchoscope.
8- The bronchoscope should be stored in a special cupboard in an upright position no tilting, the cupboard should be permeable to air with openings to help drying
9- The disinfectant used should be examined every day to check its illegibility for reuse, date of preparation, expiry date should be written on the container.
10-It is better to use the autoclavable one or any part is autoclavable it should be cleaned as before and autoclaved
11-The accessories are cleaned and disinfected as before, if any part is autoclavable, so clean and autoclave
12-All brushes used in cleaning should be cleaned dried and stored

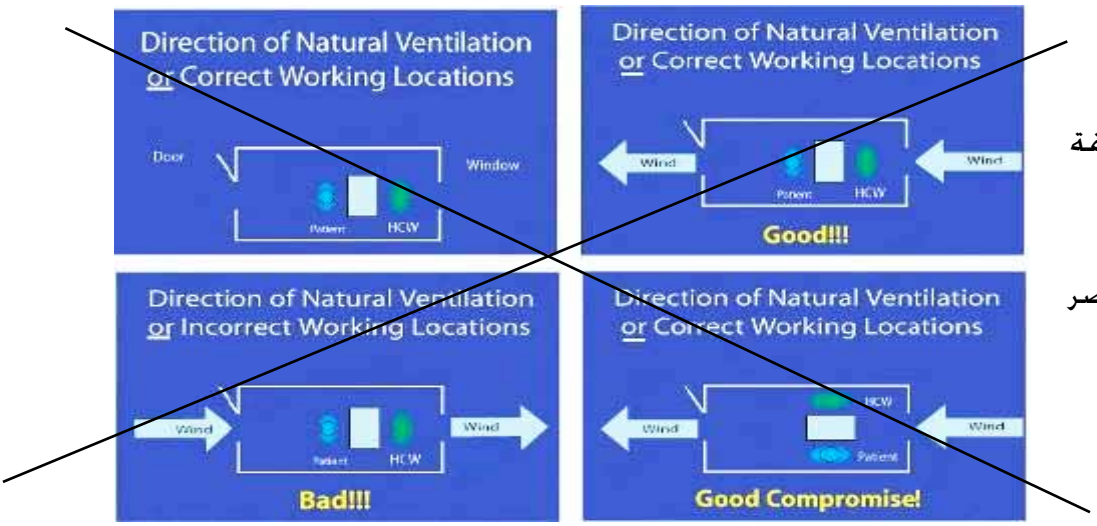
Management of TB in Emergency room and Ambulatory units

Administrative control

- Triaging should be achieved
- Suspect and confirmed patients should be triaged away from other patients of respiratory disease
- Minimize the time spent by the patient in the emergency room, by specifying an examination room.
- Airborne isolation room as waiting area should be signed in the ER with door closed away from others

Environmental control

- The TB Clinic and airborne isolation room should be well ventilated the windows should be kept opened all the time, preferred opposing each other, air change per hour 6-12 ACH.
- The direction of air should not pass away from ER-airborne isolation waiting areas to immuno-compromised patient areas, or crowded areas



الكلام جودتها ضعيفة
وفي كلام مش باين
وكذلك المساحات
الصغيرة باللون الاخضر
والازرق الفاتح

fig 20 showing correct replacement of HCWs and patient

- Natural ventilation support may be used as exhaust fans with ceiling fans and air cleaning technologies as HEPA filters placed just near the physician and UVGI can be used to increase the number of air change per hour
- After TB patient exit from the room, adequate time should be allowed to change air of the room before the entrance of another patient or HCW.

Respiratory control

- TB patient should be supplied by surgical mask during transportation, or when others are present.
- HCWs should put on N95or FFP2 respirators when entering the isolation room

TB Infection Control in ward

TB patient should be isolated and consider grouping AII room in one part of the setting to, reduce the possibility of transmission of TB, and facilitate care of TB patient.

- Fast tracking of TB patient is the most important step in TB infection control
- Facilitate patient adherence to isolation area by incentives as television,
- Adhere patient to wear surgical mask when transported to another area of the setting or to another settings
- Environmental control should be achieved as AII (mentioned before)
- Respiratory control program should be well implemented in TB – AII rooms.

MDR-TB WARDS:

1- Location and design:

- the facility should be located away from other wards with separate passage for patient access to the toilets
- adequate ventilation to ensure >12 ACH, achieved by opening windows at all times during the day and night in all seasons , complementary ventilation (as exhaust fans.) may be used to achieve the adequate ACH and it should be ensured that these should be kept open all time
- the distance between 2 adjacent beds should be optimal (at least 2m)
- Visitors should be restricted to the greatest extent.

2- General hygiene :

- Hand washing facilities should be placed
- Running water, soap, and alcohol hand rub solution should be provided
- Frequent wet mopping of the ward should be provided
- Lavatory should be kept clean

3- *Patient education* should be conducted at admission and reinforced by staff , using surgical mask when transporting patient for any reason, as performing x-ray.

4- *Fast tracking of patient*.

Recommendations of IC practices in Radiology Areas

The general administrative, environmental and personal protective measures applicable to a general outpatient setting are also relevant to the radiology department.

In addition, radiology departments should attempt to routinely practice the following principles:-

- Provide patients who are coughing, or who are known to have TB or other infectious diseases with high potential of airborne transmission, with disposable surgical masks and tissues for covering their mouth while coughing.
- Provide priority to potentially infectious patients, to minimize their stay in the department.
- Schedule inpatient chest radiographs on TB suspects and other infectious patients for non busy times (for instance in the afternoon, or towards the end of the routine morning schedule).
- Ensure that the room where chest radiographs are taken is adequately ventilated; if multiple rooms are used for radiography, the room with the best ventilation should be assigned to potentially infectious patients.

These administrative procedures for safer radiology areas should be posted on the walls in all radiology suites.

Recommendations of IC practices for Dialysis :

Certain TB patients need chronic dialysis for treatment of end stage renal disease(ESRD), the incidence of TB disease and infection in patients with ESRD is higher than the general population, especially among diabetic patients.

ESRD patient should be annually screened for TB disease (at least one test)

- Dialysis should be performed in an isolation room (AIIR)
- Staff should put on N95 or FFP2 respirator
- Certain anti-tuberculosis medications are prescribed differently for hemodialysis patient

Recommendations of IC practices for Dentistry:

Dental patients and HCWs may be exposed to various microorganisms.

Transmission of infection may be through direct contact with blood, oral secretions, or indirectly with contaminated instruments, equipment or environmental surfaces or contact with air borne contaminants present in either droplet or aerosols of respiratory secretions

Dentists should follow infection control measures:

- TB patient should be treated at the end of the day to maximize the time available for removal of airborne contamination, all equipment used should be decontaminated as intermediate or high level disinfection .
- Minimum number of HCWs should be present in dental room
- The door should be closed, minimize traffic in and out the room and in the corridor.
- If splashes occur, keep for about 10 min to settle and start the environmental cleaning with the suitable disinfectant as sodium hypochlorite (1:5) diluted in water

Infection control important recommendation :

- Wash hands properly between patients.
- Use protective attire and barrier techniques, especially Chin length face shield or N95 OR FFP2 respirators should be worn

Infection Control During the Pretreatment Period

The process of infection control begins during the period of preparation for clinical treatment. Paying attention to infection control at this time has several payoffs. In addition to reducing the risk of transmission of infectious agents during patient care, thinking ahead will make the treatment session more efficient and will also make the post treatment infection control process easier and more effective.

- Remove unnecessary items from the dental procedure area. It should be arranged to facilitate a thorough cleaning following each patient.
- Preplan the materials needed during treatment. Set out all instruments, medications, impression materials, and other items that are needed for a procedure. Thinking ahead minimizes the need to search for additional items or to enter cabinets and drawers once gloves have become contaminated.
- Utilize disposable items whenever possible to saves time during cleanup and decontamination and solves the problem of proper reprocessing.
- Use prearranged tray set-ups for routine or frequently performed procedures.

Helps to eliminate the need to go into drawers and cabinets once you have started a procedure.

- Use individualized, sterilized bur blocks for each procedure helps to eliminate the contamination of other unneeded burs and to make clean-up easier.
- When a rubber dam will be used during a clinical procedure, it also should be included on the tray setup.
- While preparing the dental procedure area prior to beginning a clinical procedure, consider which items will become contaminated during treatment. Examples of such surfaces include countertops, light handles, X-ray unit heads, tray tables etc. Decide whether to use a barrier, e.g., plastic wrap, or aluminum foil, to prevent contamination of these surfaces and items or to disinfect them when the procedure is complete.
- Avoid touching unprotected switches, handles and other equipment once gloves have been contaminated. If objects are touched or handled, they should be carefully cleaned and disinfected at the end of the procedure.
- Review patient records before initiating treatment and place radiographs on the view box. Do not leave the record on the countertop or handle it after beginning treatment. Place the record in a drawer or out of the dental procedure area, so that it doesn't become contaminated. Entries into the record should be done before and after the procedure.
- Because bacteria may grow in or accumulate within the dental unit water lines (DUWL), the lines must be maintained according to the manufacturer's directions. Run hand pieces and air- water syringes for at least 3 minutes each morning to flush out any residual material. If no water check valves are present, the lines should be flushed after each patient use.
- Prepare personnel involved in patient care. An essential pretreatment procedure is the preparation of all personnel involved in patient care. This includes the utilization of personal protective equipment (gown, eyewear, mask and gloves) and hand hygiene.

Infection Control During the Post-Treatment Period

The infection control process continues after the patient has been dismissed. Although effective pretreatment planning will simplify your task, there are a number of things that should be done following patient care to further reduce the risk of transmission of infectious agent

1- Continue to wear personal protective equipment during clean-up. The instrument

used are sent to a central sterilization for re-treatment

2- All of the barriers placed before treatment, including light handle covers and countertop barriers, should be removed. These should be placed into a leak-proof waste bag inside a trash container.

3- Dispose of blood and suctioned fluids that have been accumulated in the collection bottles during treatment. Proper disposal of these fluids is essential. Identify a special purpose sink connected to a sanitary sewer that can be used solely for the disposal of blood, liquid wastes and suctioned fluids. After the blood and suctioned fluids are poured into the sink, use a 0.5% chlorine solution to disinfect the dental unit collection bottle. The bottle should be completely filled and the solution and kept in the bottle for 10 minutes before emptying and rinsing with fresh water. As an option, disposable suction collection systems are available.

4- Clean and disinfect all items not protected by barriers.

5- Waste that is contaminated with blood or saliva should be places in leak-proof bags.

6- Handle sharps items carefully.

7- Remove personal protective equipment. After instruments have been scrubbed and packaged for sterilization and after other clean-up tasks have been completed, personal protective equipment may be removed.

- The proper method of removing the respirator is to grasp it only by the cloth or elastic strings, not by the mask itself.
- Protective eyewear and face shields should be cleaned with soap and water and then disinfected or prepared for sterilization. Remember not to touch the eyewear with ungloved hands, since it is likely to have become contaminated with spatter of blood and saliva during patient care.
- After removing the gown, immediately place it in the soiled linen container. Gowns may be washed using the normal laundry cycle.
- Utility gloves should be washed with soap before removal.
- Finally, thoroughly wash your hands.

Use and Care of Sharp Instruments and Needles

Sharp items (e.g., needles, scalpel blades, wires) contaminated with patient blood and saliva should be considered as potentially infective and handled with care prevent injuries.

- Used needles should never be recapped or manipulated utilizing two hands. If needles have to be recapped, a one-handed “scoop” technique should be employed.

- Never bend, break, or cut needles before disposal.
- Used disposable syringes and needles, scalpel blades, and other sharp items should be placed in an appropriate puncture-resistant container located as close as possible to the area in which the items were used.

Special considerations

- **TB in children**
- **BCG**
- **Co infection TB\HIV**
- **TB in home settings**
- **MDR-TB house hold precaution**
- **The correction facilities**

TB in children:

Children are at risk of progression of primary TB more than adult

They are liable of developing TB meningitis and miliary TB so they deserve special consideration:

1- Screening children contact to TB case :
   - If the child prove to have TB, treatment should be started after recording the case at the NTP
   - If the child under age of 5 years prove not to have TB, they should receive ionized preventive therapy for at least 6 months
   - Screening is done by performing chest x- ray and tuberculin skin test

2- Children who are in close contact with MDR-TB patient should receive careful follow up for at least 2 years, if active disease develop initial treatment with MDR-TB regimen, no recommendation from WHO for chemoprophylaxis to MDR-TB contacts

3- Breast feeding infants , have a high risk of infection from their mothers with smear positive pulmonary TB and of developing TB, Infants should receive ionized for 6 months followed by BCG immunization. *Breast feeding may be continued during this period*.

4- Hospital care of children in the following cases:
   - TB meningitis and miliary TB, preferred the first 2 months
   - Respiratory distress
   - Spinal TB
   - Severe adverse effect

5- If the child is HIV – infected : it is recommended to treat with 6 months regimen as non HIV child. In HIV- infected child with confirmed TB disease initiation of anti-TB treatment is the priority, then start ART 2-8 weeks after starting anti-TB treatment

BCG VACCINATION

Is a part from the national childhood immunization program.

It has protective effect against TB meningitis and miliary TB

It does not prevent primary disease and does not prevent reactivation of latent TB, and so it has a limited impact.

Recommendation for BCG vaccination:

1- Single dose should be given to the infant as soon as possible after birth.
2- BCG vaccination **should not** be given to infants and children with AIDS , or infected with HIV, and known to have other immunodeficiency disease.
3- If the infant is exposed to smear positive TB patient shortly after birth, BCG vaccination should be delayed until completion of six months of isoniazide
4- Revaccination is not recommended

TB and HIV Co-infection control

- HIV infection is the highest risk factor of progression of latent TB to TB disease.
- TB patient should be counseled and tested for HIV
- All patients with TB and HIV should be evaluated to determine if antiretroviral therapy is indicated during the course of treatment for TB.
- All care providers or contact for patient with TB especially children under 5 years, HIV infected person should be investigated for TB infection either latent or active TB.
- HIV is a blood born disease and transmitted mainly through stick injury for health care workers, or infusions that are contaminated with HIV.
- Adherence to the standard precaution using:
  - PPE: gloves
  - Needle disposal system to limit sharp exposure by getting ride of the syringe and needle in safety box which is impermeable and tightly closed container.
  - Never recap the syringes.
  - Immediate treatment of the stick injury by washing thoroughly with running water and an antiseptic solution
- Training of HCWs in safe sharp practices.
- Screening of TB patients for HIV should be done especially MDR-TB patients.
- An incident reporting system should be in place.

TB Infection Control in Home settings

Patients who are suspected to have, or have, confirmed TB disease are frequently sent home after starting treatment, even though they may still be infectious. Patients with TB disease can be sent home even if they do **not** have three negative sputum smears, if the following criteria are met:

- A follow-up plan has been made with the local TB program;
- The patient is on standard TB treatment, and directly observed therapy (DOT) has been arranged;
- No infants or children less than 4 years of age or persons with immune-compromising conditions are present in the household; and
- The patient is willing to remain isolated at home except for health-care associated visits until the patient has negative sputum smear results.
- Patients who have suspected or confirmed TB disease are more likely had already transmitted TB infection to members of their household before their TB disease was diagnosed and treatment started. However, TB patients and members of their household should take steps to prevent further spread of TB infection after they return home.
- **Patients with TB disease should be:**
  - Educated and the household members regarding the importance of taking medications as prescribed.
  - instructed to cover their mouth and nose when coughing or sneezing;
  - Sleep alone and **not** in a room with other household members; and
  - **Refrain** from having visitors in the home until they are noninfectious.
  - Household members should be informed about infection control procedures to follow at home including hand hygiene, proper cleaning and disinfection of equipment and its safe storage .
  - For semi critical equipment as thermometer should be treated by bleach (chlorine 5%) at concentration 1:5 for 5 min., isopropyl alcohol 70% for 5 min**.**
- HCWs who visit TB patients in their homes should take the following precautions to protect themselves from exposure to *M. tuberculosis:*
  - Wear a respirator when visiting the home of a patient with infectious TB disease or when transporting a patient with infectious TB disease in a vehicle; and
  - Collect specimens in a well ventilated area, away from other household members.
  - in addition, HCWs whose responsibility include visiting infectious patients should participate in an annual testing program

Table10 : precautions for patient and health care worker in home settings

Steps that Patients Can Take to Prevent Further Transmission of TB infection at the Home	Precautions for Health-Care Workers to Take to Protect Themselves from Exposure to *M. tuberculosis*
• Cover their mouth and nose when coughing or sneezing • Sleep alone and **not** in a room with other household members • **Refrain** from having visitors in the home until they are noninfectious.	• Instruct patients to cover their mouth and nose with a tissue when coughing or sneezing • Wear a respirator when visiting the home of a patient with infectious TB disease or when transporting a patient with infectious TB disease in a vehicle • Collect specimens in a well-ventilated area, away from other household members

Household precaution for MDR-TB patient:

Since patients with MDR-TB usually sputum convert later than those with drug susceptible TB and remain infectious for longer period even if treatment is initiated

Precautions of household;

1- houses should be adequately ventilated particularly rooms in which the patient spend considerable time ,windows should be kept open

2- Patient and family members should be educated on collection of sputum and its disposal, dispose sputum in paper tissue and burn.

3- If smear positive MDR-TB patient is treated at home, MDR patient require more consultation to ensure treatment adherence considering prolonged treatment.

4- Family members with immunocompromized disease as renal and liver failure, diabetic patients should not provide care for MDR patient.

5- Children below 5 years of age should spend less time as far as possible in the same living space, and should be followed up regularly with TB screening

Recommendation of IC practices at the correctional facilities:

TB can be a problematic challenge in correctional facilities, fundamental activities should be achieved :

1- Screening for TB and Latent TB patients :

- By symptoms screening
- Chest x-ray
- Sputum examination
- Tuberculin skin testing

2- isolation of these patients, prevent transmission and start treatment .

- Designing an airborne isolation room
- Environmental Respiratory control measures should be achieved

3- Monitoring and evaluation of screening and containment efforts

4- Collaboration between correctional facilities and NTP

Patient transportation:

- The patient should be transported in an ambulance whenever possible
- The driver should be physically separated , the direction of air passes from the front to the back to an exhaust fan to the outside of the vehicle, if air condition is used it should be provided by HEPA filter, if not, open the windows to supply outdoor air as possible .
- The driver and other persons joining should wear N95or: FFP2 mask, the patient should wear surgical masks.

Annex 1

TB Infection Control Committee

Aiming to increase the quality of health care services, infection control committee should be constructed to:

- Establish the plan, guideline drafts
- Establish the policies and procedures
- Identifying problems and obstacles in implementing infection control program to be resolved
- Monitoring and evaluation to identify the defects in implementation and guideline
- Surveillance for ongoing transmission of TB infection among health care workers
- Regular meeting should be held every quarter to discuss, revaluate the guidelines, policies and procedures.

NTP Infection Control Committee

Dr. Wagdy Amin	Manager of NTP and Chest diseases department MOH
Dr. Magdi Fawzi	Research coordinator NTP
Dr. Faten Shokri	Lab . coordinator NTP
Dr. Amal Salah	IPC coordinator NTP

ICP Infection Control Program

Dr. Amr Kandeel	First Under Secretary for Prevention Affairs & Endemic Disease MOHP
Dr. Mohamed Bayoumy	IPC -MOHP
Dr. Atef Salem	IPC -MOHP

Annex 2

Surveillance for TB disease among HCWs

- Routine reporting of TB disease among health care workers by:

  Symptoms sheet for HCWs already present at the facility.

  Chest x-ray ,

  Tuberculin test (or Quantiferon if available) should be done for new employees

- Consultation should be done and return to work is the consultation responsibilities
- Regular check should be held for detection of any impairment of immune system as diabetes , renal impairment or liver disease

This information should be compiled at the facility level on routine annual basis.

Tuberculin skin testing (Mantoux tuberculin test) :

Is the standard method of determining whether a person is infected with *Mycobacterium tuberculosis*, is done by injecting 0.1 ml of PPD intradermal into the inner surface of the forearm it produce a pale elevation of the skin (Wheal) 6-10 mm in diameter

It is read after 48-72 hours showing an induration (do not measure the erythema)

Interpretation: it depends on :

1. Measurement in millimeters of the induration

2. Persons risk of being infected with TB and of progression to disease if infected

Induration of 5mm or more is considered +ve in	Induration of 10mm or more is considered +ve in	Induration of 15mm or more is considered +ve in
- HIV infected person - recent contact with TB patient - immunosuppressed persons as taking >15mg/day prednisone for 1 month or longer, TNF-α antagonist - patient with organ transplant	- Recent immigrant (<5years) from high prevalence country - injection drug user - Resident and employee of high risk settings - Mycobacterium laboratory personnel - children <4 years - infants, children and adolescent exposed to adult in high risk category	- any person including persons with no known risk factors for TB

False positive reaction :

a) infection with non-tuberculosis mycobacterium

b) Previous BCG vaccination

c) Incorrect method of TST

d) Incorrect interpretation

e) Incorrect bottle of antigen used

False negative reaction :

a) person with weakened immune system

b) Recent TB infection within 8-10 weeks of exposure

c) Very old TB infection

d) Very young age less than 6 months

e) Recent live – virus vaccination

f) over whelming TB disease

g) Some viral illness as measles and chicken box

h) incorrect method of TST administration

i) Incorrect interpretation

TST is not contraindicated for any person including infants, children, pregnant women, persons with HIV, or who have been vaccinated with BCG

- It is better to do Two Step Testing initially for HCWs or nursing home residents if the first testing had gave negative result
- TST may be given to live – virus vaccinated person either on the same day of vaccination or 4-6 weeks later (at least 1 month in case of small box vaccination)

Annex3

Indications for hand hygiene

- At the beginning of the working day for 1 minute with an antiseptic solution, if available; otherwise, plain non-antimicrobial soap is sufficient.
- Before donning gloves.
- Between each patient.
- After glove removal.
- After barehanded contact with contaminated equipment or surfaces and before leaving treatment areas.
- Before and after eating.
- After using the toilet.
- At the end of the day

Steps of hand-washing

1- Remove jewelry

2- Wet hands with running water and apply soap. Make sure to rub all parts of your hands for 15 seconds.

3- Rinse and dry hands completely before donning gloves

4- The taps should be turned off with elbows or by using a clean paper towel if elbow taps are not provided. 2

5- Before surgical procedures, scrub hands and arms to the elbows with an antiseptic soap for five minutes. Rinse and dry with sterile towel.

Hand-washing tips

- Use small bars of soap or cut large ones into small pieces.
- Keep bar soap on a rack to allow drainage.
- Keep nails short.
- Remove all jewelry. An exception can be made for the wedding ring.
- Always use running water – avoid dipping or washing hands in a basin of standing water.
- Always dry hands completely with a clean or disposable paper towel.

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