Strict Isolation

19

Abstract

Strict isolation: suspected highly infectious and transmissible virulent and pathogenic microbes, highly resistant bacterial strains and agents that are not accepted in any form of distribution in the society or in the environment. Examples are completely resistant *Mycobacterium tuberculosis*, viral haemorrhagic fevers like Ebola and Lassa, pandemic severe influenza and coronavirus like SARS, MERS, etc. In most countries, strict isolation is a rarely used isolation regime but should be a part of the national preparedness plan. For instance, in Norway, strict isolation has not been used for the last 50–60 years, except for one case of imported Ebola infection in 2014. Patients in need of strict isolation should be placed in a separate isolation ward or building.

Infection spread by contact, droplet and airborne infection, aerosols, re-aerosols, airborne microbe-carrying particles, skin cells, dust, droplets and droplet nuclei. At the same time, it is always contact transmission (contaminated environment, equipment, textiles and waste).

The source of infection is usually a patient but may also be a symptomless carrier or a zoonotic disease.

Keywords

Highly infectious · Dangerous microbes · Airborne pathogens · Droplet nuclei Air and contact transmission · Strict isolation · Personal protective equipment PPE · Healthcare personnel · control

19.1 Purpose

To prevent transmission from an infectious patient to other patients, personnel, visitors and the environment and to protect patients with impaired immune defence against infection [1–8].

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19.2 Comprise

- All patients having contagious disease that can easily be transferred directly or indirectly via contact, blood and body fluids, air/droplets or via equipment, textiles and surfaces.
- All patients with significant reduced infection defence or otherwise infection vulnerable and who should be protected against infection.

19.3 Responsibility

Hospital management should ensure necessary capacity and type of isolating units: contact- and air-droplet isolates and protective isolates. Updated isolation routines, adequate protective equipment—including PPE—routines for disinfection of rooms and surfaces and disinfectants and hand hygiene facilities should be available.

Department management should implement isolation procedures, train the use of PPE, control the use of routines and provide sufficient stock and capacity of PPE and means for disinfection and hand hygiene.

The staff should follow current guidelines for treatment of patients with infections and for patients that should be extra protected against infections.

19.4 Practical Measures

19.4.1 Strict Isolation: Red Sign on the Entrance [9]

The isolation unit is usually located in a separate isolation ward or building and has defined as negative air pressure systems (in Pascal), separate ventilation with disinfection of air extraction, a properly interlock function and also direct access from the outside. The waste water is decontaminated (autoclave). The patient room has sluice systems and bathroom with through-put decontaminator or autoclave with direct entrance from the patient room.

19.4.2 Specialized and Trained Personnel

Personnel involved in treating high-risk infections should be specialized in isolation work and be healthy, not immunosuppressed, and if possible should be vaccinated, if vaccine is available. The staff should be bound to the ward/unit while isolation treatment takes place. Fewest possible should participate in the isolation work. The staff should come and go directly to the high-risk unit and should not stay, work or visit other wards during the isolation period.

19.4.3 Surveillance and Control

The infection ward should have restricted admission with registering (name, address, date, time, etc.) and follow-up of all staff and visitors that attended the department.

19.4.4 Actual Infections or Carrier State [1, 7, 9–20]

- Pulmonary tuberculosis with total resistant *Mycobacterium tuberculosis*, lung-cavern and expectoration.
- Diphtheria, plague and anthrax.
- Viral haemorrhagic fevers: Ebola, Lassa, Sabia, Junin, Lujo, Crimean-Congo (CCHF), etc. [9]
- Dangerous coronaviruses like systemic acute respiratory syndrome (SARS) and Middle East respiratory syndrome coronavirus (MERS-CoV).
- Other high-risk viruses: Nipah virus, bird viruses (avian influenza A) (H5N1, H7N9 etc.), rabies and other high-risk agents.
- Optionally by other infectious and serious diseases which can infect both via contact and air/droplet.
- Uncontrollable outbreaks of unknown infectious agents, with severe course and relatively high mortality. These patients should always be isolated in defined airborne infection isolation units with satisfactory negative pressure (−15 to −25 Pa) in relation to adjoining rooms, wards and outdoor air pressure.

19.5 Background Information

See Chap. 21.

19.6 Strict Isolation Unit

Isolation units for airborne infections should be safe enough for high-risk cases, if used properly [1, 9, 16–34].

There should be no offices, laboratories, other patient wards or other regular human activities under, over or around this isolation unit. The unit should be located in a separate ward, preferably in a separate building with direct access via an external sluice and internal access through a negative air pressure sluice with sufficient areal for donning and doffing and for a safe treatment of infectious equipment and waste.

- Each isolate should be 35–40 m^2, including sluice (6 m^2), decontamination room/bathroom (5–6 m^2) and patient room (20–25 m^2). There should be a minimum of 2-m free zone around the patient's bed on both long sides and at the foot end.
- There must be *direct access* from the patient room to the decontamination room/bathroom.
- Interlocked doors must be included in the sluice system. Opening of the doors should be in direction from negative pressure to the positive pressure room to avoid air leaks. If the negative pressure increases in the room, the door will close even tighter.
- No through-put cabinet from the disinfection room/bathroom, because it can create imbalances in the air pressure.

- *Through-put autoclave/decontaminator* from disinfection room to the sluice may be recommended if secured and controlled against air leakage.
- *Graduated negative air pressure* is quality ensured by measurements, pressure manometer and control of ventilation.
- *Exhaust from the isolation unit* must be disinfected in a satisfactory manner so that it does not expose personnel, patients or passers-by to infection. Exhaust is usually sent out from the disinfection room, via a separate disinfection unit where the used air is treated with UV-irradiated hepafilters, and sent out over the roof (see below).
- *Waste water, sewage and other waste* should be disinfected/autoclaved before it is discharged outside the isolation area. If the isolate is not a unit for collecting and treating infectious waste/liquid, the faeces, urine and other body fluids are treated locally with 5% chloramine in 1 h before being discharged to the public sewage system.

19.6.1 Negative Air Pressure and No Air Contamination [1, 9, 16–34]

There should be written guidelines for air pressure and air flow. Negative pressure should be defined in relation to adjacent rooms and to outside pressure. Pressure conditions are checked outside of the patient unit, *before* entering the unit. There should be an increasing negative pressure from the sluice through the patient room to the disinfection room. The following negative pressure in Pascal is recommended in the unit:

o	Sluice:	−6 to −10 Pa
o	Patient:	−10 to −20 Pa
o	Bathroom/disinfection:	−25 to −45 Pa

The negative air pressure must withstand fluctuations in the pressure outside the building, for example, during high winds with increased pressure against the building. It should not be related to pressure fluctuations within buildings. The unit must be tight to prevent air leakage and pressure variations.

19.6.2 Ventilation

- *No air leaks*. All ventilation ducts must be completely sealed without any air leaks (e.g., all-welded steel pipe) and with a separate (over roof) air input and outlet for each isolation unit. Disinfection systems for air extraction/exhaust should be placed as close as possible to each isolation unit so that contaminated air does not go far in the piping on the way out. Exhaust air must be sterile after the disinfection process. Externally placed pipes for air inlet and outlets from isolates must be protected from strong winds that can create unfavourable pressure conditions. The air inlet/outlet to other parts of the hospital must also be protected against contamination from the isolates. Therefore, separate isolate buildings are the best solutions.

- *Air change*. Minimum of six changes of fresh air per hour in the patient room. This involves the replacement of all air in approximately 70 min. Avoid short circuit of the air currents.
- *Clean inlet air*—HEPA-filtered and backlash secured—is introduced from the ceiling or top of the wall of the patient room in such a way that the least possible turbulence occurs during normal use.
- *Exhaust air is contaminated* and should be disinfected and HEPA-filtered closest possible to the isolation unit. All air from the isolation unit goes out via the separate exhaust system; from the patient's room through grates on lower end of the door to the disinfection room. The exhaust air is disinfected close to—or in the isolate to avoid contaminated air in the piping. Exhaust air is never drawn directly out from the patient room or from the sluice because of risk of unfavourable air currents and increased infection burden on personnel. Exhaust air must be sterile after treatment and sent out via pipe over roof.
- *Gassing of ventilation pipes* with disinfecting gases (formaldehyde, chlorine dioxide, hydrogen peroxide, etc.) must be implemented in a regular manner. Assuming the ventilation duct is completely closed and separately for each unit, various types of gas could be used. If leakages are suspected, it may be difficult to use formaldehyde gas (allergy) and chlorine dioxide gas if other part of the building is to be used. The type of gas used must be chosen according to documented effect of the infectious agent, for instance, Ebola infection. Chlorine gas and hydrogen peroxide dry gas are among the safest gases used today. There is currently no gas which disinfects tubercle bacilli.
- *Continuous electricity supply* must be ensured in the isolation unit and the ventilation and negative pressure system.

19.6.3 Robust Fixtures, Walls and Floors

All fixtures and equipment must be disinfected with strong disinfectants, including disinfecting gases, and must be cleaned easily and satisfactorily. Note! Disinfectant gas can affect instruments and equipment. There should not be wood, tile or other building materials that are easily chipped or cracked, with storage niches for infectious agents.

There should be handwashing and suspension of automatic dispensers of disinfectants and paper towels in the sluice, patient room and disinfection room, to avoid unnecessary contamination of doorknobs, etc.

19.6.4 Water Drains and Sewers

Thermal disinfection/autoclaving of waste water from the unit should be done the closest possible to the unit to prevent other wards/departments be charged with infectious agents. The container, tank and piping must be absolutely tight and robust for heat/cold/corrosive agents and for ground movements. The drainage system must be shutdown, if needed. Air systems connected to the drain/sewer/water must be connected to isolation unit's exhaust system for full inactivation of infectious materials and must be completely sealed.

In isolation units with collection of infectious waste water in tank for further disinfection/autoclaving, it is particularly important to ensure safe and risk-free isolation conditions. This means that infected air, liquid and waste should not be spread to nearby areas, even under accidents in the decontamination process. All supply pipes to collection tanks must be sealed, controllable and withstand disinfectants. The sluicing function to such special areas for collecting and decontamination must be ensured in accordance with regulations for the airborne infection isolation units. In case of technical accidents in the collection and treatment rooms, the air should be disinfected with gases before technical personnel enters.

Technical staff, handling medical equipment, including collection tanks and autoclaves, shall be specially trained in infection control and must be able to use a sluice function with the use of PPE, when entering these disinfection areas.

19.6.5 Sluices In and Out

The sluices should be roomy with plenty of space for larger equipment, handwashing/hand disinfectant, through-put disinfection machine/autoclave, etc.

There should be a *separate out sluice* for doffing (undressing), bags for contaminated waste/equipment and opportunities to disinfect/autoclave used PPE—or parts of it—and other equipment. Room for a separate shower in the out sluice system should be considered and a room for disinfection of equipment to be reused (e.g. goggles, shoes, etc. that can be disinfected in chloramine 5% in 1 h or autoclaved).

The sluice system should be adapted for separate gas disinfection via sealed and tight pipes and interlocked system that can be implemented systematically daily or as needed, without affecting the patient in the isolation room.

Inter-locking. One of the doors in the sluice/anteroom must always be kept closed. Preferably use controlled closures for all doors.

19.6.6 Quarantine Unit and Cohort for More Patients [1, 9, 16–22]

- A *quarantine unit* should include some large patient rooms where it is a place for intensive treatment, acute surgery, dialysis and other invasive treatments, X-ray, microscopy of infectious materials, some important biochemical analyses, etc.
- *Cohort treatment* is important during larger outbreaks, i.e. two patients or more in one isolate room if they have the same infection and where reinfection does not occur.
- *Service unit associated with quarantine unit*. A separate *clean* service unit should be accessed via a separate sluice with interlocking doors for staff supervising the quarantine unit: the ward office, area 16 m^2, toilet/shower 5 m^2, storeroom

6–10 m^2, storage for large equipment 15–20 m^2, textile room 6–10 m^2, waste disposal room 10–12 m^2, etc.

19.6.7 In and Out Sluicing of Waste, Equipment and People [1, 9, 16–22]

- *Waste, reusable equipment,* etc. *from the patient or disinfection room* should be autoclaved in the through-put autoclave (or disinfection machine) from the disinfection room or patient room to a clean sluice where it can be taken out and treated as noninfectious. All equipment from patient unit must be autoclaved or disinfected in an appropriate manner. Equipment can be decontaminated at high temperature (>90° C) in an instrument washing/decontamination machine or submerged in a bath of chloramine 5% 1 h (or peracetic acid or household bleach 10%), depending on the agent in question. s.
- *In-sluicing and donning (dressing)* is done in a clean sluice before entering the unit, with clean, new clothes and clean, new PPE every time. Reuse of disposal PPE is not recommended.
- *Out sluicing* needs plenty of space for washbasin and suitable hand disinfectant, for doffing (undressing) and for the use of at least three waste bags (disposal, textiles and reusable equipment). PPE must be removed carefully, following guidelines, and placed in a waste bag which is then placed directly in through-put autoclave. Reusable equipment (goggles, shoes, etc.) that can be decontaminated/autoclaved are placed in separate containers for reuse. Then shower with, for instance, chlorhexidine (Hibiscrub) disinfectant in disposable packages, optionally soap in disposable packages. The shower head is set low and with weak force to avoid aerosols against the face. After the shower is finished, the entire cabinet interior, including the floor, is treated with hot water (>75 °C). Self-disinfecting shower unit (after use) is advantageous (gas or disinfectant liquid). Used towels are put in the textile bag. New, clean clothes are taken on in a clean wardrobe. Only the hospital's clothing and shoes are used.

19.6.8 Donning (Dressing) PPE Before Entering the Isolation Unit [1, 9, 16–20]

- *Gown*—disposable, with tight-fitting cuffs and discarded after each use. It should have long sleeves, be tight around the neck, long and liquid tight. The opening should be on the back; it should be tied back, never on front. Option: disposable coveralls with hood or full and tight costume.
- *Cap/hood—surgical*—covering all the hair and ears. Keeps the hair in place and covers the ears. Respiratory protection is set on the outside of the cap.
- *Respiratory mask*, *P3-level*, check leakage with leak test (to be learned). In special cases, a turbo equipment (PAPR, powered air-purifying respirators) or fresh

air/compressed air system is used. Remember that battery and reusable parts should be disinfected between each use.
- "Phantom hood" (surgical large disposable hood) is placed gently over the head and covers the neck and cheeks.
- *Face protection.* Tight-fitting goggles if high risk. Face shield with danger of splatter of infectious material.
- *Gloves* with long "cuff", double gloves to make work in isolation easier. Latex gloves are denser than vinyl gloves.
- *Shoe covers/room-bound shoes* that may be autoclaved after use or boots that are submerged in chloramine bath or other disinfectant after each use.
- *Special leg covering* up to the knee at high risk, serious infection.

19.6.9 Doffing (Undressing) of PPE when Leaving the Isolate for out Sluicing: [1, 9, 16–20]

Follow the hospital's procedure that must be learned, trained and supervised.

Check if waste bags and equipment for undressing are available in the sluice out. All work in the sluice out, like assistance with undressing, takes place only with full dressed PPE. As a rule, there are two people when undressing; a person who can advise and provide assistance, double pack infection bags and take care of equipment to be autoclaved. The assistant uses full, clean PPE. Gloves and hand disinfectant must be used before any handling of the equipment. All undressing must occur very carefully and quiet to minimal re-aerosols of microbes from the PPE.

Remove the individual infection equipment in such a way that you do not contaminate yourself or the environment. Carried out in this order:

1. Hand disinfection while the gloves are on.
2. Room-bound shoes/boots are tilted off and put foot straight into clean shoes. Reusable shoes or boots are put in a separate container for autoclaving or disinfection. Shoe covers—if used—are carefully removed one after another and placed gently in the waste bag. Rinse the shoes on chloramine inserted diaper lying on the floor.
3. Hand disinfection while the gloves are on.
4. Gloves—double gloves are removed simultaneously—learn the method. Grab the left glove at the wrist (not higher up) and gently turn inside out when doffing. The inside of this glove is usually clean and can be used as a "cloth" placed on the right hand to grab through to remove (roll off) the other glove. Learn the technique. For left-handed do the opposite. Place gently in the waste bag.
5. Hand disinfection.
6. Put on clean gloves for further undressing—not over the cuff.
7. Gown—learn the method, open closure on the back (neck first). Pull the cuffs over gloves and roll the gown gently along from the side and from above downwards without touching the outer side. Place gently in the waste bag.

8. Hand disinfection while the gloves are on.
9. Goggles: take back and bend the body forwards to avoid contact with the skin, hair and cloths while taking off the goggles carefully. Place in container for autoclaving of reuse.
10. Face shield/visor—loosen from behind as mask and take off bending forward.
11. Gloves—learn the method to take off without recontamination (see above). Placed gently in the waste bag.
12. Hand disinfection.
13. "Phantom hood"; take back on the lower part of the hood that has been covered by the gown, and with both hands tear it up along the seam behind while bending the body forwards to avoid contact with the skin, hair and cloths; take off the hood slowly, and put it in the waste bag.
14. Hand disinfection.
15. Respiratory protection mask—grasp the elastic back on the head; bend the body forwards to avoid contact with the skin, hair and cloths; take off carefully, and place the mask in the waste bag.
16. Hand disinfection.
17. The surgical cap/hood—which was under masks and phantom hood; take off from behind, bend the body forwards to avoid contact with the skin, hair and cloths and place the cap in the waste bag.
18. Hand disinfection.
19. Showers and dressing of new clothes as described above.

19.6.10 Textiles

Autoclaved or heat disinfected (85–90 °C for 10 min) or submerged in disinfectants (chloramine 5%, household bleach 10% or peracetic acid) before normal processing.

Option: All textiles are treated as infected and put in a container for used textiles. Contaminated/wet fabrics are packed in plastic before placing in waterproof textile bag. The outside of the bag is decontaminated and washed with 5% chloramine before double packed with a new clean bag in the sluice. The outside will then be clean during transport for further treatment. The type of the infectious agent and local possibility determine further treatment of textiles (heat washing, chemicals, autoclaving, burning).

19.6.11 Reusable Equipment

Excess equipment should be removed before the patient arrives. Used equipment should be autoclaved in a through-put autoclave before the normal treatment.

Option: Disinfected in the isolation unit's disinfection room. Equipment that can withstand heat is heat disinfected in decontaminator or instrument washing machine. Heat-sensitive components like thermometers are disinfected in 5% chloramine or other disinfectants for 1 h.

19.6.12 Crockery/Cutlery

Used equipment should be autoclaved in a through-put autoclave before normal treatment.

Option: Decontaminated in the isolation unit's disinfection room (85–90 °C) or double packed and brought to the decontamination room in the ward for decontamination—and then processed as usual. Disposable equipment is treated as infectious waste.

19.6.13 Waste

Infectious waste is autoclaved in through-put autoclave, before processing as ordinary waste.

Option: All waste is double packed and treated as special infectious waste. The outside of the bag is decontaminated and washed with 5% chloramine before double packed with a new clean bag in the sluice. The outside will then be clean during transport for further transport and treatment. Infectious waste is brought directly to incineration without intermediate storage.

19.6.14 Syringes/Needles

Follow general guidelines. The boxes may be autoclaved in through-put autoclave, before processing as ordinary waste.

Option: Boxes are double packed and treated as special infectious waste. The box must not be filled more than about ¾ full. See labelling for filling level. The outside of the bag is decontaminated and washed with 5% chloramine before double packed with a new clean bag in the sluice. The outside will then be clean during transport for further special transport and destruction. Infectious waste is brought directly to incineration without intermediate storage.

19.6.15 Examination/Treatment/Death

In most cases it is not recommended to bring the patient out of isolation during the period of active infection. Special solutions should be made for these. If transport out of the isolate is necessary, everything must be planned carefully in advance. Death bodies are wrapped in body bag, double packed in the sluice and sent directly to the pathologist or burial. Remember information in advance!

19.6.16 Laboratory Tests

Follow general guidelines and contact serving microbiological laboratory or the National Institute of Public Health before transport of sampled biological materials form the patient! Sampling/preparation for transfer of infectious sample material should be provided in the patient room or its disinfection room. Sample vials and outside of the package must be clean before transport. Blood samples from patients with blood-carrying infection are packaged in special cases (sleeves) before transport. The outer package is put on in the sluice. NB! A good cleaning and disinfection of the workplace!

Note on the outer bag suspected high-risk agent with red ink! Special transportation!

Contact receiver in advance, and ask how to bring the samples to the laboratory.

SEND NO SAMPLES AS POST IN PNEUMATIC TUBE!

19.6.17 Transport of the Patient

Only essential transport is allowed, depending on infectious agents. Patient, cloth and stretcher/bed should be clean during transport. Bandages must be clean, and drains, etc. must be covered and free of leaks. Staff transporting and receiving the patient must be informed about the infection *in advance* and guided on individual infection prevention and the use of PPE. Patients with respiratory infection should wear surgical mask or respiratory mask (P1–P3 level) outside the isolate.

The transport should not go through wards or crowded areas and avoid the use of a lift. Internal transport in hospitals is not recommended in certain highly infectious and severe illnesses.

19.6.18 Books and Newspapers

In agreement with the patient library, the patient can borrow books that can be discarded. The books are kept in isolation. All books are treated as infectious waste by termination of the isolation.

19.6.19 Visitor

Restricted admittance and use the same guidelines and PPE (donning and doffing) as for the staff. Handwashing is required when the sluice is left. Limit visits to a minimum, especially with highly infectious diseases such as SARS.

19.6.20 Daily Cleaning

The cleaning and disinfection is performed by trained personnel with required attire and use of PPE. Regular detergent, water and clean equipment are used if no other routine is ordered. Bucket and squeegee are disinfected in the decontaminator of the isolation unit; shaft is disinfected chemically in 5% chloramine (or household bleach) in 1 h and kept in the unit during the entire treatment. Use only disposable mops and cloths placed in yellow plastic bag in yellow infectious waste bag and autoclaved in the isolation unit. Discard as infectious waste after appointment.

Option if not autoclave/decontaminator in the isolation unit: Infectious waste bag is treated exterior with 5% chloramine and double packed in new yellow thick plastic bag in the sluice. Special infectious waste is brought directly for burning/autoclaving. In case of spills, the nursing staff should immediately remove the spill and disinfect the area with 5% chloramine 1 h (covered by plastic) before cleaning.

19.6.21 Termination of Isolation: Disinfection

Before regular disinfection of the isolation unit after terminated isolation, it is recommended to treat the unit with hydrogen peroxide dry gas, three cycles, using a spore control. Only trained personnel are participating in the work with disinfection, and they use mandatory infection control equipment. The nurse, in cooperation with infection control personnel, is responsible for informing the staff about what should be disinfected and how.

Bedding, curtains, drapes, etc. should be autoclaved, if possible, before sending it to laundry or to incineration. Floors, walls, ceilings, all horizontal surfaces, ceiling suspension, lighting in ceilings, etc., handles, dial string (changed), levers, buttons, switches, bed, waterproof mattresses, bedside tables and other fixtures and equipment (TV, telephone, computer, etc.) are disinfected with 5% chloramine (or household bleach 10%) for 1 h.

Textiles, reusable equipment and waste: follow described above recommendations. Unused disposal equipment that has been inside the isolation unit is disposed of as infectious waste.

After manual disinfection, all rooms and ventilation systems are gassed once more. This is done in collaboration between the ward, housekeeping/technical and infection control personnel. To treat with gas disinfection before and after manual disinfection is recommended to reduce the infectious airborne agent (aerosols and re-aerosols) in the unit.

After the recommended effect period of the disinfectant, the rooms are cleaned with ordinary detergent, water and clean equipment.

There are many discussions concerning the degree of airborne transmissions and how to protect personnel, especially against dangerous infections; see the background information [1, 9, 16–20, 27–50] (Fig. 19.1).

Isolation regimens should not prevent treatment but be included in the diagnosis and treatment.

NB! Good hand hygiene is important! It prevents the spread of infection!

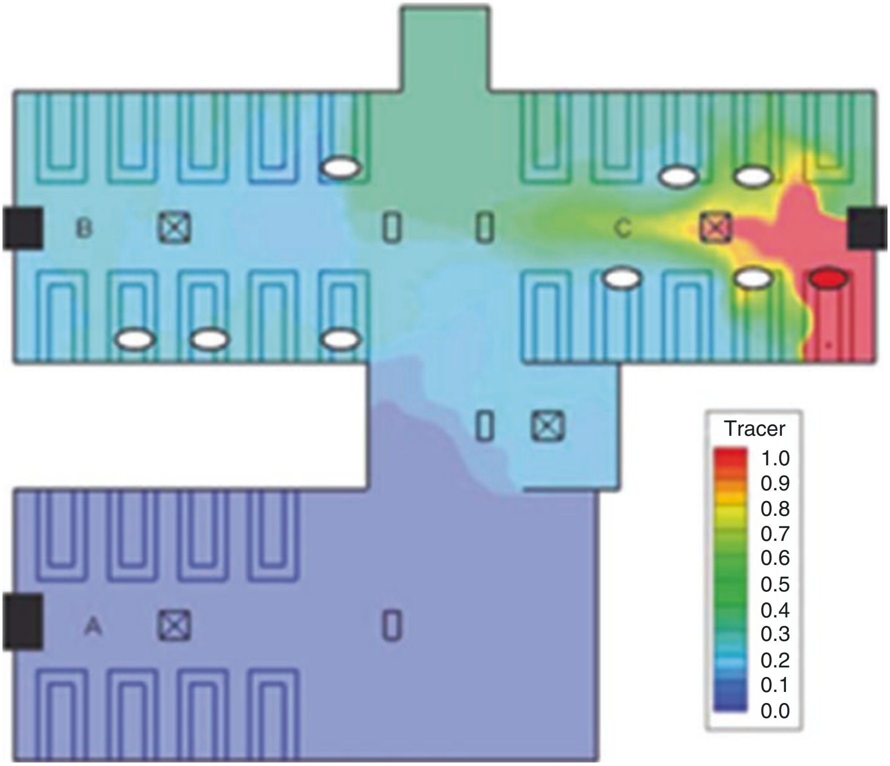

Fig. 19.1 Example: possible aerosol transmission in an outbreak with influenza virus. Airborne transmission with airborne indicator in an intensive unit. Distribution in rooms of generated, normal concentrations of hypothetical, virus-borne, marked aerosols—like droplet nuclei—in a level of 1.1 meter over the floor, traced with an instrument. A defined airflow was used. Three HEPA filters in the unit were estimated to be 100% effective concerning filtration of droplet nuclei and are shown as black boxes on the figure. Four inlet channels are shown with rectangular X and four outlets with small rectangular filled boxes. Infected patients are defined by white ovals and index patient with a red oval. *Source*: Wong BCK, Lee N, Li Y et al. Possible Role of Aerosol Transmission in a Hospital Outbreak of Influenza. *Clin Infect Dis* 2010; 51:1176–1183 [45]

References

1. Andersen BM. Handbook of hygiene and infection control in hospitals. Part 1 Microbiology and Infection Control. Bergen: Fagbokforlaget; 2014.
2. Infectious Disease Act. Law 5 August 1994 no. 55 of protection against infectious diseases.
3. Regulations in infection control in health facilities - hospital infections, established by the Health and Social Affairs July 5, 1996 and July 17, 2005 pursuant to § 4–7 and § 7–11 of the Act on Aug. 5, 1994 no. 55 of protection against infectious diseases.
4. Action plan for infection control in Norwegian hospitals, Health Directorate's Guidance series 2–92. Directorate of Health.
5. Use of isolation to prevent spread of infection in hospitals. Health Directorate's Guidance series: Directorate of Health, Oslo; 1988: 2–88.
6. Health Personnel Act. Department of Health and Social Affairs. Act 1999-07-02 No. 64: 2001.

7. European Parliament and Council Directive 2000/54/EC of 18 September 2000 on the protection of workers from the risks related to exposure to biological agents at work.
8. CDC Draft Guideline for Isolation Precautions in Hospital. Federal Register 59, 55552–55570, 1994 and 2004.
9. Andersen BM. Isolation. In: Handbook of hygiene and infection control in hospitals. Oslo: Ullevål University Hospital; 2008. p. 216–48.
10. CDC Draft Guideline for Isolation Precautions in Hospital. Fed Regist. 1994;59:55552–70. and 2004
11. Garner JS. Guideline for isolation precautions in hospitals. Infect Control Hosp Epidemiol. 1996;17:53–80.
12. Edmond M. Isolation. Infect Control Hosp Epidemiol. 1997;18:58–64.
13. CDC Draft Guideline for Preventing the transmission of *Mycobacterium tuberculosis* in health care facilities. Fed Regist. 1994;59:54242–303. and 2004; 69: 33034
14. Barlow G, Sachdev N, Nathwani D. The use of adult isolation facilities in a UK infectious disease unit. J Hosp Infect. 2002;50:127–32.
15. Siegel JD, Rhinehart E, Jackson M et al. 2007 Guideline for Isolation Precautions: preventing transmission of infectious agents in healthcare settings. CDC. 2007.
16. Andersen BM, Hochlin K, Lereim I. Isolation of dangerous infections. In: Handbook of hygiene and infection control in hospitals. Oslo: Ullevål University Hospital; 2008. p. 563–6.
17. Andersen BM. Scenario pandemic influenza and pandemic avian influenza. In: Handbook of hygiene and infection control in hospitals. Part 1 microbiology and infection control. Bergen: Fagbokforlaget; 2014. p. 310–8.
18. Andersen BM. Avian influenza with pandemic potential. In: Handbook of hygiene and infection control in hospitals. Part 1 microbiology and infection control, vol. 2014. Bergen: Fagbokforlaget. p. 300–9.
19. Andersen BM. SARS and MERS - dangerous coronavirus. In: Handbook of hygiene and infection control in hospitals. Part 1 microbiology and infection control. Bergen: Fagbokforlaget; 2014. p. 319–46.
20. Andersen BM. Ebola-, Lassa-, and other hemorrhagic viruses. In: Handbook of hygiene and infection control in hospitals. Part 1 microbiology and infection control. Bergen: Fagbokforlaget; 2014. p. 291–9.
21. Marier RL. The design of isolation rooms. Infect Control Hosp Epidemiol. 1996;17:3–4.
22. Walker JT, Hoffman P, Bennett AM, Vos MC, Thomas M, Tomlinson N. Hospital and community acquired infection and the built environment- design and testing of infection control rooms. J Hosp Infect. 2007;65:43–9.
23. Tang JW, Eames In Li Y, et al. Door-opening motion can potentially lead to a transient breakdown in negative-pressure isolation conditions: the importance of vorticity and buoyancy airflows. J Hosp Infect. 2005;61:283–6.
24. Fusco FM, Puro V, Baka A, et al. Isolation rooms for highly infectious diseases: an inventory of capabilities in European countries. J Hosp Infect. 2009;73:15–23.
25. Marklund LA. Patient care in a biological safety level 4 (BSL-4) environment. Crit Care Nurs Clin North Am. 2003;15:245–55.
26. Zimring C, Denham ME, Jacob JT, et al. Evidence-based design of health care facilities: Opportunities for research and practice in infection prevention. Infect Control Hosp Epidemiol. 2013;34(5):514–6.
27. Zimring C, Jacob JT, Denham ME, et al. The role of facility design in preventing the transmission of healthcare-associated Infections: background and conceptual framework. Health Environ Res Design J. 2013;7:18–30.
28. Jacob TJ, Kasali A, Steinberg JP, Zimring C, Denham ME. The role of the hospital environment in preventing healthcare-associated infections caused by pathogens transmitted through the air. Health Environ Res Design J. 2013;7:74–98.
29. Beggs CB. The airborne transmission of infection in hospital buildings: fact or fiction? Indoor Built Environ. 2003;12:1–10.

30. Li Y, Leung GM, Tang JW, et al. Role of ventilation in airborne transmission of infectious agents in the built environment- a multi-disiplinary systematic review. Indoor Air. 2007;17:2–18.
31. Kao PH, Yang RJ. Virus diffusion in isolation rooms. J Hosp Infect. 2006;62:338–45.
32. Tellier R. Review of aerosol transmission of influenza A virus. Emerg Infect Dis. 2006;12:1657–62.
33. Aintablian N, Walpita P, Sawyer MH. Detection of *Bordetella pertussis* and respiratory syncytial virus in air samples from hospital rooms. Infect Control Hosp Epidemiol. 1998;19:918–23.
34. Gehanno JF, Louvel A, Nouvellon M, Caillard JF, Pestel-Caron M. Aerial dispersal of methicillin-resistant *Staphylococcus aureus* in hospital rooms by infected and colonised Patients. J Hosp Infect. 2009;71:256–62.
35. Creamer E, Shore AC, Deasy EC, et al. Air and surface contamination patterns of methicillin-resistant Staphylococcus *aureus* on eight acute hospital wards. J Hosp Infect. 2014;86:201–8.
36. Bernard MC, Lanotte P, Lawrence C, Goudeau A, Bernard L. Air contamination around patients colonized with multidrug-resistant organisms. Infect Control Hosp Epidemiol. 2012;33:949–51.
37. Andersen BM. International infection control guidelines may not protect against Ebola. Hospital Health Care. 2015.
38. Andersen BM. Infection control guidelines that did not work against Ebola in 2014. www.webbertraining.com. October 5, 2017.
39. Schiøtz C. Textbook of hygiene. Oslo: Fabritius & Sønner Forlag; 1937.
40. Bourouiba L, Dehandschoewerker E, Bush JWM. Violent expiratory events: on coughing and sneezing. J Fluid Mech. 2014;845:537–63.
41. Best EL, Fawlewy WN, Parnell P, Wilcox MH. The potential for airborne dispersal of *Clostridium difficile* from symptomatic patients. Clin Infect Dis. 2010;50:1450–7.
42. Andersen BM. Virus associated with skin rash and children's diseases. In: Handbook of hygiene and infection control in hospitals. Part 1 microbiology and infection control. Bergen: Fagbokforlaget; 2014. p. 256–67.
43. Andersen BM. Bordetella pertussis - whooping cough. In: Handbook of hygiene and infection control in hospitals. Part 1 microbiology and infection control. Bergen: Fagbokforlaget; 2014. p. 120.
44. Bischoff WE, Bassetti S, Bassetti-Wyss BA, Wallis ML, et al. Aiborne dispersal as a novel transmission route of coagulase-negative staphylococci, interaction between coagulase-negative staphylococci and rhinovirus infection. Infect Control Hosp Epidemiol. 2004;25:504–11.
45. Wong BCK, Lee N, Li Y, et al. Possible role of aerosol transmission in a hospital outbreak of influenza. Clin Infect Dis. 2010;51:1176–83.
46. Derrick JL, Li PTY, Tang SPY, Gomersall CD. Protecting staff against airborne viral particles: in vivo efficiency of laser masks. J Hosp Infect. 2006;64:278–81.
47. Morawska L. Droplet fate in indoor environments, or can we prevent the spread of infection? Proceedings: Indoor Air. 2005: P9–23.
48. Richard V, Riehm JM, Herindrainy P, et al. Pneumonic plague outbreak, Northern Madagascar 2011. Emerg Infect Dis. 2015;21:8–15.
49. Chee CBE, Gan SH, Ong RT, et al. Multi drug-resistant tuberculosis outbreak in gaming centres, Singapore, 2012. Emerg Infect Dis. 2015;21:179–80.
50. Conger NG, Paolino KM, Osborne EC, et al. Health care response to CCHF in US soldier and nosocomial transmission to health care providers, Germany, 2009. Emerg Infect Dis. 2015;21:23–31.