WHO operational handbook on tuberculosis

Module 1: Prevention

Infection prevention and control

World Health Organization

WHO operational handbook on tuberculosis

Module 1: Prevention

Infection prevention and control

World Health Organization

WHO operational handbook on tuberculosis. Module 1: prevention - infection prevention and control

ISBN 978-92-4-007815-4 (electronic version)
ISBN 978-92-4-007816-1 (print version)

© World Health Organization 2023

Some rights reserved. This work is available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo).

Under the terms of this licence, you may copy, redistribute and adapt the work for non-commercial purposes, provided the work is appropriately cited, as indicated below. In any use of this work, there should be no suggestion that WHO endorses any specific organization, products or services. The use of the WHO logo is not permitted. If you adapt the work, then you must license your work under the same or equivalent Creative Commons licence. If you create a translation of this work, you should add the following disclaimer along with the suggested citation: "This translation was not created by the World Health Organization (WHO). WHO is not responsible for the content or accuracy of this translation. The original English edition shall be the binding and authentic edition".

Any mediation relating to disputes arising under the licence shall be conducted in accordance with the mediation rules of the World Intellectual Property Organization (http://www.wipo.int/amc/en/mediation/rules/).

Suggested citation. WHO operational handbook on tuberculosis. Module 1: prevention - infection prevention and control. Geneva: World Health Organization; 2023. Licence: CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at http://apps.who.int/iris.

Sales, rights and licensing. To purchase WHO publications, see https://www.who.int/publications/book-orders. To submit requests for commercial use and queries on rights and licensing, see https://www.who.int/copyright.

Third-party materials. If you wish to reuse material from this work that is attributed to a third party, such as tables, figures or images, it is your responsibility to determine whether permission is needed for that reuse and to obtain permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

General disclaimers. The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by WHO in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

All reasonable precautions have been taken by WHO to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall WHO be liable for damages arising from its use.

Design by Inís Communication

Contents

Acknowledgements v

Abbreviations and acronyms vi

Definitions vii

1. Introduction 1

2. Administrative controls 11

3. Environmental controls 29

4. Respiratory protection 55

5. TB IPC in special situations 63

6. Monitoring and evaluation 65

References 67

Annex 1. Data elements for monitoring implementation of tuberculosis infection prevention and control 71

Annex 2. Facility tuberculosis risk assessment tool 75

Annex 3. Example of an outline of facility tuberculosis infection prevention and control plan 79

Annex 4. Health care worker tuberculosis screening form 81

Annex 5. Health care worker TB screening register 82

Annex 6. Sample posters for health education 83

Annex 7. How to choose upper-room germicidal ultraviolet light fixtures 87

Annex 8. Choosing a radiometer for measurement of ultraviolet C irradiation 90

Annex 9. Checklist for the review of programmatic implementation of tuberculosis infection prevention and control 92

Annex 10. Country example: education messages for tuberculosis and for tuberculosis infection prevention and control 96

Acknowledgements

The production and writing of this World Health Organization (WHO) document – the WHO operational handbook on tuberculosis, Module 1: Prevention – tuberculosis infection prevention and control – was coordinated by Avinash Kanchar and Dennis Falzon, under the guidance of Matteo Zignol and the overall direction of Tereza Kasaeva, Director of the WHO Global Tuberculosis Programme (WHO/GTB). The text of the handbook builds on the recommendations and remarks of the WHO tuberculosis (TB) infection prevention and control guidelines, which were coordinated by Fuad Mirzayev and Lice González-Angulo in 2019. The initial draft of this document was developed by Giovanni Battista Migliori of the WHO Collaborating Centre for Tuberculosis and Lung Diseases, Tradate, Italy, and Lia D'Ambrosio of the Public Health Consulting Group, Lugano, Switzerland. We thank Lisa Chen, Paul Jensen and Kelly Musoke, in particular, for their help in sharing content from the *Practical manual for preventing TB*, which was developed by the Curry International Tuberculosis Center, University of California, San Francisco, United States of America (USA). We thank Anand Date and the team from US Centers for Disease Control and Prevention, USA, for sharing content from the TB BASICS toolkit, that contributed significantly to Annexes 3, 4, 5, and 9 and Box 2.4 and 2.5.

WHO acknowledges and is grateful for the time and support of all individuals who have contributed to these efforts, and gratefully acknowledges the contribution of all experts involved in the production of this operational handbook. The following also reviewed the handbook and provided comments: Paul Jensen, Matsie Mphahlele, Carrie Tudor and Grigory Volchenkov (End TB Transmission Initiative); Sevim Ahmedov and Peter Kerndt (United States Agency for International Development, USA); Anand Date, Rajesh Deshmukh, Diana Forno Rodriguez and Christine Ho (US Centers for Disease Control and Prevention, USA); Malik Parmar, Ranjani Ramachandran and Anand Sridhar (WHO Country Office, India); Benedetta Allegranzi (WHO Integrated Health Services, Switzerland), Nizam Damani and Peter Hoffman (WHO independent consultants); Martin Van Den Boom (WHO Regional Office for the Eastern Mediterranean, Egypt); Aye Thida and Vineet Bhatia (WHO Regional Office for South-East Asia, India); and Saskia Den Boon and Lice González-Angulo (WHO/GTB).

We acknowledge financial support from the United States Agency for International Development (USAID) and the European Respiratory Society (ERS).

Abbreviations and acronyms

ACH	air changes per hour
AMR	antimicrobial resistance
ART	antiretroviral therapy
DNA	deoxyribonucleic acid
DR-TB	drug-resistant TB
DS-TB	drug-susceptible TB
DST	drug-susceptibility testing
FAST	finding TB cases actively, separating safely and treating
GDG	guideline development group
GUV	germicidal ultraviolet light
HAI	health care-associated infection
HEPA	high-efficiency particulate air (filter)
HIV	human immunodeficiency virus
HVAC	heating, ventilation and air conditioning
IPC	infection prevention and control
M. tuberculosis	*Mycobacterium tuberculosis*
MDR-TB	multidrug-resistant TB
NCD	noncommunicable disease
NTP	national TB programme
REL	recommended exposure limit
RNA	ribonucleic acid
SOP	standard operating procedure
TB	tuberculosis
TB IPC	tuberculosis infection prevention and control
TLV	threshold limit value
TPT	TB preventive treatment
TST	tuberculin skin test
UV	ultraviolet
UVC	ultraviolet light C
UVGI	ultraviolet germicidal irradiation
WHO	World Health Organization

Definitions

Note: Unless otherwise specified, the definitions listed below apply to the terms as used in this handbook. They may have different meanings in other contexts.

Airborne *Mycobacterium tuberculosis* transmission: Spread of aerosolized *M. tuberculosis* caused by the dissemination of infectious respiratory particles when suspended in air over long distances and time.[1]

Air changes per hour (ACH): The number of times that the total air volume in a room or space is completely removed and replaced in an hour.

Air purifier or air cleaner: A portable electrical indoor device intended to remove potentially harmful particles from the circulating air, or to inactivate or destroy them.

Antimicrobial resistance (AMR): The loss of effectiveness of any anti-infective medicine, including antiviral, antifungal, antibacterial and antiparasitic medicines.

Community setting: In the context of health care, a setting (e.g. primary care facility or other health care facility at community level) where interventions aimed at maintenance, protection and improvement of health status are provided at or near to places of residence.

Congregate settings: Institutional (non-health care) settings where people reside in close proximity to each other. Congregate settings range from correctional facilities (prisons and jails) to homeless shelters, refugee camps, army barracks, hospices, dormitories and nursing homes.

Contagious (infectious) tuberculosis (TB) patient: A patient with pulmonary TB disease (confirmed or undetected) who can spread infectious respiratory particles containing viable *M. tuberculosis* while coughing, sneezing, talking or conducting any other respiratory manoeuvres.

Droplet transmission: The spread of an infectious agent caused by the dissemination of droplets. Droplets are primarily generated from an infected (source) person during coughing, sneezing or talking. Transmission occurs when the droplets that contain microorganisms are propelled (usually <1 m) through the air and deposited on the conjunctivae, the mouth, or the nasal, throat, or pharynx mucosa of another person. Most of the volume (>99%) comprises large droplets that travel short distances (<1 m) and do not remain suspended in the air.

General hospital: A health care institution providing medical or surgical treatment (or both), and nursing care for sick or injured people.

General population: All individuals, without reference to any specific characteristic.

Germicidal ultraviolet (UV) light (GUV): A modern term for UVG irradiation (UVGI). The word "irradiation" has been removed from the abbreviation to help alleviate end-users' fears of ionizing radiation, which GUV does not contain.

GUV fixture or luminaire: A piece of apparatus that distributes the GUV energy emitted from one or more sources. It does not include the sources themselves but does include all the parts necessary

[1] For a more global WHO definition of airborne transmission, see Natural ventilation for infection control in health care settings. Geneva: World Health Organization; 2009 (https://apps.who.int/iris/handle/10665/44167).

for safe and effective operation, with the means for connecting the sources to the electricity supply[2] (the functional unit is composed of the fixture plus the GUV source or lamp).

Health care-associated infection (HAI): An infection occurring in a patient during the process of care in a hospital or other health care facility, which was not present or incubating at the time of admission. HAIs can also appear after discharge.

Health care facility: Any establishment (public or private) that is engaged in direct care of patients on site.

Health care setting: A setting where health care is provided (e.g. hospital, outpatient clinic or home).

Health care workers: All people engaged in actions whose primary intent is to enhance health as defined by the World Health Organization (WHO).[3]

Hierarchy of TB infection prevention and control (IPC) measures: TB IPC consists of a combination of measures designed to minimize the risk of *M. tuberculosis* transmission within populations. A three-level hierarchy of controls comprising administrative controls, environmental controls and respiratory protection, reduces exposure to *M. tuberculosis* and helps prevent transmission.

- **Administrative controls**: These are at the top of the hierarchy of TB IPC measures. They are management measures that are intended to reduce the risk of exposure to persons with infectious TB.
- **Environmental controls**: These are at the second level of the hierarchy. They prevent the spread of infectious respiratory particles and reduce their concentration.
- **Respiratory protection**: These are at the third level of the hierarchy. Respiratory protection control refers to the use of personal protective equipment over the nose and mouth in situations that pose a high risk of exposure to *M. tuberculosis*.

Household contact of TB patient: A person who shared the same enclosed living space with the index patient for one or more nights or for frequent or extended periods during the day during the 3 months before the start of current treatment.

Infectiousness: Probability of TB transmission from an individual with TB disease (usually pulmonary TB) to a susceptible individual through aerosols containing viable *M. tuberculosis* while the infected individual was, for example, coughing, sneezing, or talking.

Inpatient health care setting: A health care facility where patients are admitted and assigned a bed while undergoing diagnosis and receiving treatment and care, for at least one overnight stay.

Mechanical ventilation: Ventilation created mechanically using an air supply or an exhaust fan (or both), to force air into or out of a room.

Medical masks: Medical or procedure masks that are flat or pleated and are affixed to the head with straps around the ears, the head or both. Their performance standards are tested using a set of standardized test methods – American Society for Testing Materials (ASTM) ASTM F2100, EN 14683 or equivalent – that aim to balance high filtration, adequate breathability and (optionally) fluid penetration resistance.[4]

Mixed-mode ventilation: A ventilation system that combines both mechanical and natural ventilation, providing the opportunity to choose the most appropriate ventilation mode based on the circumstances.

---

[2] International lighting vocabulary. Vienna: International Commission on Illumination; 2011 (https://cie.co.at/publications/international-lighting-vocabulary).

[3] The world health report: 2006: working together for health. Geneva: World Health Organization; 2006 (https://apps.who.int/iris/handle/10665/43432).

[4] Technical specifications of personal protective equipment for COVID-19. Geneva: World Health Organization; 2020 (https://www.who.int/publications/i/item/WHO-2019-nCoV-PPE_specifications-2020.1).

Multimodal IPC: IPC that is implemented in an integrated way, with the aim of improving an outcome and changing behaviour.[5] Such a strategy includes tools (e.g. bundles and checklists) developed by multidisciplinary teams that take into account local conditions. The five most common components are: system change (availability of the appropriate infrastructure and supplies to enable good IPC practices); education and training of health care workers and key players (e.g. managers); monitoring of infrastructure, practices, processes and outcomes, and provision of data feedback; reminders or communications in the workplace; and culture change within the establishment or strengthening of a safety climate.[6]

Natural ventilation: Use of natural forces to introduce outdoor air into or push it out of a building and to distribute it around a space. These forces can be wind pressure, or pressure generated by the density difference between indoor and outdoor air.[7],[8]

Negative-pressure mechanical ventilation system: A mechanical ventilation system in which the exhaust airflow rate is higher than the supply airflow rate. This system is used to ensure that a room is at a lower pressure than the surrounding areas.

Negative-pressure room: A room in which mechanical ventilation keeps the exhaust airflow rate higher than the supply airflow rate. The room will be at a lower pressure than the surrounding areas.

Outpatient health care setting: A health care facility where patients are undergoing diagnosis and receiving treatment and care but are not admitted for an overnight stay (e.g. an ambulatory clinic or a dispensary).

Particulate respirator (N95 or FFP2): A special type of closely fitting face cover that can filter particles, to protect the wearer against inhaling infectious droplets.

The N95 respirator has a filter efficiency level of 95% or more against particulate aerosols free of oil, when tested against 0.3 µm particles. The "N" denotes that the respirator is not resistant to oil, and the "95" refers to a 95% filter efficiency.

The FFP2 respirator has a filter efficiency level of 94% or more against 0.4 µm solid particles and is tested against both an oil and a non-oil aerosol.

The performance of N95 respirators is approved by the National Institute for Occupational Safety and Health (NIOSH) of the United States Centers for Disease Control and Prevention. The performance of FFP2 respirators must comply with the essential health and safety requirements set out in European directives; that is, with "Conformité européenne" (CE).[9]

Person with presumptive TB: A person who presents with symptoms or signs suggestive of active TB disease.

Positive-pressure mechanical ventilation system: A mechanical ventilation system in which the supply airflow rate is higher than the exhaust airflow rate. This system is used to ensure that a room is at a higher pressure than the surrounding areas.

Positive-pressure room: A room in which mechanical ventilation keeps the supply airflow rate higher than the exhaust airflow rate. The room will be at a higher pressure than the surrounding

---

[5] Evidence-based care bundles [website]. Boston, USA: Institute for Health care Improvement; 2023 (https://www.ihi.org/Topics/Bundles/Pages/default.aspx).

[6] Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level. Geneva: World Health Organization; 2016 (https://apps.who.int/iris/handle/10665/251730).

[7] Differences in air density are commonly caused by temperature gradients, because warm air is less dense and tends to rise above colder air.

[8] Natural ventilation for infection control in health care settings. Geneva: World Health Organization; 2009 (https://apps.who.int/iris/handle/10665/44167).

[9] For more details see also Technical specifications of personal protective equipment for COVID-19. Geneva: World Health Organization; 2020 (https://www.who.int/publications/i/item/WHO-2019-nCoV-PPE_specifications-2020.1).

areas. Under this condition, if an opening exists, air will flow from the positively pressurized space outward to the surrounding areas.[10]

Recirculated air filtration: Ventilation systems used in enclosed spaces, buildings, aircraft and vehicles, through which various proportions of outside air and recirculated air are mixed, conditioned and filtered before being fed into the enclosed space.

Respirator fit test: A test protocol conducted to verify that a respirator correctly fits the wearer, to minimize ambient air entering the wearer's respiratory tract. Qualitative fit testing verifies the respirator's fit using test agents, and is detected either *qualitatively* by the wearer's sense of taste or smell or by their involuntary cough reflex (e.g. caused by irritants such as smoke), or *quantitatively* by an instrument. Quantitative fit-testing uses ambient aerosols or artificially generated sodium chloride aerosols, and quantitative fit-testing measures aerosol concentrations inside and outside the respirator.

Respiratory hygiene or cough etiquette: The practice of covering the mouth and nose during coughing or sneezing (e.g. by wearing a medical mask or cloth mask, or covering the mouth with a tissue, sleeve, flexed elbow or hand) to reduce the dispersal of respiratory secretions that may contain infectious particles.

Respiratory protection programme: A plan of action aimed at accomplishing an effective and sustainable use of particulate respirators by health care workers in settings that pose a high risk of *M. tuberculosis* transmission. The plan includes activities, responsibilities, and timelines, and outlines the means or resources that will be used. Examples of activities are policy development; education and training of health care workers; respirator fit testing; selection of respirator models and sizes; budgeting; procurement of respirators; and installation of signage about mandatory respirator use, supervision, and disposal in high-risk areas of a facility.

Respiratory separation (or isolation): Measures aimed at decreasing or eliminating the risk of airborne *M. tuberculosis* transmission from infectious individuals to other people seeking medical attention in a health care facility or to health care workers; such methods include use of pressure rooms, individual rooms or designated units, or timing of care procedures.

Risk of *M. tuberculosis* transmission: The probability of passing *M. tuberculosis* to another individual. This may be influenced by factors such as the frequency of contact with the source person, proximity to the person, duration of contact, use of respiratory protection, environmental factors (e.g. dilution of air, ventilation and other air disinfection), infectiousness of the source person and immune status of the exposed person.

Seal check: The person using a respirator must perform a seal check to determine whether the respirator is being properly worn. The user gently inhales and holds their breath for a few seconds. The facepiece should collapse slightly on the face. The seal check is successful if the facepiece remains collapsed while the person breathes.[11]

Settings with a high risk of *M. tuberculosis* transmission: Settings where infectious TB patients or individuals with undetected or undiagnosed active TB are present. TB patients are most infectious when they are untreated (e.g. before diagnosis) or inadequately treated (e.g. if they have undiagnosed drug-resistant TB and are treated with first-line drugs). Transmission will be increased by aerosol-generating procedures (e.g. bronchoscopy or sputum induction).

TB incidence: The number of new and recurrent (relapse) episodes of TB disease (all forms) occurring in a given year.[12]

---

[10] Roadmap to improve and ensure good indoor ventilation in the context of COVID-19. Geneva: World Health Organization; 2021 (https://www.who.int/publications/i/item/9789240021280).

[11] How to perform a respirator seal check. Geneva: World Health Organization; 2007 (https://apps.who.int/iris/bitstream/handle/10665/70064/WHO_CDS_EPR_2007.8b_eng.pdf?sequence=1&isAllowed=y).

[12] Methods used by WHO to estimate the global burden of TB disease. Geneva: World Health Organization; 2021 (https://www.who.int/publications/m/item/methods-used-by-who-to-estimate-the-global-burden-of-tb-disease).

TB prevalence: The number of people with TB disease (all forms) at a given point in time.[13]

TB infection: A state of persistent immune response to stimulation by *M. tuberculosis* antigens with no evidence of clinically manifest TB disease. This was previously referred to as latent TB infection, (LTBI), but that term is now being discarded given that infection cannot always be considered to be dormant.

TB infection, incidence: The number of new persons identified with TB infection within a specified period of time.

TB infection, prevalence: The number of persons identified with TB infection at a given point in time.

TB symptoms: General manifestation of active pulmonary TB disease, including cough for longer than 2 weeks, with sputum production (and could have blood at times), chest pains, fatigue, loss of appetite, weight loss, fever and night sweats.

Triage: In the context of TB IPC, this refers to a simple and preliminary intervention for identifying people with signs or symptoms of TB among those seeking medical attention in health care facilities. Triage is used to fast-track the diagnosis of TB infections and facilitate further separation or other precautions, when necessary, to minimize transmission from infectious patients.

UVGI: The use of UV light C (UVC) to kill or inactivate microorganisms. UVGI is generated by germicidal lamps and can kill or inactivate microorganisms that are airborne or on directly irradiated surfaces. Low-pressure mercury-vapour lamps emit UVC. (See also Germicidal UV light (GUV) above.)

Upper-room GUV: GUV systems that are designed to generate high levels of UVC irradiance above the heads of room occupants, and to minimize UVC exposure in the lower or occupied portion of the room.

Ventilation: Provision of outdoor air into a building or a room and distribution of air within the building. The purpose of ventilation in buildings is to provide healthy air for breathing by diluting pollutants originating in the building with clean air, and by providing an airflow rate to change this air at a given rate. Ventilation is also used for odour control, containment control and climatic control (i.e. temperature and relative humidity). Ventilation may also be used to maintain pressure differentials to prevent the spread of contaminants outside a room or to prevent contaminants from entering a room.[14]

[13] Methods used by WHO to estimate the global burden of TB disease. Geneva: World Health Organization; 2021 (https://www.who.int/publications/m/item/methods-used-by-who-to-estimate-the-global-burden-of-tb-disease).

[14] See other WHO definition in Roadmap to improve and ensure good indoor ventilation in the context of COVID-19. Geneva: World Health Organization; 2021 (https://www.who.int/publications/i/item/9789240021280).

1. Introduction

1.1 Rationale for TB infection prevention and control

Tuberculosis (TB) continues to be a major public health concern and one of the leading causes of death from a single infectious microorganism at the global level *(1)*. Although recent decades have witnessed increased efforts in the fight to end TB, there are still fundamental systemic gaps, particularly in resource-constrained settings and places with a high TB burden. The World Health Organization (WHO) estimates that about 74 million TB deaths were averted between 2000 and 2021 because of global TB prevention and care efforts. However, about 10.6 million people fell ill with TB in 2021 alone and 1.6 million people died of TB in that year *(1)*.

Although TB can affect everyone, specific population groups have a higher risk of acquiring TB infection or progressing to TB disease once infected *(2, 3)*. These vulnerable populations include people living with HIV, health care workers, children and individuals in congregate settings (e.g. prisons, correction centres, refugee camps and aged care homes). The difficulty and high cost of managing TB disease, especially its drug-resistant forms *(4, 5)*, both to the individual and to the community, underlines the importance of preventing transmission of *Mycobacterium tuberculosis* within health care facilities, congregate settings, workplaces and the households of TB patients. To achieve the global targets and end the TB epidemic, it is vital to break the chain of *M. tuberculosis* transmission *(6, 7)*; this requires rapid identification of individuals who have TB disease, prompt treatment and preventive treatment of those at risk, limiting exposure to individuals who may transmit *M. tuberculosis* and reducing the concentration of infectious particles in the ambient air. In programmatic settings, implementation of these TB infection prevention and control (IPC) interventions *(5, 8)* is currently lacking, particularly in countries with a high burden of TB and HIV, owing to competing priorities for ministries of health (MoHs). To implement TB IPC guidelines, TB IPC interventions must be prioritized, human and financial resources must be allocated, and there must be systematic engagement with the broader health system and other line ministries within national governments.

One of the targets of the United Nations Sustainable Development Goals (SDGs) for 2015–2030 is to end the global TB epidemic. Therefore, the WHO End TB Strategy, which was approved by the World Health Assembly in 2014, calls for a 90% reduction in TB deaths and an 80% decrease in the TB incidence rate by 2030 compared with 2015 *(9)*. The strategy emphasizes the need to strengthen TB prevention efforts across its three pillars, including TB IPC in health care facilities and settings with a high risk of transmission *of M. tuberculosis*. In 1999, WHO published recommendations for TB IPC in health care facilities in resource-limited settings *(10)*; these recommendations were expanded in 2009 to provide specific guidance on interventions at health care facilities, in congregate settings and in households *(11)*. A framework for the implementation of TB infection control measures was also developed, to complement the 2009 WHO policy document *(12)*. In 2019, WHO published updated and consolidated guidelines on TB IPC, based on the latest evidence and linked with the core components of general IPC programmes, published in 2016 *(13)*.

1.2 Objective and target audience

The **objective** of this handbook is to provide practical advice on how to implement the WHO recommendations on TB IPC within the clinical and programmatic management of TB, using a public health approach. This handbook emphasizes the importance of building integrated, well-coordinated, multisectoral actions across all levels of health care and other settings where there is a high risk of *M. tuberculosis* transmission. It shares best practices and experiences and provides checklists and job aids to support the implementation and monitoring of actions to cut transmissions. There is also an inherent risk of transmission of *M. tuberculosis* in congregate settings. This document promotes the implementation of a hierarchy of TB IPC interventions across all settings and emphasizes the importance of implementing an integrated package of interventions.

The **target audience** for this document includes policy-makers at national and subnational level; programme managers for TB, HIV and noncommunicable disease (NCD) programmes; managers and clinicians at inpatient and outpatient health care facilities; managers at various congregate settings; occupational health officials; engineers; medical practitioners; frontline health care workers; and other key stakeholders in the public and private sectors. This document does not cover TB laboratory biosafety or airborne infection control in the context of coronavirus disease 2019 (COVID-19); these topics are covered in other resources *(14, 15)*.

1.3 Adopting the core principles of IPC in TB programmes

Before discussing TB-specific measures in more detail, it is important to consider how universal principles of IPC apply to TB IPC. MoHs should embed TB IPC interventions within the broader framework of IPC, from the national to the facility level. In 2016, WHO issued a set of guidelines identifying eight core components of IPC *(16)* based on the most recent evidence. The aim was to address the current threats posed by infectious disease and to prevent future threats by strengthening health system resilience and combating antimicrobial resistance (AMR). The 2016 guidelines are also intended to support countries in the development of their own national protocols for IPC. The eight core components in the 2016 guidelines include 11 recommendations and three good practice statements developed in a separate WHO guideline development process *(17)*. These are summarized in **Fig. 1.1** and **Table 1.1.** They provide a broader health systems framework for the implementation of IPC. Although the core components in the 2016 IPC guidelines focus on the prevention of hospital-acquired infections, infections with epidemic potential and AMR, the underlying principles apply to all IPC programmes, including the actions aimed at preventing and reducing TB in health facilities and congregate settings. The core components were considered by the WHO guideline development group (GDG) when formulating their recommendations for the 2019 TB IPC guidelines.

Table 1.1. Core components of a national IPC programme, including recommendations and good practices

Core component 1. IPC programmes

1a. Health care facility level

The panel recommends that an IPC programme with a dedicated, trained team should be in place in each acute health care facility for the purpose of preventing HAIs and combating AMR through IPC good practices.
(Strong recommendation, very low quality of evidence)

1b. National level

Active, standalone, national IPC programmes with clearly defined objectives, functions and activities should be established for the purpose of preventing HAIs and combating AMR through IPC good practices. National IPC programmes should be linked with other relevant national and professional organizations.
(Good practice statement)

Core component 2. National and facility-level IPC guidelines

The panel recommends that evidence-based guidelines should be developed and implemented for the purpose of reducing HAI and AMR. The education and training of relevant health care workers on the guideline recommendations and the monitoring of adherence with guideline recommendations should be undertaken to achieve successful implementation. (*Strong recommendation, very low quality of evidence*)

Core component 3. IPC education and training

3a. Health care facility level

The panel recommends that IPC education should be in place for all health care workers by utilizing team- and task-based strategies that are participatory and include bedside and simulation training to reduce the risk of HAI and AMR.
(Strong recommendation, very low quality of evidence)

3b. National level

The national IPC programme should support the education and training of the health workforce as one of its core functions.
(Good practice statement)

Core component 4. Health care-associated infection surveillance

4a. Health care facility level

The panel recommends that facility-based HAI surveillance should be performed to guide IPC interventions and detect outbreaks, including AMR surveillance, with timely feedback of results to health care workers and stakeholders is essential and should be carried out through national networks.
(Strong recommendation, very low quality of evidence)

4b. National level

The panel recommends that national HAI surveillance programmes and networks that include mechanisms for timely data feedback and with the potential to be used for benchmarking purposes should be established to reduce HAI and AMR.
(Strong recommendation, very low quality of evidence)

Core component 5. Multimodal strategies for implementing IPC activities

5a. Health care facility level

The panel recommends that IPC activities using multimodal strategies should be implemented to improve practices and reduce HAIs and AMR.
(Strong recommendation, low quality of evidence)

5b. National level

The panel recommends that national IPC programmes should coordinate and facilitate the implementation of IPC activities through multimodal strategies on a nationwide or subnational level.
(Strong recommendation, low quality of evidence)

Core component 6. Monitoring/audit of IPC practices and feedback and control activities

6a. Health care facility level

The panel recommends that regular monitoring/audit and timely feedback of health care practices, according to IPC standards should be performed to prevent and control HAI and AMR at the health care facility level. Feedback should be provided to all audited persons and relevant staff.
(Strong recommendation, low quality of evidence)

6b. National level

The panel recommends that a national IPC monitoring and evaluation programme should be established to assess the extent to which standards are being met and activities are being performed according to the programme's goals and objectives. Hand hygiene monitoring with feedback should be considered as a key performance indicator at the national level.
(Strong recommendation, moderate quality of evidence)

Core component 7. Workload, staffing and bed occupancy at the facility level

The panel recommends that the following elements should be adhered to in order to reduce the risk of HAI and the spread of AMR: (1) bed occupancy should not exceed the standard capacity of the facility; (2) health care worker staffing levels should be adequately assigned according to patient workload.
(Strong recommendation, very low quality of evidence)

Core component 8. Built environment, materials and equipment for IPC at the facility level

8a. General principles

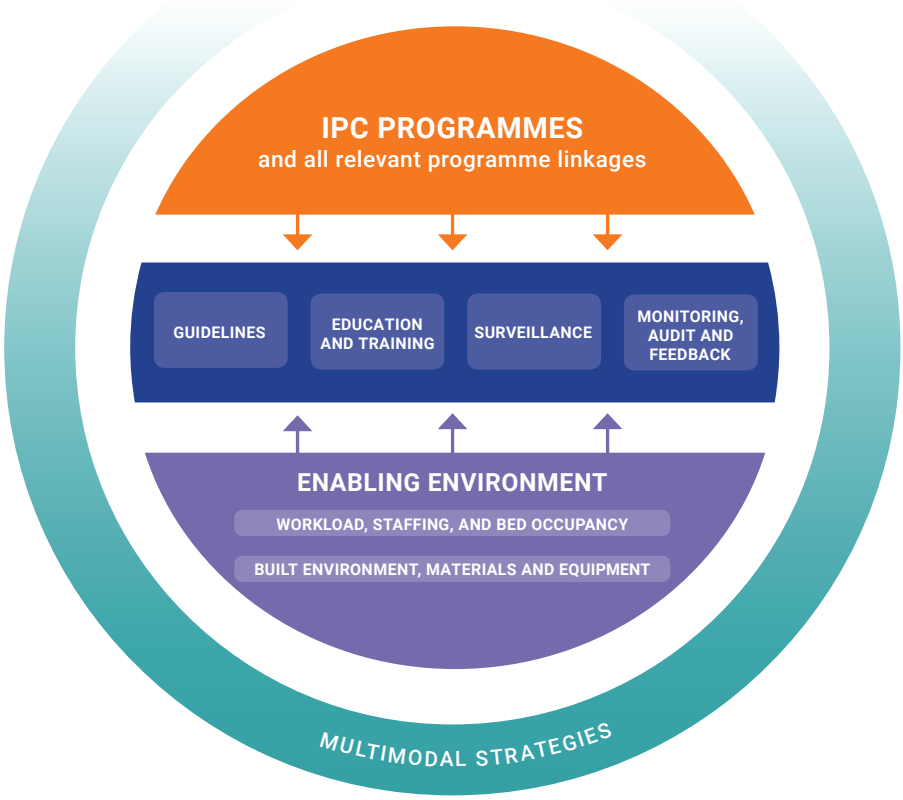
Patient-care activities should be undertaken in a clean or hygienic environment that facilitates practices related to the prevention and control of HAI, as well as AMR, including all elements around the WASH infrastructure and services and the availability of appropriate IPC materials and equipment.
(Good practice statement)

8b. Materials, equipment, and ergonomics for appropriate hand hygiene

The panel recommends that materials and equipment to perform appropriate hand hygiene should be readily available at the point of care.
(Strong recommendation, very low quality of evidence)

AMR: antimicrobial resistance; HAI: health-care-associated infection; IPC: infection prevention and control; WASH: water, sanitation and hygiene.

Fig. 1.1. Core components of WHO IPC



IPC: infection prevention and control; WHO: World Health Organization.

Source: WHO (2019) *(17)*.

The following paragraphs provide suggestions on how countries can integrate TB-specific actions into broader national IPC programmes for each of the core components.

Core component 1, IPC programmes: Health facilities may already have IPC committees that have relevant expertise (e.g. in blood transfusion safety, hepatitis and other bloodborne infections, and infections after general and orthopaedic surgery, delivery and postpartum). The IPC committees often work in isolation and do not prioritize control of airborne infections such as TB. Therefore, the MoH should ensure that IPC committees prioritize TB IPC and systematically incorporate it into their mandate at all levels. A TB focal person should be included on all IPC committees across the health system.

Core component 2, IPC guidelines: The MoH should ensure that TB IPC recommendations are adequately reflected in the national IPC guidelines, implementation protocols and standard operating procedures (SOPs), to facilitate systematic implementation across all levels of health services.

Core component 3, Education and training: Training and on-the-job education of health care workers and facility staff should include training in the TB IPC recommendations. Furthermore, standard education tools (e.g. posters and flow charts targeting staff, patients and visitors to the health facilities or congregate settings) should cover actions for TB IPC. The facility's focal person for TB IPC should facilitate the training and education of staff and visitors on TB IPC actions.

Core component 4, HAI infection surveillance: Central to the successful implementation of TB IPC are surveillance of the TB burden at the facility, national and subnational levels, and provision of timely feedback to staff. MoHs should also ensure that key data variables related to TB IPC interventions are

systematically reviewed at all levels (see also **Chapter 6** and **Annex 1**). TB among health workers is a proxy indicator for the quality of TB IPC actions in a health care facility or congregate setting *(18)*. This calls for the establishment of a programme for periodic screening of health workers or staff for TB, rapid identification of TB disease, notification, and prompt start of TB treatment.

Core component 5, Multimodal strategies for implementing activities: The following multimodal strategies were applied in the studies reviewed by the GDG for the 2016 WHO IPC guidelines *(6, 7, 16)*:

- **system change** – that is, the availability of the appropriate infrastructure and supplies to implement IPC good practices.
- **education and training** of health workers and key stakeholders (e.g. facility managers);
- **increased accountability** via monitoring and timely feedback
- **reminders** in the workplace; and
- **culture change** within the establishment (if necessary), with leadership engagement and positive reinforcement strategies to promote practices that ensure patient safety.

Effective integration of TB IPC into each of these strategies, at an appropriate level, should be ensured.

Core component 6, Monitoring/audit and feedback: TB IPC activities should be regularly monitored and aligned with other IPC interventions at the national and local health care facility levels, and feedback should be provided to the staff concerned for quality improvement purposes (see also **Chapter 6** and **Annex 1**). Periodic surveys may also be undertaken to capture data not routinely collected for the monitoring of TB IPC, and to understand the extent of implementation or adherence to national IPC protocols and SOPs.

Core component 7, Workload, staffing and bed occupancy: It is important to limit hospital admission for TB to those with severe disease (e.g. life-threatening conditions, severe adverse events or comorbidities) *(6, 7, 16)*. It is also important to the ensure that sufficient staff are available to serve the number of patients covered by the health facility with high-quality care and effective TB IPC. WHO encourages ambulatory or decentralized and home-based treatment for TB, in preference to inpatient care or isolation *(19)*.

Core component 8, Built environment, materials, and equipment: In the context of TB, this component may imply that respiratory protection equipment should be made available not only to staff but also to visitors. Equipment and tools for disinfection and dilution of ambient air through effective ventilation systems should also be considered.

Key point: TB IPC interventions should be an integral part of the overall national IPC programme.

1.4 WHO recommendations on TB IPC

The 2019 WHO TB IPC guidelines provide four recommendations on administrative controls (Recommendations 1–4), two on environmental controls (Recommendations 5–6) and one on respiratory protection (Recommendation 7) *(13)*. The **administrative controls** are management measures aimed at reducing the risk of exposure to *M. tuberculosis* for individuals attending health facilities or a congregate setting. The **environmental controls** are intended to prevent the spread of infectious droplets and reduce their concentration in the ambient air. **Respiratory protection** comprises the use of personal protective equipment (PPE) to limit the risk of acquiring *M. tuberculosis* infection. In addition, as discussed in Section 1.3, the 2019 guidelines include good practice statements that reflect general principles of IPC that apply to TB. The latest recommendations on TB IPC are summarized in **Table 1.2**. These controls are discussed in detail in Chapters 2–4.

Table 1.2. Latest recommendations on TB IPC

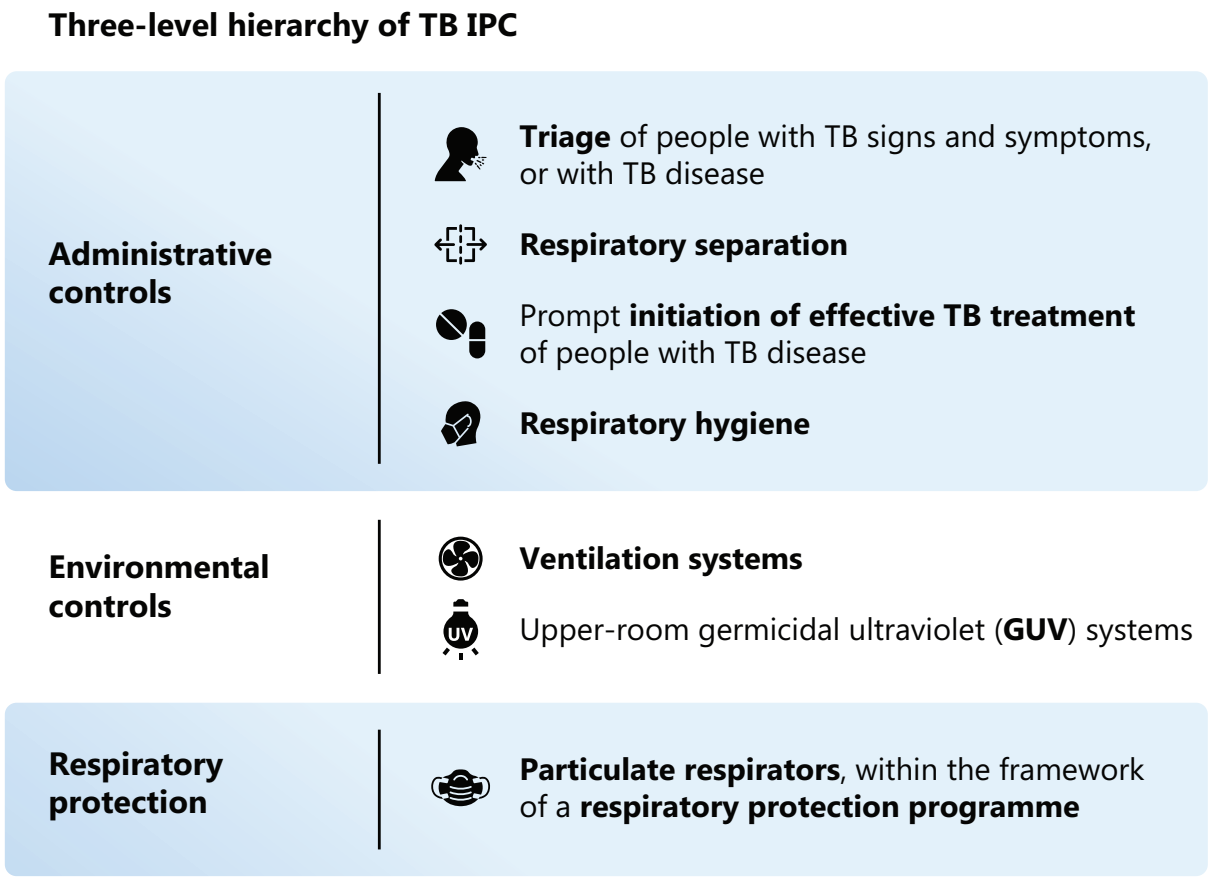
Administrative controls
Recommendation 1: Triage of people with TB signs and symptoms, or with TB disease, is recommended to reduce *M. tuberculosis* transmission to health workers (including community health workers), persons attending health care facilities or other persons in settings with a high risk of transmission. (*Conditional recommendation based on very low certainty in the estimates of effects*)
Recommendation 2: Respiratory separation / isolation of people with presumed or demonstrated infectious TB is recommended to reduce *M. tuberculosis* transmission to health workers or other persons attending health care facilities. (*Conditional recommendation based on very low certainty in the estimates of effects*)
Recommendation 3: Prompt initiation of effective TB treatment of people with TB disease is recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission. (*Strong recommendation based on very low certainty in the estimates of effects*)
Recommendation 4: Respiratory hygiene (including cough etiquette) in people with presumed or confirmed TB is recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission. (*Strong recommendation based on low certainty in the estimates of effects*).
Environmental controls
Recommendation 5: Upper-room germicidal ultraviolet (GUV) systems are recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission. (*Conditional recommendation based on moderate certainty in the estimates of effects*)
Recommendation 6: Ventilation systems (including natural, mixed-mode, mechanical ventilation, and recirculated air through high-efficiency particulate air [HEPA] filters) are recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission. (*Conditional recommendation based on very low certainty in the estimates of effects*).
Respiratory protection
Recommendation 7: Particulate respirators, within the framework of a respiratory protection programme, are recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission. (*Conditional recommendation based on very low certainty in the estimates of effects*).

IPC: infection prevention and control; *M. tuberculosis;* TB: tuberculosis.

Source: WHO (2019) *(17)*.

To achieve the optimum impact on TB transmission, the recommended interventions given above should be implemented as a package, not selectively. In settings where there is a high risk of *M. tuberculosis* transmission, it is important to develop and implement integrated, well-coordinated and multisectoral actions for TB IPC across the health and non-health sectors. These actions should include administrative, environmental, and respiratory control measures, as summarized in **Fig. 1.2.**

Fig. 1.2. Integrated package of TB-specific interventions for infection prevention and control



IPC: infection prevention and control; TB: tuberculosis.

Key point: Effective implementation of WHO recommendations on TB IPC relies on interventions within the three-level hierarchy of IPC being implemented as an ***integrated package*** (not prioritized individually or implemented separately).

2. Administrative controls

Administrative controls are interventions aimed at reducing exposure and thus the transmission of *M. tuberculosis* in health facilities and congregate settings. These controls include triage to identify people with presumptive TB and then separate them, prompt evaluation for TB, initiation of effective TB treatment, and access to tools for respiratory protection. Implementation of administrative controls involves the development of institutional policies, protocols, education and oversight aimed at establishing mechanisms for reducing exposure to and transmission of TB within the facility *(20)*. Actions to consider as part of administrative controls include the following:

- assign responsibility for TB IPC to a specific person within the facility IPC committee;
- conduct a TB transmission risk assessment at the facility;
- develop a written TB IPC plan;
- train and educate all staff and volunteers on TB IPC;
- educate patients and visitors at the health care facility about TB IPC;
- display appropriate signage and promote respiratory hygiene throughout the facility;
- separate coughing patients from others in waiting areas;
- fast-track coughing patients through care, and minimize the time they spend in the health facility;
- provide coughing patients with medical masks;
- establish a system for baseline and periodic TB screening and evaluation of staff based on their risk of TB exposure, and provide free TB treatment and TB preventive treatment (TPT);
- implement protocols for triage and airborne precautions following epidemiological principles, applying criteria for isolation or separation of patients with presumptive and infectious TB;
- ensure proper cleaning, sterilization or disinfection of equipment (particularly equipment used during procedures such as sputum induction, bronchoscopy, anaesthesia or surgery);
- ensure access to rapid molecular testing for people with presumptive TB;
- promptly start effective TB treatment based on drug-susceptibility testing (DST) results when TB is confirmed and ensure support for people to adhere to treatment as prescribed;
- implement organizational measures to ensure effective and sustainable use of environmental controls and personal respiratory protection;
- facilitate collection and review of TB data by the IPC committee; and
- ensure that all individuals identified as having TB are notified and that appropriate follow-up actions are taken.

The rest of this chapter outlines mechanisms for the programmatic implementation of these administrative control activities and thus of the package of TB IPC interventions.

2.1 Coordination and planning of TB IPC activities

2.1.1 National level

At the national level, the MoH should designate a senior officer as a focal person to coordinate the implementation of TB IPC activities. The focal person should be tasked with planning, resource mobilization, capacity-building and monitoring of the implementation of the TB IPC programme at the national level. Indicative terms of reference for the national TB IPC focal person are as follows:

- develop a national TB IPC plan and incorporate TB within the broader national IPC plan when available;
- facilitate the development and updating of relevant national norms and regulations, in accordance with the national TB IPC guidelines;
- coordinate the development and systematic dissemination of educational and advocacy material on TB IPC to all stakeholders at relevant service delivery points in the country;
- advocate for funding and resources from different ministries and donors to implement TB IPC at national and subnational levels;
- coordinate the implementation of TB IPC activities with other national programmes (e.g. for HIV, nutrition and NCDs such as diabetes mellitus) and other sectors beyond health (e.g. in congregate settings);
- facilitate the implementation of TB IPC activities through community-based organizations and private health care providers;
- facilitate the systematic recording, reporting and monitoring of the implementation of TB IPC activities through the national health management information system (HMIS) or special TB IPC surveys; and
- facilitate operational research to document best practices and experiences within the country or in specific congregate settings.

2.1.2 Subnational and facility-level IPC focal person

Systematic implementation of TB IPC at subnational and facility levels requires the availability of designated staff to coordinate it. For the implementation to be successful, the officer in charge of TB IPC needs to have the support and authority, budget and human resources to implement it *(20)*. Support should include the authority to conduct TB risk assessments for facilities; develop regional, facility- and department-level budgeted plans; and facilitate the implementation of TB IPC policies and plans. Specific actions suggested are as follows:

- A health care worker who is employed full time, such as a nurse, must be relieved of part or all of their clinical duties, depending on the size of the institution, to ensure that adequate time is available for oversight of IPC implementation, including TB IPC. In a small clinic, one person may be sufficient for IPC; however, in a large hospital, several people will probably be needed.
- The person or people responsible for TB IPC should ideally have clinical experience, to understand the nature of transmission of *M. tuberculosis* and its infectivity. If an individual without any clinical background is appointed to oversee TB IPC, they must be trained in basic TB IPC (including the mechanics of *M. tuberculosis* transmission) and be knowledgeable about the populations most at risk of TB infection in the facility's service areas.
- The IPC focal person or people should identify populations vulnerable to TB disease progression and ensure that they are given priority. Such populations include children and people with HIV, cancer or other immunocompromising conditions, including those caused by their medication (e.g. steroids, chemotherapy or immunosuppressive drugs). The IPC focal person should ensure that the recommended TB screening, training and education of health care personnel and other staff at risk are undertaken regularly.

2.1.3 IPC committee at facility level

In addition to an IPC programme leader, facilities such as hospitals and outpatient clinics serving a large population may create multidisciplinary IPC committees that bring together key members of staff. In a large facility or hospital, the committee should include a range of representatives who can advise on policy and protocols and assist with implementation. This could include representatives from facility management; the microbiology laboratory; multiple clinical disciplines (e.g. medicine, nursing, surgery and paediatrics); and the occupational health, environmental science, engineering, quality assurance and facility maintenance departments. The key to effective IPC is to motivate staff,

clients, and visitors to follow IPC procedures and policies for airborne infection control. The TB IPC focal person and the IPC committee should undertake the following actions:

- develop a TB IPC implementation plan aligned to the national IPC guidelines; the plan should include a budget to strengthen TB IPC measures, which takes into account the risk of TB transmission;
- advise facility administration on the choice of IPC tools (e.g. certified respirators, masks, germicidal ultraviolet [GUV], signage and location of waiting areas) and ventilation equipment suitable for the local context;
- liaise with relevant authorities and staff in the facility (e.g. procurement, maintenance, waste management, pharmacy and housekeeping services) to ensure that the required materials are available and that the TB IPC is implemented smoothly;
- review the status of implementation of TB IPC in the facility and identify key gaps;
- undertake assessment of risk of transmission of *M. tuberculosis* across the health facility, including waiting areas, consultation rooms for all health care workers, inpatient wards, pharmacy and investigation rooms (e.g. laboratory and radiology unit);
- introduce any system changes that are needed to minimize the risk of transmission of *M. tuberculosis*, including establishing appropriate patient flows and seating arrangements, installation of equipment and provision of PPE, as necessary;
- ensure the availability and use of SOPs and working protocols for all levels of staff;
- convene regular meetings (e.g. monthly or quarterly), assign responsibilities for implementation of TB IPC activities within the facility and designate members from the IPC committee for oversight;
- develop a schedule and mechanism for monitoring the implementation of TB IPC;
- organize initial and regular refresher training programmes for health care workers and other staff;
- organize ongoing education and capacity-building activities that are practical and participatory for facility staff, and organize education sessions for patients and visitors to the facility;
- recruit and make use of TB champions and other leaders, and ensure that signs and educational materials are displayed across the facility.
- In terms of oversight:
  - undertake annual reviews to update facility SOPs and working protocols for TB IPC, in accordance with national IPC guidelines;
  - establish a mechanism for routine monitoring of compliance with SOPs or working protocols by health care workers, other staff, patients and visitors to the health facility;
  - establish a mechanism for routine (e.g. monthly or quarterly) review of data on TB and TB infection among health care workers and other staff, to identify high-risk settings and situations; and
  - immediately investigate any outbreak of TB or drug-resistant TB (DR-TB) reported in the facility.

2.1.4 TB IPC facility risk assessment

The IPC committee and TB IPC focal person should undertake TB risk assessments of the facility. The assessment team should include knowledgeable facility staff and health care workers who are familiar with the flow of patients and functional issues (e.g. patient crowding at certain times of day; windows that do not open easily; problematic heating, ventilation or air-conditioning systems and GUV fixtures; use of medical masks; and status of fit-testing). The assessment will help to identify areas of the TB IPC programme that might benefit from change or enhancement, and it should be undertaken at least once a year. The assessment should include evaluation of the effectiveness and level of implementation of the IPC plan, and review of previous recommendations for change. Key elements that should be assessed are outlined below:

- The assessment team should review:
  - patient flow at various times of day, identifying areas of overcrowding;
  - seasonal increases in patient flow;
  - the location and scheduling of TB services (e.g. are the services immediately adjacent to the HIV clinic or oncology clinic, with potential overflow of waiting patients?);

  - high-risk areas such as congregation and waiting areas, hospital wards and the area used for sputum induction (e.g. is this outdoors or in a well-ventilated space, a booth or a negative-pressure room); and
  - the implementation status of environmental controls and the respiratory protection measures used by staff and visitors.
- The team should undertake additional risk assessment of:
  - any ongoing construction or renovation of the facility;
  - creation of any new patient waiting or treatment areas;
  - implementation of new TB diagnostic and treatment guidelines; and
  - availability of staff to manage the workload in the facility.

The findings from the risk assessment should be systematically documented and shared with the IPC committee for review; any recommended actions should be systematically implemented and monitored. **Annex 2** provides an example of a TB risk assessment tool for a facility.

2.1.5 Facility TB IPC implementation plan

Following the risk assessment, a facility TB IPC implementation plan should be developed or updated to address identified gaps and to scale up best practices. The plan should receive input from the IPC committee, facility staff and management, to ensure that sufficient human and financial resources are allocated. The plan may include short-, medium- and long-term actions along with estimated cost. If structural changes are deemed necessary to improve TB IPC measures (e.g. measures to decrease overcrowding or improve ventilation), an engineer should also have input into the TB IPC plan. The person in charge of the facility should formally sign off on the plan to ensure accountability for implementation. In general, the TB IPC plan should include:

- basic information:
  - location, basic information about the setting;
  - service or services offered;
  - updated TB epidemiology (at facility, state and local level; people in the community served by the facility who are at increased risk of TB; and staff);
  - results of the latest TB IPC facility risk assessment and areas at potential high risk of TB;
- administrative controls:
  - assignment of responsibilities for TB IPC;
  - contact information of the TB IPC focal person;
  - a training and education plan for staff;
  - an education plan for patients, clients and visitors;
  - a schedule for TB screening and evaluation of health care workers and other staff, including TB treatment and provision of TPT;
  - protocols for triage and precautions against airborne infections;
  - signage and support for respiratory hygiene;
  - policies and protocols for communication and collaboration with local or state health departments and clinical and laboratory services;
- environmental controls:
  - policies and protocols to ensure cleaning and maintenance of TB IPC equipment (e.g. GUV fixtures and mechanical ventilation systems);
  - measures to improve mechanical and natural ventilation;
  - measures to improve adherence to SOPs for upper-room GUV systems (including adequate air mixing);
- respiratory protection:
  - a personal respiratory protection programme for at-risk employees:
    - training and on-the-job education on the use of respirators;
    - adequate supply of different sizes and models or brands of certified respirators for staff and care providers in the community, and for households;

        - fit-testing for respirators;
    - medical masks (for potential and confirmed TB patients, clients and visitors);
- sustainable TB IPC implementation:
    - identification of human resources and appropriate assignment of TB IPC responsibilities;
    - mobilization and allocation of funding for implementation of TB IPC activities; and
    - allocation of human and financial resources for continual quality improvement activities.

An example of a TB IPC plan developed by the US Centers for Disease Control (CDC) – the *Basic TB infection control risk assessment tool* – is included in **Annex 3.**

2.2 Implementation of administrative controls

2.2.1 Triage

In the context of TB IPC, triage implies a preliminary intervention to identify individuals with signs or symptoms of TB among those visiting a facility. It is used to fast-track those with signs or symptoms through the waiting areas to the facilities for clinical evaluation, TB investigation, provision of treatment, and isolation or respiratory separation, as necessary. The purpose is to minimize the time a potentially infectious individual spends in the health facility or congregate setting and thus the chance of them transmitting TB to others. Triage alone is estimated to reduce the absolute risk of incident TB infection by about 6% among health care workers in all settings (the absolute risk reduction may vary from 3% in settings with a low TB burden to 1.7% in settings with a high TB burden); among non-health care workers the risk reduction was found to be 12.6% *(13)*.

Programmatic implementation of triage requires the following steps for identification and management of individuals having presumptive or confirmed TB:

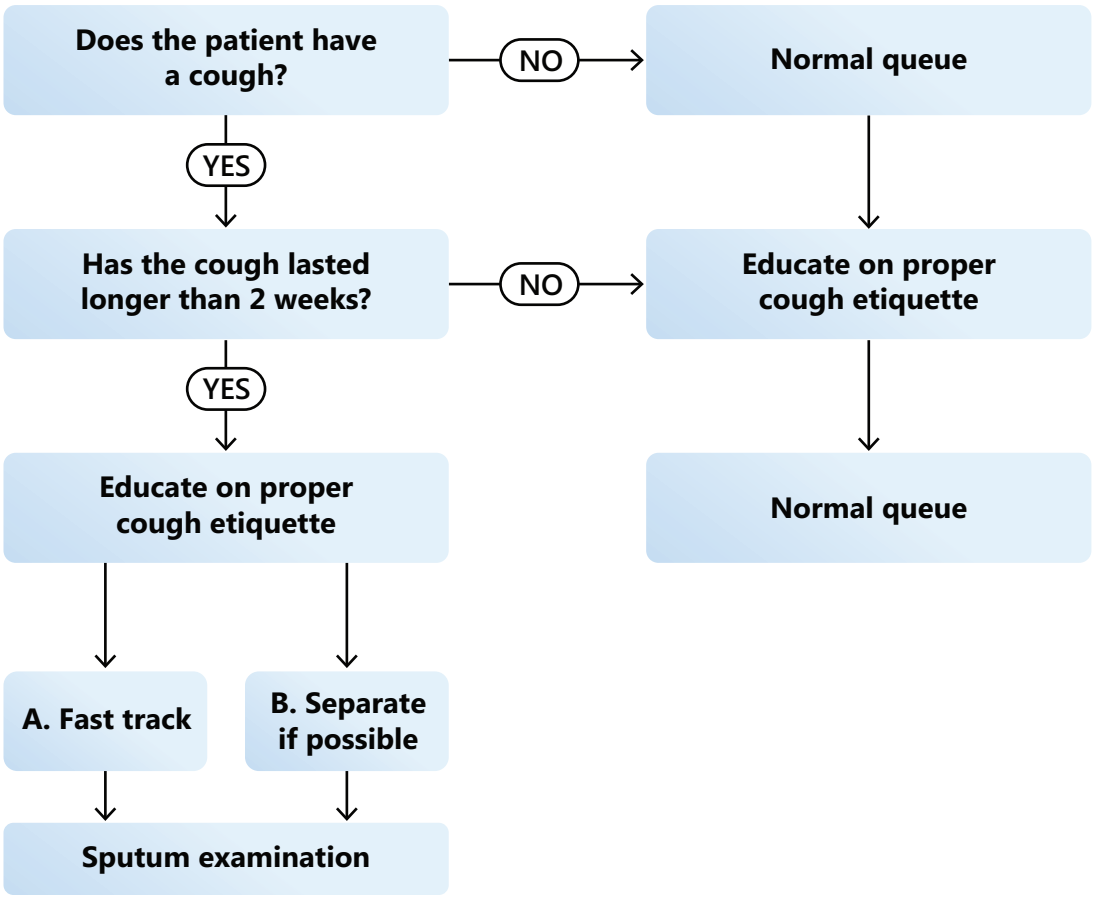
1. Health care workers or community volunteers working at the health facility may be designated to assess visitors at the facility entry, or as soon as visitors are seated in the waiting area.
2. The designated individuals should watch for people who cough and should use a checklist to assess whether those people are exhibiting signs or symptoms that are suggestive of TB; health care personnel need to maintain a relatively high level of vigilance for TB.
3. Once identified, individuals with a cough or other signs and symptoms of TB should be separated from other visitors and fast-tracked through all queues for medical evaluation and diagnostic testing, following proper precautions for airborne infections.
4. All medical staff caring for individuals who are potential TB patients should wear certified respirators (N95, filtering facepiece 2 [FFP2] or elastomeric) when in contact with patients who are or who may be infectious.
5. Health care personnel or staff should educate patients and caregivers about TB transmission within the hospital and the home – care should be taken to reduce potential stigma for the patient, particularly from family or community members.
6. The IPC focal person for the facility should talk to patients and visitors on a regular basis, to understand their perspectives on the way triage and fast-tracking are carried out. The focal person should aim to make the process more subtle and acceptable, to avoid stigmatization or alienation of the patients.
7. Triage may sometimes be followed by respiratory separation or isolation, or the start of TB treatment if TB is confirmed.
8. People living with HIV should be systematically screened for TB at each visit *(21)*. HIV testing should be offered to all patients with presumptive and diagnosed TB, especially in settings with a high burden of HIV *(22)*.

9. Triage may also be implemented at dedicated diabetes clinics and other medical facilities where patients may be at high risk of TB. Triage at other locations with a high risk of TB transmission is also likely to be of benefit *(13)*, particularly where those with presumed TB may congregate; for example, in long-term care facilities or correctional facilities.

Fig. 2.1 provides an illustrative example of patient flow from a health facility in Ghana, a country with a high burden of both TB and HIV *(12)*. An example of triage implementation is presented in Box 2.1.

Key point: Consultation and continued dialogue with health care workers, patients and visitors are needed to implement TB IPC properly and avoid the worsening of stigma or the alienation of patients.

Fig. 2.1. Example of patient flow at an outpatient clinic in Ghana



Source: Implementing the WHO Policy on TB Infection Control in Health-Care Facilities, Congregate Settings and Households. (12)

Box 2.1. An illustrative example of triage in a busy antiretroviral therapy (ART) centre in a setting with a high burden of TB

The person in charge of the hospital recently entrusted a trained community volunteer with the task of identifying any individuals with a cough presenting either at the reception of the ART centre or in the waiting area. The volunteer is required to perform triage in a patient-friendly manner, without stigmatizing the individual or disrupting care for other patients. Also, the volunteer is instructed to use a medical mask at all times and to offer medical masks to individuals with signs or symptoms of TB.

Once the volunteer identifies an individual with signs or symptoms of TB, they accompany that person to the front of the queue to see the nurse or doctor. Following evaluation by the nurse or doctor, the volunteer takes the patient quickly to the head of the queue at the pharmacy to collect antiretroviral (ARV) drugs. The volunteer then hands the patient to a second volunteer, who accompanies the patient to a sputum testing centre. Once the sputum specimen has been submitted, the patient is asked to leave the health facility and to return for review of the results of the investigation, when available.

Key point: The purpose of triage is to fast-track the clinical management of patients with presumed TB, to minimize the time they spend in the facility and reduce their contact with others. Rapid testing and prompt initiation of treatment for TB patients is critical.

2.2.2 Respiratory separation or isolation

Evidence

Overall, the studies reporting on the impact of administrative control measures in TB IPC have serious limitations; for example, the studies have small estimates of effect and large variance. In the few relevant studies included in systematic reviews considered by the WHO GDG, an absolute risk reduction of 2% was noted among health care workers when individuals with presumed or confirmed TB underwent respiratory separation or isolation; however, no studies are available in other populations. In low TB burden settings, respiratory separation as a part of a package of interventions achieved a risk reduction of 12.6% for TB disease in those attending secondary- or tertiary-level health facilities *(13)*.

Implementation of respiratory separation or isolation

Respiratory separation or isolation should be implemented as part of a package of TB IPC interventions in situations where good-quality patient care and support are offered, TB treatment is available and other measures to prevent airborne transmission are in place. The preferred approach is prompt TB treatment, health education, counselling and constant dialogue with the patient and their family. Providing treatment and support and ensuring adherence through patient-friendly and decentralized models of care, is often adequate to obtain successful outcomes and minimize transmission in health facilities. However, when these measures fail and there is a real risk that *M. tuberculosis* will be transmitted to the immediate family or the community, health providers or authorities may need to decide on and implement respiratory separation or isolation of the patient.

Prior to separation or isolation, individual risk assessment should be undertaken, using a human-rights-based approach that balances the potential risks and benefits to both the patient and the health care

workers, and the community in general. In situations where isolation is deemed necessary, it should be implemented in consultation with the patient and their family or caregivers in a medically appropriate setting. Respiratory separation or isolation should be discontinued as soon as the infectious period has been completed. The following are examples of patients for whom respiratory separation or isolation may be required *(6, 7)*:

- respiratory separation or inpatient care:
  - a person with infectious severe pulmonary TB or DR-TB requiring hospital admission; for example, for respiratory failure or a condition requiring medical intervention (e.g. haemorrhage, pneumothorax and pleural effusion);
  - a person with TB with severe comorbidities (e.g. HIV, liver disease, renal disease or uncontrolled diabetes);
  - a TB patient on treatment, presenting with severe adverse events (e.g. hepatitis, psychosis, renal failure, hearing loss or arrythmias);
- isolation:
  - treatment failure;
  - infectious TB patients housed in congregate settings or long-stay health facilities;
  - situations where effective and safe TB treatment cannot be ensured in an outpatient, community or home setting (e.g. people who are homeless, have chronic alcoholism, pose a risk of exposure to children aged <5 years, are immunocompromised or are pregnant); and
  - nonadherence to treatment (as a last resort when other care options are exhausted).

When respiratory separation or isolation is necessary, precautions should be more stringent for individuals with bacteriologically confirmed TB and those who are immunosuppressed (e.g. HIV-positive). If patients are bacteriologically negative, they are less likely to infect others and can even be placed in general wards. Infectious TB patients should be admitted to wards with adequate TB IPC measures and adequate distance between beds. HIV-infected individuals should not share space with TB patients; in particular, the exposure of individuals with HIV to infectious TB patients should be avoided.

The use of involuntary hospitalization and incarceration of TB cases is not specifically addressed in the WHO TB IPC guidelines *(13, 23)*. Isolation should be regarded as a last resort, when all other options have failed. Authorities and those implementing the controls need to consider patient rights, and balance individual liberties with the advancement of the common good *(24)*. Prerequisites for programmatic implementation of isolation include:

- availability of:
  - clear protocols and guidance;
  - isolation rooms (i.e. spaces with or without negative-pressure ventilation and that meet minimum standards for patient care and hygiene);
  - staff trained in counselling and in explaining the rationale behind isolation measures;
  - adequate human and financial resources to ensure proper isolation while protecting patient rights and not increasing TB risks for health care workers or other attendants;
- clear criteria for de-isolation being available and disseminated;
- health care workers trained to undertake mental health risk assessments, identify signs and symptoms of anxiety and depression, and provide the necessary support – this is important because individuals isolated for extended periods may experience greater levels of anxiety, depression, anger or feelings of imprisonment;
- measures to minimize the risk posed by infectious patients to health care workers, other patients and visitors; for example, adequate ventilation (e.g. 12 air changes per hour [ACH] with natural ventilation), provision of respirators for health care workers and medical masks for visitors, facilities for hand washing and sanitization, and regular disinfection of floors; and
- open spaces that allow patients to socialize without the risk of transmission.

Fig. 2.2. Inpatient care ward for infectious TB patients



Source: TB and Leprosy Hospital, Damien Foundation, Shambhuganj, Bangladesh.

Policy for visitors and attendants

It is important to keep to a minimum the number of people visiting isolated patients, while still allowing some visitors or attendants for the patient's emotional well-being and care. Patients should be educated about the cause, spread and prevention of TB infection. Also, the need for isolation or admission and for restrictions on the number of visitors should be explained. Children, pregnant women and people who are immunocompromised should not be allowed to enter isolation areas. Visitors should wear a medical mask or respirator at all times; they should not sit or lie down on the patient's bed; and they should maintain personal hygiene through hand washing or use of alcohol hand rub before and after meeting the patient. If a patient is ambulatory and weather permits, visitors may be encouraged to meet the patient in a designated outdoor space if available.

Respiratory separation is also possible at home, in situations where patients are sputum smear positive but do not require admission or where patients have no comorbidities and not suffering from adverse events. The person may be provided a separate, well-ventilated room, given a medical mask, and told not to visit crowded places or use public transportation; in addition, household members should be trained in the basics of TB IPC.

Key point: National programmes should promote good-quality patient care and support measures to provide effective TB treatment with decentralized models of care. Isolation is usually only necessary for a brief period – typically a couple of weeks – until the patient is no longer infectious.

2.2.3 Prompt TB treatment

Evidence

A systematic review found that delay in initiation of TB treatment contributed to an extended period of infectiousness and increased the risk of ongoing TB transmission *(13)*. Also, in settings where patients rapidly received effective TB treatment guided by DST, health care workers experienced an absolute TB risk reduction of 3.4% compared with settings where treatment was delayed. A reduction of 6.2% in TB incidence was noted among HIV-positive individuals who were admitted to health care facilities, from 8.8% to 2.6%, following the implementation of specific IPC measures (including prompt TB treatment, which also has a direct effect on survival) *(13)*. Patients on TB treatment appear to be less infectious than patients not receiving effective TB treatment; however, data are lacking on the exact time it takes for patients to become noninfectious and there is considerable variation in the time taken to achieve bacteriological (sputum smear and culture) conversion in patients receiving appropriate first-line or second-line TB treatment *(4, 6, 7, 25)*. Experts have suggested that reduction in infectiousness occurs much earlier than culture or smear conversion – possibly as early 2–3 days after the initiation of effective TB treatment among patients with drug-susceptible TB (DS-TB) and 2 weeks after effective TB treatment among patients with DR-TB.

Implementation considerations

National TB programmes (NTPs) should ensure prompt initiation of TB treatment after diagnosis *(4, 25)*. Access to WHO-recommended rapid tests (e.g. Xpert® MTB/Rif or Truenat TB assay) paves the way for earlier detection and prompt start of treatment *(25)*. If rifampicin resistance is detected *(4)*, access to rapid testing for resistance to second-line drugs and phenotypic DST should also be ensured so that the treatment can be tailored to the resistance pattern. NTPs should also extend support (e.g. for treatment adherence and linkage to social protection schemes to prevent financial hardship, nutritional support and health education to patients and their families) to increase the likelihood that treatment is completed. All these measures help to render the patient noninfectious as early as possible.

Box 2.2. FAST: an approach for rapid detection, separation and early start of TB treatment *(26)*

TB patients who are undiagnosed and are not being treated present a particular risk for transmission of TB. Undiagnosed TB patients may be in clinics, waiting areas, hospital emergency rooms or wards for general medical or other clinical services. Asking all those seeking care at a health care facility about TB symptoms can help to diagnose previously undetected TB. Prompt collection of a sputum specimen for a WHO-recommended rapid diagnostic test, and clinical evaluation with chest X-ray can speed up diagnosis. Patients diagnosed with TB or multidrug-resistant TB (MDR-TB) should be triaged to a well-ventilated area to prevent transmission to other patients, and treatment should be started as soon as possible, to reduce the duration of infectiousness. FAST is an approach that focuses on **f**inding TB cases **a**ctively, **s**eparating safely and **t**reating effectively *(26)*. The FAST strategy builds on a renewed appreciation that effective TB treatment rapidly reduces the spread of TB spread, even before the sputum smear and culture turn negative. FAST aims to triage individuals with respiratory symptoms, use rapid diagnostics to identify *M. tuberculosis*, undertake DST, and immediately start effective TB treatment and monitoring.

Source: Nardell (2019) *(26)*.

2.2.4 Respiratory hygiene

Evidence

Respiratory hygiene (or hygiene measures) is defined as the practice of covering the mouth and nose during breathing, coughing or sneezing to reduce the dispersal of airborne respiratory secretions that may contain *M. tuberculosis* bacilli; for example, by wearing a respirator, a medical mask or a cloth mask, or covering the mouth with a tissue, sleeve, or flexed elbow or hand, followed by hand hygiene *(6, 7, 13)*. Respiratory hygiene (including cough etiquette) is a key measure for interrupting transmission. Although there is literature on the dynamics of cough aerosols containing *M. tuberculosis*, data to compare the effectiveness of different respiratory hygiene manoeuvres are scarce.

Only five relevant studies were identified through a systematic review of evidence ahead of the latest update of the WHO guidelines *(13)*. Meta-analysis was not possible because of significant differences between the intervention and study populations. Despite the low certainty of the evidence, the GDG deemed the recommendation for respiratory hygiene to be strong, given its potential for preventing a life-threatening or catastrophic situation, which could occur if health care workers or other contacts were to develop TB infection and progress to TB disease. The GDG stressed that the use of this measure as part of a package of interventions can help to reduce TB transmission. One of the studies included reported a reduction of 4.1–12.4 tuberculin skin test (TST) conversions per 1000 person-months among health care workers when surgical mask were used by patients until isolated (alongside other TB IPC interventions). Another study reported a reduction of about 15% in risk of incident TB infections among health care workers when people with presumed or confirmed TB used surgical masks. However, the effect of wearing a medical mask in reducing incidence of TB disease is modest or absent.

Implementation considerations

Respiratory hygiene measures should be promoted among individuals with confirmed or presumed TB in all health care settings, and in other settings where the risk of transmission is high (e.g. in households and nonhealth care congregate settings). These measures should be brought in regardless of the burden of TB disease in the given country, setting or community, and regardless of the level of the health care facility (primary, secondary or tertiary). Places where it is particularly important to promote such measures include consultation rooms, inpatient facilities, and the waiting areas in health facilities. Areas to be considered for programmatic implementation of respiratory hygiene include the following:

- Health education on respiratory hygiene and cough etiquette for health care workers, patients and community members.
- Counselling on respiratory hygiene for TB patients and their families, as part of a comprehensive package of TB care.
- Efforts to mainstream respiratory hygiene practices or cough etiquette as standard practice for all individuals with a cough in the health facilities or congregate settings, not just at TB facilities. Such efforts will also help to alleviate the social stigma associated with TB.
- Provision of disposable handkerchiefs and medical masks to all symptomatic individuals. All such individuals should be instructed to cover their mouths until TB is ruled out.
- When designing guidelines, protocols and SOPs for children with TB, it is important to note that children are generally paucibacillary and contribute much less to *M. tuberculosis* transmission, and that those with severe illness may have difficulty in breathing when masked.
- Consideration that the implementation of respiratory hygiene activity at health facilities and in congregate settings using medical masks requires additional funds, and adequate reflection of this situation in annual health facility IPC plans and budgets.
- Consideration that medical masks are a standard item for procurement at health care facilities, along with other medical supplies. Enough medical masks should be procured to cater for all patients

with a cough visiting the health facility, all patients diagnosed with TB and all accompanying visitors. Supply problems are sometimes encountered in congregate settings because medical masks may not be a standard item for procurement; TB programme managers should advocate with the authorities at such facilities to ensure that a budget is allocated for procurement of medical masks.
- Signage can be an effective way of educating patients, visitors and staff, and of reinforcing key messages. All waiting areas in the facility should display posters or banners in local languages with simple messages. The signage should promote cough etiquette and knowledge of the signs and symptoms of TB and should explain that TB is both preventable and curable.

2.3 Staff training and education on TB IPC

2.3.1 TB prevention among health care workers

Health care workers are at increased risk of acquiring TB infection and disease when IPC measures are not effective. These workers have the right to work in a safe environment, and a professional obligation to act in a way that minimizes the risk of harm to those under their care *(24)*. Governments and programmes should therefore strengthen measures to reduce these risks, as follows:

- uninterrupted access to PPE, including appropriately fitting respirators, should be ensured for health care workers, particularly those engaged in TB patient care;
- all health care workers should receive appropriate information and rapid TB diagnostic testing if they have signs and symptoms suggestive of TB *(27)*;
- all health care workers (including those newly recruited) and other staff engaged in direct patient care should receive periodic screening for TB symptoms, chest X-rays and testing for TB infection *(2)*;
- based on the results of the evaluation, health care workers should receive, free of charge, either TPT (preferably a shorter rifamycin-containing TPT) or a full course of TB treatment;
- all health care workers should be given information about HIV and access to HIV testing and counselling *(27)* – if diagnosed with HIV, they should be offered a package of HIV prevention, treatment and care that includes regular screening for TB disease and access to ART and TPT;
- HIV-positive health care workers should not be allocated to posts involving care of patients with known or presumed TB or DR-TB; instead, they should be offered positions where exposure to untreated TB is low; and
- if found to have TB disease, health care workers should be notified to the NTP and linked to any other benefits (e.g. paid leave and illness allowance), as per the country's national occupational health policy.

Annex 4 provides a template for routine TB screening among health care workers and **Annex 5** provides an example of a register that can be used to record screening and treatment progress.

2.3.2 Training of staff

Training and continuing education are key to the successful implementation of administrative controls and other aspects of IPC. All health care and other personnel working in the facility – whether clinical, laboratory, maintenance, office or other staff and volunteers who routinely work in the facility – must receive TB IPC training. In a large institution, clinical and nonclinical staff may be trained separately, to allow for open dialogue and free discussion on ways to strengthen TB IPC. The training and education should aim to cover the following areas:

- *M. tuberculosis* and how TB bacilli cause infection and disease, and the differences between the infection and the disease;
- transmission and acquisition of TB (e.g. through coughing, sneezing, speaking or ingestion);
- signs and symptoms of TB disease;
- how overcrowding and other environmental factors affect TB transmission;

- how environmental controls can reduce the risk of transmission in health facilities or congregate settings;
- how and when to use appropriate respiratory protection such as respirators and medical masks;
- fit-testing and seal checks (**Fig. 4.1**), and how to store and dispose of used respirators and medical masks;
- information on the availability and effectiveness of treatment for both TB disease and TB infection, and communication of the fact that shorter regimens with improved safety profiles are now available for the treatment of DS-TB, DR-TB and TB infection; and
- the importance of screening all individuals with signs and symptoms of TB using appropriate referrals, including access to chest X-ray, tests for TB infection and linkage with TB treatment or TPT.

Box 2.3 summarizes suggested content on triage that may be covered during training, sensitization or review meetings involving staff and volunteers. This content may be used to develop a standard questionnaire and checklist to assist health care workers in performing triage *(28, 29)*.

Box 2.3. Key content for training and sensitization on triage

- ➔ Why triage? Principles underlying triage and practical aspects of its organization.
- ➔ Steps to take once individuals with signs and symptoms suggestive of TB are identified:
  - education on cough etiquette;
  - promotion of the use of medical masks;
  - respiratory separation and evaluation for TB; and
  - prompt TB treatment if TB disease is detected.
- ➔ Personal protection for health workers and staff:
  - education on how to wear a particulate respirator correctly;
  - the importance of continued use of masks or respirators;
  - how to avoid contamination during use, removal and disposal of medical masks and respirators; and
  - when to change the medical mask or respirator (e.g. when it gets wet or dirty with secretions).

Source: Visca et al. (2021) *(28)*; TB/COVID-19 Global Study Group (2021) *(29)*.

2.3.3 Education of patients and visitors

In addition to regular training and sensitization of staff and volunteers, the IPC committee and the staff in charge of the facility should ensure that culturally appropriate education material and messages are available in the local language, to educate patients and visitors. Such education material should be used in signage, brochures, posters or videos displayed in waiting areas or offered through individual or group education sessions by trained facility staff. The following are template messages that may be developed to suit the local context:

- TB spreads through the air when an infectious TB patient coughs, sneezes or sings;
- if you have a cough, you need to have it investigated with a sputum examination, chest X-ray or other investigation advised by health workers;

- cover your mouth and nose with a tissue or clean handkerchief when you cough or sneeze – in the absence of a handkerchief or tissue, cough or sneeze into your elbow;
- follow cough etiquette and do not spit indiscriminately; collect sputum in a dedicated container and learn how to dispose of it safely when at home;
- sleep in a well-ventilated room, preferably with cross-ventilation; ensure your other rooms are also well ventilated;
- do not travel to or visit congregate settings if you have a cough or if TB is diagnosed;
- if TB is diagnosed:
  - start treatment immediately and complete it as advised by health workers;
  - encourage your close contacts and people in your household to take up TPT; and
  - ensure you adhere to your treatment plan – regular uninterrupted TB treatment is critical to reduce transmission of TB to family members and contacts and for you to get cured.

Fig. 2.3. Examples of education sessions on TB IPC for visitors and health care workers in health facilities



Source: US CDC (2022) *(30)*.

Annex 6 provides examples of education materials that can be developed for different stakeholders. These can be tailored to the local context and adapted for use at health facilities. **Box 2.4** describes how a TB IPC toolkit was implemented in Nigeria and **Box 2.5** describes how the Ministry of Health and Family Welfare (MoHFW) in India, implemented TB IPC interventions.

Box 2.4. Country experience – implementing a TB IPC toolkit in Nigeria

In 2015, the TB BASICS toolkit, developed by the United States Centers for Disease Control and Prevention (CDC), was piloted in Nigeria. The pilot implementation was done in collaboration with the MoH at seven facilities across three states that collectively served a population of 1.48 million, including about 1600 TB patients, at the time of the pilot. The intervention comprised four steps: training of health care workers, baseline assessment, implementation of changes to fill the gaps, and follow-up assessments.

About 50 health care workers received a 3-day training of trainers on the TB IPC toolkit. Knowledge gaps were identified, and education materials were provided for dissemination to other staff. The baseline assessment included interviews, direct observation of activities and policy review. Assessment teams were made up of MoH staff from the state, regional and national levels; representatives from the implementing partners (CDC, WHO and the US President's Emergency Plan for AIDS Relief [PEPFAR]); health care providers from the selected facilities; and residents from the Nigeria Field Epidemiology and Laboratory Training Program (NFELTP).

The assessment teams noted particularly large gaps in the implementation of administrative controls. Sites received feedback, which was used to develop facility-specific plans. Interventions that did not require additional funds were implemented immediately, followed by the acquisition of posters, pamphlets and supplies such as PPEs. Renovations were done as required and an occupational health programme was implemented. Three follow-up assessments were conducted at 2-month intervals by NFELTP residents, with the full assessment team joining for the final evaluation. The table below summarizes the results at baseline and at the final 6-month follow-up.

Class of indicator	Total measures	Number of measures in place at all facilities	
		At baseline	At 6-month follow-up
Administrative controls	27	2	23
Environmental controls	7	1	4
Respiratory protection	3	0	3

In addition to the marked improvement in the number of IPC measures implemented, three cases of TB among health care workers were detected, about 200 health care workers were trained. The pilot study helped to build local capacity to implement and monitor TB IPC interventions.

Source: Dokubo et al. (2016) *(31)*.

Box 2.5. Country experience – evolution of TB IPC efforts in India

In India, the Ministry of Health and Family Welfare (MoHFW) has proactively implemented tuberculosis (TB) infection prevention and control (IPC) interventions since 2010, as part of the broader national airborne infection control (AIC) policy. Following the release of the World Health Organization (WHO) guidelines on TB IPC in 2009, the MoHFW established the National AIC Committee. The committee had a mandate to serve as a multi-speciality coordinating group to develop national AIC guidelines for India and provide guidance for their implementation, evaluation and revision. In 2010, national guidelines on AIC were developed, with support from WHO India *(1)*. The committee recommended to undertake AIC baseline assessments and capacity building at 35 health facilities (from primary to tertiary level), in both the public and private sectors in three states, and to start pilot implementation *(2)*. The National Institute of Tuberculosis and Respiratory Diseases (NITRD), New Delhi, organized a national capacity-building workshop with technical support from WHO India and the United State Centers for Disease Control and Prevention (US CDC). In addition, PATH – an international, global health organization (USA) – supported capacity-building of architects and engineers and organized an experience-sharing workshop. During the pilot phase it became clear that the effective implementation of AIC policies and practices requires a combination of capacity-building and systems strengthening. Following the pilot phase, the implementation of TB IPC was prioritized in settings with a high risk of TB, such as multidrug-resistant TB (MDR-TB) centres, TB culture laboratories and anti-retroviral therapy (ART) centres. TB IPC training was mandated for staff at these facilities. In 2014–15, an AIC assessment was conducted at 30 ART and TB centres across five states. The assessment highlighted the need to strengthen implementation of TB IPC, and enhance resource allocation and the availability of trained staff to implement TB IPC *(3)*.

In 2014, experts from US CDC and the Harvard School of Public Health provided training in engineering aspects of infection control. The training was given to faculty and staff at the Lokmanya Tilak Municipal Medical College – a large medical college hospital in Mumbai – and to engineers and medical officers working with the Municipal Corporation of Greater Mumbai (MCGM). An assessment of MCGM health facilities was undertaken and various cadres of health workers were trained. In 2018, the US CDC and MCGM established an AIC unit to support TB IPC training, 4-monthly facility assessments and development of site-specific AIC plans, including timelines and identification of those responsible for mitigating identified deficiencies. This support was later extended to all 24 administrative units in Mumbai.

In 2020, the MoHFW updated the national guidelines for IPC *(4)* and aligned the TB IPC section with the latest WHO recommendations *(5)*. In addition, information and communication materials targeting community, health workers and the media were developed and were widely disseminated, including during the coronavirus (COVID-19) pandemic. Since 2022, the MoHFW – with support from the Foundation for Innovative New Diagnostics (FIND), WHO India, the US CDC and NITRD – has implemented independent AIC assessments, facility upgrades and training at more than 100 institutions with co-located centres for drug-resistant TB, using the C19RM funding from the Global Fund to Fight AIDS, Tuberculosis and Malaria. The NTEP has also implemented a project (Germ-free TB IPC) that is supported by the US CDC and SHARE India at 60 facilities in 10 states. The project developed and tested mentorship models, training content, toolkits and awareness materials for capacity-building of health care workers.

The MoHFW India considers TB IPC to be an integral component of the prevention pillar of the national TB strategic plan, along with TB preventive treatment (TPT) and, in the future, evidence-based adult TB vaccination to end TB. In additions at subnational level, states are taking innovative action to implement TB IPC measures, such as establishment of "cough corners" in health facilities to educate, segregate and fast-track symptomatic individuals, and distribute AIC kits along with education materials to the patients and visitors (e.g. Gujarat, Himachal Pradesh and Kerala).

References for Box 2.5

1. Guidelines on airborne infection control in healthcare and other settings. New Delhi: Directorate General of Health Services Ministry of Health & Family Welfare; 2010 (https://tbcindia.gov.in/WriteReadData/l892s/4830321476Guidelines_on_Airborne_Infection_Control_April2010Provisional.pdf)
2. Parmar MM, Sachdeva K, Rade K, Ghedia M, Bansal A, Nagaraja SB et al. Airborne infection control in India: baseline assessment of health facilities. Indian J Tuberc. 2015;62:211–7. doi: https://doi.org/10.1016/j.ijtb.2015.11.006.
3. Sachdeva K, Deshmukh R, Seguy N, Nair S, Rewari B, Ramchandran R et al. Tuberculosis infection control measures at health care facilities offering HIV and tuberculosis services in India: A baseline assessment. Indian J Tuberc. 2018;65:280–4. doi: https://doi.org/10.1016/j.ijtb.2018.04.004.
4. National guidelines for infection prevention and control in healthcare facilities. New Delhi: Directorate General of Health Services Ministry of Health & Family Welfare; 2020 (https://www.mohfw.gov.in/pdf/National%20Guidelines%20for%20IPC%20in%20HCF%20-%20final%281%29.pdf).
5. WHO guidelines on tuberculosis infection prevention and control, 2019 update. Geneva: World Health Organization; 2019 (https://apps.who.int/iris/handle/10665/311259).

3. Environmental controls

Environmental controls are the second pillar of the triad of IPC measures and should be implemented in combination with other TB IPC measures. The aim is to reduce the concentration of infectious particles in the air through a mix of interventions for dilution, removal, filtration or disinfection. In settings with a high risk of TB transmission, to protect health care workers and other individuals, WHO recommends the use of upper-room GUV systems and ventilation systems, including natural ventilation, mechanical ventilation and recirculated air through high-efficiency particulate air (HEPA) filters (**Table 1.2**). The evidence reviewed by the WHO GDG includes a study that showed an 8.8% reduction in TST conversion among health workers with the use of a package of interventions, including placement of upper-room GUV fixtures in patient rooms and common areas. A study using mechanical ventilation with GUV systems showed a 4.1% reduction *(13)*, and data extrapolated from two animal studies showed a relative risk reduction of TB infection of about 72% *(13)*. This chapter discusses GUV and ventilation systems in detail.

3.1 Upper-room GUV systems

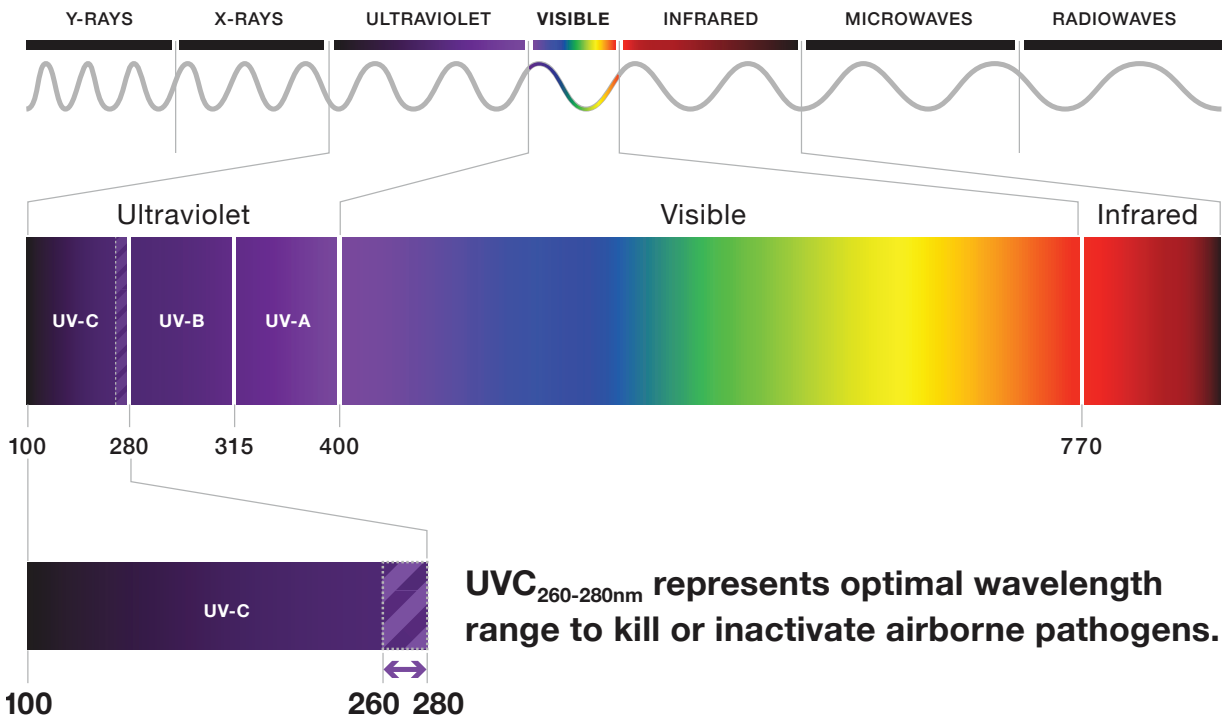
GUV is the current term for what used to be termed "ultraviolet germicidal irradiation" (UVGI). The term "GUV" is preferred because patients and the community may wrongly associate "irradiation" with exposure to harmful ionizing radiation that may cause cancer. The effectiveness of GUV systems depends on the specifications of the GUV fixtures installed, the place of installation, quality of maintenance, the duration of exposure of contaminated air to ultraviolet (UV) light (i.e. total exposure time) and the adequacy of air mixing to ensure exposure of all infectious particles to the UV light. Upper-room GUV systems can be installed in both health facilities and congregate settings where there is a high risk of *M. tuberculosis* transmission. Owing to the need for capital investment, technical capacity and funding for continued maintenance, large-scale implementation of GUV systems is less feasible in low- and middle-income countries; however, implementers in such settings may prioritize locations with the highest risk of TB transmission for the installation of GUV systems.

Key point: GUV systems should be installed as part of the package of IPC interventions, not as a standalone intervention, to avoid giving a false sense of security when administrative controls and respiratory protection measures are lacking, particularly in settings with high TB transmission.

Fig. 3.1 depicts the electromagnetic spectrum of radiation *(20)*. UV is the region of the electromagnetic spectrum from 100 to 400 nm, which is not visible to the human eye and is further split into subregions A, B and C. The *visible light* spectrum runs from about 400 to 700 nm whereas *infrared waves* may have wavelengths closer to visible light, but which are perceived more as heat. The UV light C (UVC), with wavelengths of 260–280 nm, is considered optimal for killing or inactivating most bacteria, viruses and fungi. It works by damaging DNA, RNA or proteins *(20)* in the microorganism and interrupting cell replication. The subregion of 200–260 nm is also germicidal but to a lesser extent and may have a better safety profile. The UVC dose required to inactivate *M. tuberculosis* is generally highly effective against most viruses and other bacterial pathogens; fungal spores are more UV-resistant, but they do not spread from person to person. Commercially available germicidal lamps contain mercury

vapours under low pressure that emit nonionizing electromagnetic radiation in the UVC wavelength range with about 90% of the total spectral power emitted at 254 nm (UVC_{254}). The utility of UVC_{254} to disinfect room air and reduce the transmission of disease has been known since the late 1930s, when it was first applied in schools to combat an epidemic of measles. Since then, much has been learned about the efficacy and safety of UVC_{254} to prevent *M. tuberculosis* transmission.

Fig. 3.1. Electromagnetic spectrum from UV to infrared radiation



Source: Curry International Tuberculosis Center (2022) *(20)*.

Upper-room GUV systems aim to create a disinfection zone located above the people occupying a room. They kill or inactivate any airborne pathogens that pass through the disinfection zone and thus reduce the risk of airborne infection. Upper-room GUVs can be considered an add-on to ventilation strategies in high-risk areas, particularly where unidentified infectious patients may be present. Such high-risk areas include emergency departments in hospitals, waiting rooms in busy health facilities, congregate settings or homeless shelters. GUV systems may also be suitable for:

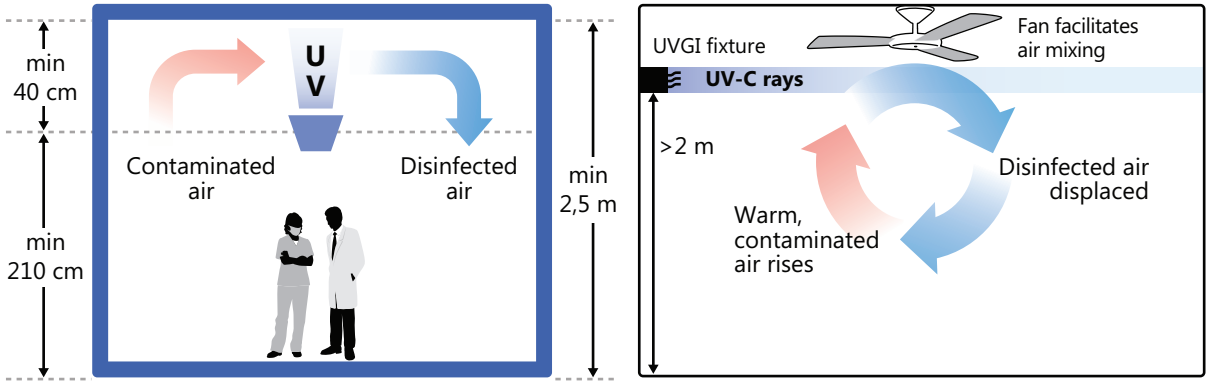
- inpatient facilities for TB and DR-TB;
- sputum induction booths and TB treatment centres;
- isolation areas;
- facilities where natural ventilation is restricted by closed doors and windows because of cold weather; and
- spaces with insufficient or no mechanical heating, ventilation, and air conditioning (HVAC) systems.

3.1.1 GUV fixtures

Current upper-room GUV systems can disinfect the air within a space of about 40 cm from the lamp. The GUV fixture is therefore placed 40 cm from the ceiling, so that the space in between represents an area where UV radiation is effective. As with any light, the energy of UV light diminishes as the distance from the source increases. Therefore, the number of GUV fixtures required for a room depends on the size of the room. A room with GUV systems should have a ceiling that is high enough to prevent people looking into the lamp; this is shown schematically in **Fig. 3.2** with a ceiling 2.5 m high, a

shielded GUV device and a lamp that is oriented towards the roof. For the device to be effective, a "river" of circulating air needs to be created, to allow the "dirty" air to pass periodically through the space that has the UV radiation, to be "cleaned".

Fig. 3.2. A "river of air" facilitates movement of contaminated air for exposure to GUV

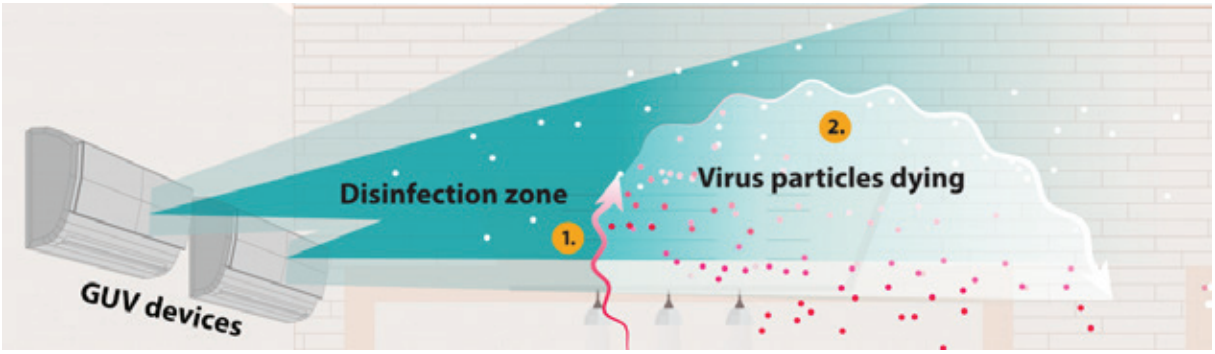


Source: images supplied by GB Migliori.

The GUV fixtures may be suspended from the ceiling or attached to the walls. The bottom of the fixture is usually shielded or louvred to direct the radiation upward above a predetermined height (**Fig. 3.3**). The aim is to inactivate airborne infectious agents in the upper part of the room, while minimizing the exposure to radiation of people in the lower part of the room. Panel D of **Fig. 3.3** shows different types of GUV fixtures.

Fig. 3.3. Examples of GUV fixtures

Panel A. Scheme of louvred[a] upper-room GUV fixture and its functioning[b]



[a] Louvres are window blinds or shutters with horizontal slats that are angled to admit light and air.

[b] Air rises to the disinfection zone (Area 1) from the HVAC system, fans or open windows. The airborne pathogens are killed once they receive an appropriate amount of UVC light (Area 2). The particles remain in the air but are no longer infectious. For airborne organisms, upper-room GUV systems provide air changes per hour that are similar to the introduction of clean air into the space.

Source: US CDC (2021) *(32)*.

Panel B. Example of an open upper-room GUV fixture for spaces with ceiling heights of at least 2.7 m



Source: End TB Transmission Initiative (2017) *(33)*.

Panel C. Example of a louvred upper-room GUV fixture for spaces of at least 2.4 m in height



Source: End TB Transmission Initiative (2017) *(33)*.

Panel D. Different types of ceiling, corner and upper-room GUV fixtures



GUV: germicidal ultraviolet light; HVAC: heating, ventilation and air-conditioning; UV: ultraviolet.

Source: Stop TB Partnership (2009) *(12)*.

Examples of GUV fixtures that are used to produce UVC wavelengths are *(20)*:

- low-pressure mercury (Hg) lamps (emitting UVC at 254 nm);
- krypton-chloride lamps (emitting UVC at 222 nm);
- pulsed xenon lamps (emitting UVC at 220–750 nm); and
- wavelength-specific light-emitting diodes (emitting UVC at 260–280 nm).

The rest of this section discusses features of UVC_{254}, which is the most common wavelength obtained in commercially available fixtures.

Factors influencing the effectiveness of UVC_{254}

The effectiveness of UVC_{254} increases with an increase in *(20)*:

- **irradiance** – the brightness or intensity of the UVC_{254} lamp or radiant flux per unit area, which is typically expressed in microwatts per square centimetre ($\mu W/cm^2$);
- **length of pathogen exposure time** – the duration that the infectious particles containing a pathogen remain in the area of high irradiance; the exposure time will depend on how quickly the air containing infectious particles moves past the lamp or through the disinfection (irradiated) zone;
- **dose of UVC_{254}** – a product of the irradiance ($\mu W/cm^2$) and length of exposure (seconds), expressed in microjoules per square centimetre ($\mu J/cm^2$); effectiveness and safety criteria for UVC_{254} are based on the dose of UVC obtained;
- **output of the UVC_{254} fixture** – relates to the UVC_{254} wattage (which may be a fraction of the stated lamp wattage), and the condition of the lamp and fixture; lamp intensity decreases with age and dust accumulation; also, the design of the UVC_{254} fixture may reduce the functional output of UVC_{254};
- **proximity of infectious particles to the UVC_{254} lamp or fixture** – depends on the placement and number of UVC_{254} lamps used; adequate mixing of the room air is needed to move infectious particles through the disinfection zone, to effectively inactivate pathogens when using upper-room UVC_{254} (**Fig. 3.3**, Panel A);

The effectiveness of UVC_{254} decreases with the following:

- **High humidity** – for optimum efficiency, relative humidity should be controlled to 60% or less (ideally at 30–60%) *(13, 34–36)*. The effectiveness of GUV fixtures appears to reduce when the humidity in the ambient air is above 50–60% *(13)*. More evidence is needed to determine the effectiveness of GUV fixtures above the 70% relative humidity threshold. UVC_{254} dosing requirements increase when the humidity of the air is greater than 70%; generally, the UVC dose will need to be increased by up to two thirds to compensate for constant humidity in this range. If high humidity is a normal occurrence, it may be necessary to install a system that has greater upper-room irradiance levels or to reduce the humidity using air-conditioning *(35)*.
- **Lower ambient temperatures** – a temperature range of 20–24 °C is consistent with the optimal use of the low-pressure mercury lamps used in upper-room GUV systems. UVC_{254} dosing requirements increase when ambient temperatures are below 15°C.

The effectiveness of an upper-room GUV system relies on air mixing between the upper and lower parts of a room. Factors that may affect the vertical air movement and transport of the infectious microorganisms to the upper portion of the room include the temperature differential between the supply air and room air, ventilation rate and velocity of air emitted from the ventilation diffuser.

3.1.2 Considerations for the deployment of GUV systems in programmatic settings

This section outlines various factors to consider when deploying GUV systems in programmatic settings *(20)*.

Suitability of a room for installation of GUV fixture

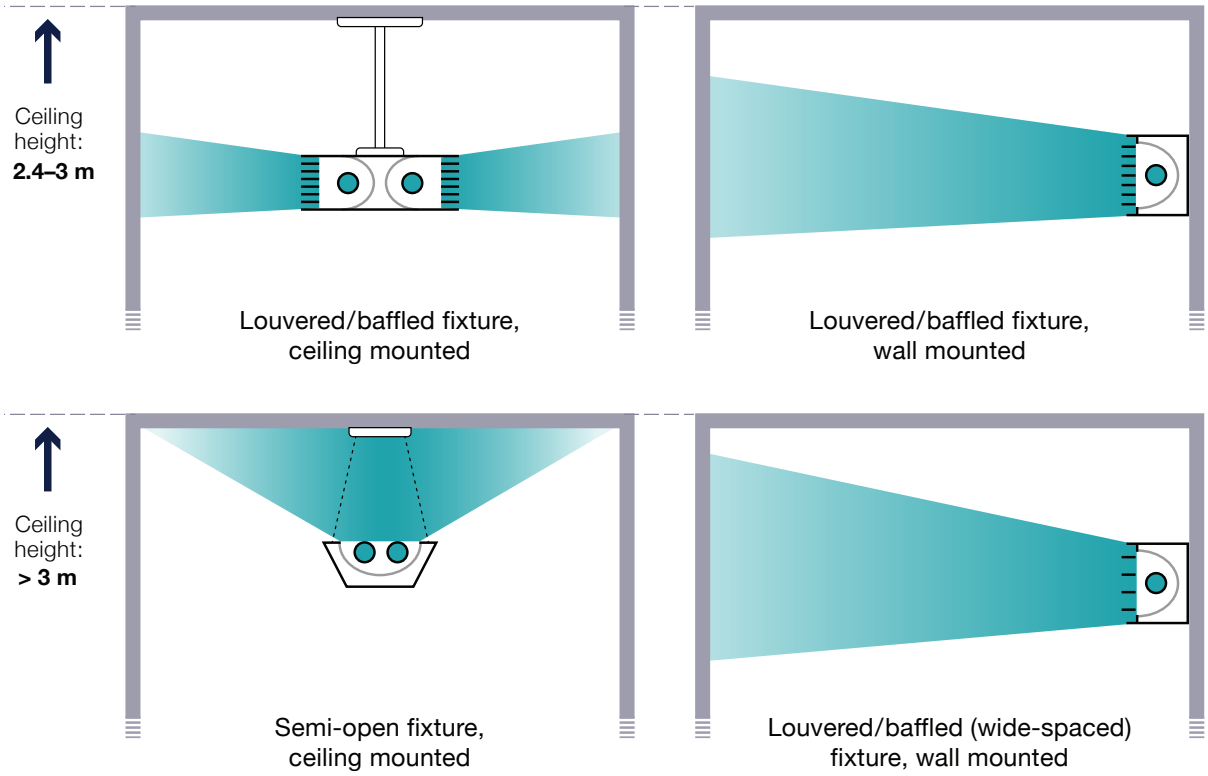
In determining the suitability of a room for the installation of a GUV fixture, it is important to consider architectural details as well as utilities and other engineering features in the upper room that may affect UVC coverage. For example, ceilings and walls may need to be repainted to reduce reflection and improve UVC_{254} safety. A room must meet the following criteria for upper-room UVC to be used:

- ceiling height at least 2.4 m – for many commercially available GUV fixtures, a minimum ceiling height of 2.6–2.7 m is recommended;

- the GUV fixtures must be installed at a height of at least 2.1–2.3 m above the floor, to ensure that people cannot look directly into the lamps or accidently bump into the fixtures;
- in rooms with lower ceilings (2.4–3.0 m), a louvred or baffled GUV fixture is needed to ensure that stray light does not overexpose occupants in the room or space; in rooms with higher ceilings (>3 m), GUV fixtures with wider spacing between the slats, or open GUV fixtures may be used;
- larger rooms or spaces may require more than one GUV fixture;
- in congregate settings, use of bunk beds should be avoided unless the rooms have very high ceilings and the GUV fixtures are placed high enough above the bunk beds to avoid overexposure; and
- fans for mixing the room air or appropriate ventilation diffusers are recommended to help increase airflow from the occupied space to the upper room and from the upper room back to the occupied space *(37)*; the room-air fans or HVAC system fans should operate continuously while the building is occupied.

Fig. 3.4 shows which types of upper-room GUV fixtures are best, depending on the room height.

Fig. 3.4. Types of upper-room GUV fixtures best suited for different room heights



GUV: germicidal ultraviolet light.

Source: Curry International Tuberculosis Center (2022) *(20)*.

The degree of disinfection achievable using a GUV device also depends on the **UVC dose**. Pathogens must either receive a dose that is sufficient to inactivate them during one pass through the disinfection zone, or they must pass through the disinfection zone multiple times until they receive a sufficient cumulative UVC dose to be inactivated.

The target UVC_{254} dose required to effectively disinfect for TB can be calculated using the size of the room in volume (height × width × length) or area (width × length). The volumetric dosing criterion is **12 mW/m^3** and the area dosing criterion is **0.035 mW/m^2**, assuming a maximum functional ceiling height of 3 m or less. A separate set of exposure dose criteria are used for the safety of room occupants.

For upper-room UVC_{254} systems to optimally disinfect the air, the air from the breathing zone must pass through the disinfection zone or upper room before returning to the breathing zone. **Adequate "air mixing"** is a key component of an upper-room GUV system design plan. Existing ventilation systems may need to be supplemented with ceiling or wall fans, or different supply-air diffusers, to accomplish adequate airflow patterns for this purpose. In the latter case, it may be necessary to keep the ventilation system fan operating at all times (i.e. constant air volume setting) during building occupancy, to ensure adequate air mixing.

The simplest way to check airflow patterns is with ventilation "smoke tubes" that can be used to show the air movement. The goal is to see the smoke moving up to the disinfection zone and back to the breathing zone in several locations. The critical criterion is the direction rather than the speed of the smoke movement.

Appropriate installation of upper-room GUV fixtures has been shown to achieve up to 24 ACH. Specialized expertise and equipment are needed to establish an effective upper room GUV system. Only a qualified contractor, working closely with the representative of a GUV fixture manufacturer, may design, install and test an upper-room UVC_{254} system.

Placement and number of fixtures

GUV fixtures should be placed such that radiation in the upper room is relatively uniform, continuous and complete. The number of fixtures needed to reach the target effective dose depends on the room volume (in m^3), area (in m^2) and shape, and the UVC_{254} output of the fixtures. **Annex 7** has examples that illustrate how to choose GUV fixtures.

3.1.3 Exposure, safety and maintenance of upper-room GUV fixtures

Measurement of irradiance from GUV fixtures

To ensure both efficacy and safety (particularly with upper-room UVC_{254}), irradiance should be measured and systematically recorded at the initial installation, after annual maintenance or in cases of any reported complaints or concerns related to the upper-room GUV system. The measurements and fixture maintenance should be undertaken by an industrial hygienist, health physicist, qualified engineer or technician, or a hired professional trained in measuring UV. Where feasible, training to build competency in taking measurements may also be developed within the facility. The effectiveness of GUV and the safety of fixtures are measured using a radiometer, also commonly known as a UVGI meter[15] (see **Annex 8**). Most radiometers are programmed to display results in total irradiance.[16] Radiometers take measurements to confirm the following *(20)*:

Performance: The radiometer is used to check that the UVC_{254} source (the lamp) is working. The radiometer should be calibrated to measure the UVC irradiation wavelength of interest (e.g. UVC_{254}), in accordance with the lamp manufacturers' specifications.

Safety: The radiometer is used to check that the level of **effective irradiance** in the occupied areas is safe for people in the room (when using upper-room UVC_{254}). A broad range of possible irradiation levels (0.1–2000 $\mu W/cm^2$) is needed to measure both the low end of the range (to gauge safety levels in the occupied zone of a room) and the upper end of the range (to check GUV fixture performance). Proper radiometer and detector selection is critical to verify the expected irradiance levels. Depending

[15] Examples of devices used to monitor UV dose levels include the International Light meter model 1400A with SEL240 detector and the Gigahertz-Optik X1–1-UV-3718 UVC radiometer.

[16] The actual irradiance at each wavelength is referred to as the spectral irradiance. The total irradiance (for photobiologic activity) at each wavelength can vary and differs from the measured effective irradiance (except at 270 nm, where they are the same). Most radiometers are programmed to display results in total irradiance rather than effective irradiance. The relationship between effective irradiance and spectral irradiance for each wavelength requires a conversion factor. For UVC_{254}, multiplying the total irradiance by 2 gives the effective irradiance.

on the type of radiometer, two separate devices may be needed to accurately obtain both sets of measurements (**Annex 8**).

Safety

Safety is an important consideration when using UVC_{254} in programmatic settings. Exposure to UVC_{254} radiation can occur directly or indirectly (e.g. while cleaning a fixture with the lamp turned on, or if UVC_{254} is unexpectedly reflected by a UV-reflective surface on the ceiling and down to occupied areas). Overexposure to UVC_{254} can cause temporary harm to the eyes (photokeratitis) and skin (erythema). Proper design, installation, and safety and maintenance protocols are essential to minimize the chances of overexposure *(20)*. Systems must be monitored to ensure that optimal UV dose levels are achieved within a permissible limit of irradiance. People in the room that houses a GUV device should be shielded from excessive exposure by shields attached to the fixtures (in the form of louvres or baffles) to block the radiation and prevent it from descending below the horizontal plane of the fixture. Unshielded GUV lamps should be used only in areas that are not occupied, and the following safety features should be installed to avoid overexposure *(20)*:

- a power cut-off switch that automatically turns the system off when a door is opened; and
- motion detectors designed to automatically turn off the fixtures when something moves above a certain height above the floor.

What level of UVC_{254} is safe?

Safety recommendations for UVC_{254} *(20)* are based on dose of exposure (mJ/cm^2) for an individual; that is, the intensity of the radiation (irradiance, $\mu W/cm^2$) from the source that reaches the individual and the duration of exposure time. There are two sets of recommendations for exposure – the recommended exposure limit (REL)[17] and the threshold limit value (TLV)[18] – and they are not entirely consistent:

- the REL is **6 mJ/cm^2** for an 8-hour exposure for both the eyes and skin; and
- the TLV for UVC_{254} for eye exposure is **6 mJ/cm^2** whereas for skin exposure it is **10 mJ/cm^2**.

UVC_{254} safety education and signage

Staff and clients may have concerns about health hazards from UVC_{254}. To address these, facilities should provide simple education on the purpose, benefits and risks associated with upper-room UVC_{254}; for example, by:

- posting a UVC_{254} information sheet on the wall of the room for occupants (staff and clients);
- developing written site-specific protocols for testing, cleaning, maintenance, repair and replacement of UVC_{254} fixtures and providing specialized training to appropriate staff;
- ensuring that on and off switches for lamps are accessible to appropriate staff members but not located where clients may turn off the fixtures (it may be useful to consider lockable switches or placement of switches in areas restricted to staff); and
- posting warning signs, in all appropriate languages, on the GUV fixtures and other locations as appropriate (e.g. overhead storage areas), with an appropriate message, depending on the type of GUV system used *(20)*; examples are shown in **Fig. 3.5**.

[17] CDC/National Institute for Occupational Safety and Health (CDC/NIOSH), USA, Recommended exposure limit for GUV energy at the UVC_{254} wavelength published in 1973.

[18] The American Conference of Governmental Industrial Hygienists (ACGIH) updated the TLV for ultraviolet radiation and designated separate values for eye exposure and for skin exposure by wavelength in 2022.

Fig. 3.5. Examples of *appropriate wording for warning signs on UVC$_{254}$ systems*

EXAMPLE. **Educational sign at occupant level**

FOR YOUR SAFETY

THIS BUILDING IS EQUIPPED WITH UPPER-ROOM UVC$_{254}$ AIR DISINFECTION SYSTEMS

EXAMPLE. **Safety warning sign near areas needing precaution**

CAUTION

Ultraviolet Energy

Turn off UVC$_{254}$ lamps before entering the upper part of the room

(space above the UVC$_{254}$ fixtures).

Source: Curry International Tuberculosis Center (2022) *(20)*.

Routine upkeep of GUV fixtures

One member of staff should be designated as the in-house monitor for GUV fixtures. That person should be trained in the basic principles of GUV operation and safety, and should be responsible for cleaning, maintaining and replacing the lamps, following maintenance instructions from the manufacturer.

Practical steps in routine maintenance are as follows:

- The UVC$_{254}$ output should be verified. It is important to ensure that the lamps are not burned out or broken. If the tubes are working, they will emit a violet-blue glow (note: this is not an indicator of the lamp's effectiveness, which can only be confirmed by measuring output with a calibrated radiometer).
- Dust can reduce the efficacy of GUV lamps:
  - the GUV fixtures should therefore be cleaned at least once every 3 months (or more frequently, depending on local conditions);
  - at least one staff member should be trained in how to clean the fixtures safely;
  - before cleaning, the GUV fixtures should be turned off to avoid contact of the light with the skin and eyes and prevent heat burn;
  - cleaning should be undertaken using a solution of 60–80% alcohol and a clean, soft cloth, such as a microfiber cloth; and
  - the bulb and fixture should be wiped clean of dust; also, in a louvred fixture, all louvres should be cleaned (**Fig. 3.6** shows a GUV device being cleaned).
- The performance of GUV fixtures should be measured 3–4 days after initial installation and then every 3 months until replacement. Before measuring the output, the fixtures should be cleaned and potential interferences (e.g. fluorescent lights or sunlight) should be blocked. Radiometers should be held 1 m away from the geometric centre of the fixture, with the face of the sensor parallel to the fixture's louvres. Additional measurements should be taken slightly above, below, to the left and to the right of the geometric centre (**Fig. 3.7**).
- The irradiation level at each fixture should meet the lamp manufacturer's recommendation. Most manufacturers will give a minimum irradiance[19] (μW/cm^2) value at 0.91 m from the UVC fixture, along the centreline. Lamps should be replaced once a year or as recommended by the manufacturer (or earlier if the irradiance levels are below the manufacturer's recommended minimum levels). If a lamp has a decline of 30% or more in UV ray emission, its bulb should be replaced, even if it is still within the scheduled replacement date.

[19] Most manufacturers give irradiance based on effective irradiance; however, most UVC$_{254}$ radiometers measure total irradiance, and total irradiance results should be multiplied by 2 (conversion factor to effective irradiance).

- The person performing the measurement should ensure that their eyes are protected during the process. Either UV-specific eyewear or at least clear glass or plastic eye shields should be used to block UVC.
- Radiometers should be calibrated regularly. This can be done by the supplier of the radiometer.
- A record should be kept in a logbook of all maintenance and monitoring, including radiometer readings, dates and any remedial action taken. This will help to determine the average life of the lamps. Lamps should be purchased close to the planned replacement time because prolonged storage may result in a loss of radiation intensity. **Fig. 3.8** provides an example of a maintenance record.

Fig. 3.6. Cleaning a GUV fixture in a health care facility



Source: Granich et al. (1999) *(10)*.

Fig. 3.7. Measuring the effectiveness of UVC_{254} and the safety of fixtures at eye level using a radiometer



Source: End TB Transmission Initiative (2017) *(33)*. (Photo courtesy of P. Jensen).

Fig. 3.8. Example of a GUV fixture maintenance register

Facility		**Room name**				
Irradiance ($\mu W/cm^2$)		**Acceptance criteria** XX=($\mu W/cm^2$@1m)	**Record quarterly readings (pre and post cleaning)**			
			Quarter 1	**Quarter 2**	**Quarter 3**	**Quarter 4**
Fixture ID: Model/ manufacturer Installed:		Less than 70% of xx				
Fixture ID: Model/ manufacturer Installed:		Less than 70% of xx				
Fixture ID: Model/ manufacturer Installed:		Less than 70% of xx				
Lower room:		≤0.4µW/cm^2				
Model and serial number of UV-c meter: Date of Calibration:						
Date:						
GUV lamps replaced/Date:						
Comments:						
Approved by:		Name: Signature:				

Source: End TB Transmission Initiative (2017) *(33)*.

3.1.4 Cost considerations

Over the lifetime of a GUV system, most of the costs are typically for long-term operation and maintenance. The items listed in **Table 3.1** should be considered when calculating the lifecycle cost of a GUV fixture, assuming that the "life" of a GUV fixture is 15 years.

Table 3.1. Cost considerations for a UVC_{254} fixture

Initial costs	Recurring costs
• Upper-room UVC_{254} fixture or fixtures • Shipping, customs and taxes • Air-mixing system (e.g. diffusers and fans) • Layout design • Installation (e.g. fixture, fans and electricals) • Acceptance testing (upper-room UVC_{254} performance for inactivation and safety) • UVC meter	• Quarterly maintenance • Annual maintenance • Annual electricity • Annual calibration of radiometer

UVC: Ultraviolet light C.

In general, the average annual cost of operating and maintaining an upper-room GUV system is 10–20% of the initial acquisition cost *(38)*. This cost may be included as a new annual budget line for operation and maintenance at the facility level.

Key point: Upper-room GUV systems rely on effective air mixing; hence, it is necessary to ensure adequate air movement. NTPs should ensure that adequate resources are allocated for the proper installation, running and maintenance and overall sustainability of the systems.

3.2 Ventilation systems

WHO recommends the use of ventilation systems (including natural, mixed-mode, mechanical ventilation and recirculated air through HEPA filters) to reduce *M. tuberculosis* transmission to people in settings with a high risk of *M. tuberculosis* transmission. Ventilation systems, whether natural or mechanical, take advantage of air movement to push or pull infectious particles out of a space. The aim is to achieve enough air movement – as measured in terms of ACH cycles – to dilute the amount of infectious material and facilitate its removal from the room. Natural ventilation facilitates the movement of outside air into the building through doors and windows; wind pressures or the pressure gradient created by the difference in density between indoor and outdoor air determines the force of the movement. Although effective, this air movement is controlled by external environmental factors. The same effect can be achieved with mechanical ventilation systems used for air supply, air removal or both. Mechanical ventilation can also be combined with air-conditioning and filtration systems or linked with natural ventilation; this is referred to as "mixed-mode ventilation".

There is a limited amount of evidence regarding the use and effects of standalone ventilation systems. Most of the evidence relates to mechanical and mixed-mode ventilation. The WHO GDG decided to extrapolate these data to other ventilation systems (apart from portable air cleaner appliances). All but one of the 10 studies reviewed showed reduced incidence of TB infection, with the reduction ranging from 2.9% to 11.5%. Studies reporting the use of negative-pressure isolation rooms with HEPA

filtration and 20 ACH showed a reduction in TST conversion from 12–19 to 7–8 per 1000 person-years. The studies evaluating the mixed-mode ventilation also showed reductions in the rate of TB infection among health care workers.

Overall, ventilation systems are effective in diluting the concentration of particles in high-risk settings, and in effectively reducing the concentration of airborne *M. tuberculosis* in the air, provided the equipment is appropriately installed and functional. However, ventilation systems may actually increase airborne transmission risk if they are wrongly installed or poorly maintained. In terms of performance, the natural, mixed-mode and mechanical ventilation systems can be considered equivalent when they are well designed, installed and maintained, as shown in **Fig. 3.9**.

Fig. 3.9. Comparative assessment of different ventilation systems[a]

	Natural ventilation	Mixed-mode ventilation	Mechanical ventilation	Recirculated air with filtration
Balance of effects	★★★★☆	★★★★☆	★★★★☆	★★★☆☆
Resources required	★★★★☆	★★★☆☆	★☆☆☆☆	★★☆☆☆
Cost effectiveness	★★★★★	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Equity	★★★★☆	★★★☆☆	★★☆☆☆	★★☆☆☆
Acceptability	★★★★★	★★★★☆	★★★★☆	★★★★☆
Feasibility	★★★★☆	★★★☆☆	★★☆☆☆	★☆☆☆☆

[a] Comparative assessment using a Likert-type model for comparison of interventions through the Grading of Recommendations Assessment, Development and Evaluation (GRADE) GRADEpro Guideline Development Tool (GDT) software. All the items in this scale use the five-point answer format, where the lower number of qualifiers (stars) indicates the least preferred system, based on data extrapolation and on individual judgements and perceptions of each member of the Guideline Development Group on feasibility, resources required and other criteria.

Source: WHO (2019) *(13)*.

Natural ventilation has a low cost and is simple to implement and maintain. However, it is unpredictable and not always feasible, particularly in settings with extremely hot or cold climates. Mixed-mode ventilation can overcome some of these limitations and is expected to be more affordable than fully mechanical systems, including recirculated air filtration systems. **Fig. 3.10** summarizes the relative advantages and disadvantages of natural, mixed-mode and mechanical ventilation systems.

Fig. 3.10. Advantages and disadvantages of mechanical, natural and mixed-mode ventilation

	Mechanical ventilation	Natural ventilation	Hybrid (mixed mode) ventilation
Advantages	Suitable for all climates and weather	Suitable for warm and temperate climates	Suitable for most climates and weather
	More controlled and comfortable environment	Lower capital, operational, maintenance costs for simple implementations	Energy saving, relative to mechanical ventilation
	Occupants have limited control to affect ventilation	Capable of achieving very high ventilation rates	More flexible
Disadvantages	Expensive to install and maintain	Easily affected by outdoor climate and occupant's behavior	May be more costly or difficult to design
	Can fail to deliver required ventilation rates through faulty design, maintenance or operation	May be difficult to plan, design, and predict performance	
	Noise from equipment	Reduced comfort level of occupants in extreme weather	
		Cannot achieve directional control of airflow, if required	

Source: Ministry of Health and Family Welfare, New Delhi (2010) *(39)*.

Key point: A portable in-room air cleaner *does not* reduce the risk of TB transmission and should *not* be used as a TB IPC intervention.

3.2.1 Air changes per hour

Air changes per hour (ACH) is the number of times that the total air volume in a room or space is completely removed and replaced in an hour. ACH is a key consideration in determining the effectiveness of ventilation systems for the control of airborne infection. Removal of stale air and infusion of fresh air dilutes the concentration of infectious airborne organisms and reduces the risk of transmission to occupants or visitors. It is calculated by measuring the airflow rate (m^3/hour) against the volume of the room (m^3). **Table 3.2** summarizes the estimated time required to remove 99% or 99.9% of the infectious particles from the air by dilution ventilation if no aerosol generation takes place in a room. For example, with six ACH, it would take 46 minutes to remove 99% of the particles and 69 minutes to remove 99.9% *(11, 40)*. With 12 ACH, it would take 23–35 minutes to remove 99–99.9% of particles, which is considered achievable and adequate. In high-transmission situations (e.g. sputum

specimen collection booths) the installation of an electrical motor fan can help to achieve up to 20 ACH and allow safe use by a new patient 15–20 minutes after previous use.

Table 3.2. ACH and time required for removal efficiencies of 99% and 99.9% of airborne contaminants

ACH (numbers)	Minutes required for 99% removal of particles	Minutes required for 99.9% removal of particles
2	138	207
4	69	104
6	46	69
12	**23**	**35**
15	18	28
20	14	21
50	6	8
400	<1	1

Source: Jensen et al. (2005) *(40)*.

A vaneometer™ can be used to measure average air velocity (in m/second). Using a vane anemometer or adding a vane probe to an anemometer enables measurement of air volume flow and flow rate. A smoke tube or incense stick can be used to determine the direction of flow. **Fig. 3.11** depicts the tools used to measure ACH. The measurement will also involve assessment of room volume and area of windows.

Fig. 3.11. Tools to measure ACH (including example of vaneometer with different units)



Source: image supplied by GB Migliori.

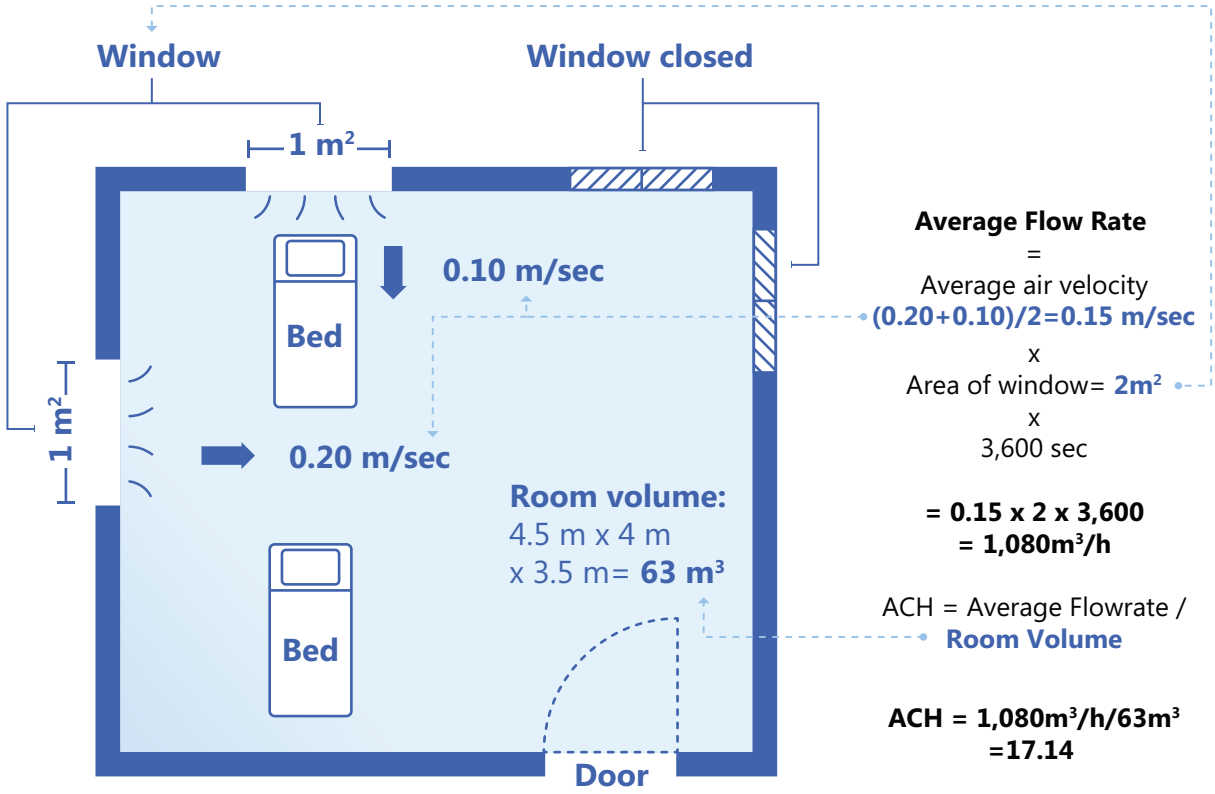
ACH measurement

The vaneometer is positioned at the level of a door or window, to measure air velocity. Multiple measurements are taken at different levels – ideally, three measurements each at the top, middle and lower third of the window or door opening – to compute an average air velocity (in m/second). Fig. 3.12 provides an example of an ACH measurement in a room with two beds, two closed windows, two open windows and a door. It shows the dimensions of the room (4.5 m × 4.0 m × 3.5 m) and the

open windows (1 m × 1 m), as well as the related air velocities (0.2 m/s and 0.1 m/s), as measured with a vaneometer. The diagram and the box to its right in **Fig. 3.12** depict the steps used to calculate ACH for this room, which are as follows:

- **Step 1**. Calculate the room volume.
- **Step 2**. Calculate the area of the open windows.
- **Step 3**. Measure the air velocity using the vaneometer and calculate the average air velocity using the three readings per window.
- **Step 4**. Multiply the average air velocity by the area of the windows and the measure of time (i.e. 3600 seconds) to obtain the average flow rate per hour.
- **Step 5**. Determine the ACH required to clean the air in this room by dividing the average flow rate per hour by the volume of the room. The required ACH is 17.14 in the example shown in **Fig. 3.12**.

Fig. 3.12. Steps for calculating ACH for a room



Source: image supplied by GB Migliori.

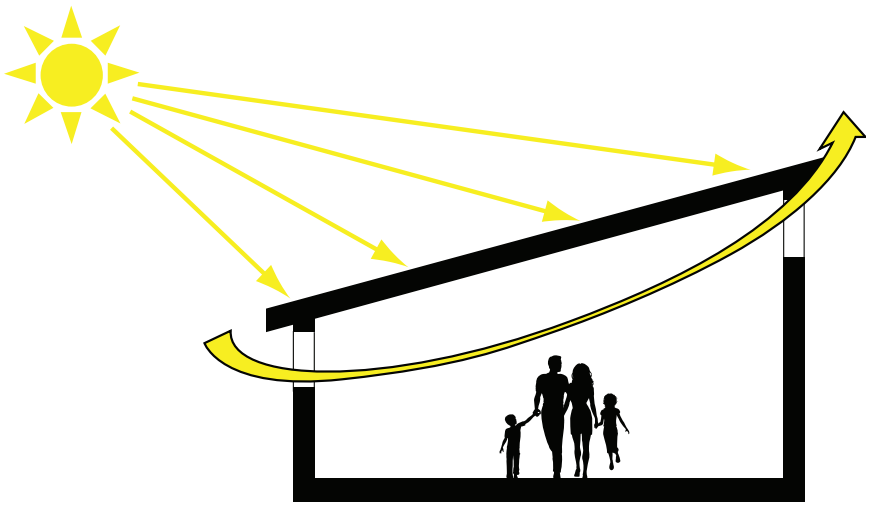
Choice of ventilation system

The decision on which ventilation system to use (i.e. natural, mechanical, mixed-mode ventilation or recirculated air with HEPA filtration) depends on the IPC needs in a particular setting; that is, level of risk of TB transmission, weather, cost-effectiveness and sustainability (**Fig. 3.9** and **Fig. 3.10**). Installing poorly designed ventilation systems, or failing to maintain ventilation systems, produces results contrary to those intended and may cause health care-associated transmission of *M. tuberculosis*. Such suboptimal ventilation systems also increase risks in congregate settings. The subsections below discuss the different ventilation systems.

3.2.2 Natural ventilation

Natural ventilation is achieved with natural airflow caused by the temperature differential between spaces or by a wind-driven pressure differential. As the air warms, its density lowers and it rises to the upper part of a space, towards a chimney, tower or windows. Such differences in air density create a gradient within the room or between the interior and exterior air columns, causing a vertical pressure difference. When the room air is warmer than the outside air, the room air is less dense; hence, it rises and escapes from outlets around the roof. Cooler air then enters the building through lower openings, heats up and rises to escape from openings at the upper level, creating a cycle. This phenomenon, which occurs because of the natural heat transfer, is called a *stack effect* or a *chimney effect* **Fig. 3.13**. The possibility of stack ventilation should be considered during the construction of a building *(41)* because it generates passive cooling during summers. The airflow direction may sometimes (albeit rarely) reverse when the room air is cooler or denser than the outside air; in such cases, air may enter through upper openings and escape through lower openings. Natural ventilation does not need any electricity and can work 24 hours a day without maintenance or running costs. Naturally ventilated rooms can achieve a high rate of ACH. However, changes in wind direction or temperature can affect the airflow rate, and climate strongly influences the quality of ventilation. On a windy or rainy day, there may be excessive ventilation, much more humidity and greater air velocity, creating a need for airflow control using dampers or shutters. Nevertheless, natural ventilation may be preferred in resource-limited settings that may lack capital investment, uninterrupted availability of electricity and skilled staff to maintain complex mechanical systems.

Fig. 3.13. Stack ventilation



Source: Stop TB Partnership (2009) *(12)*.

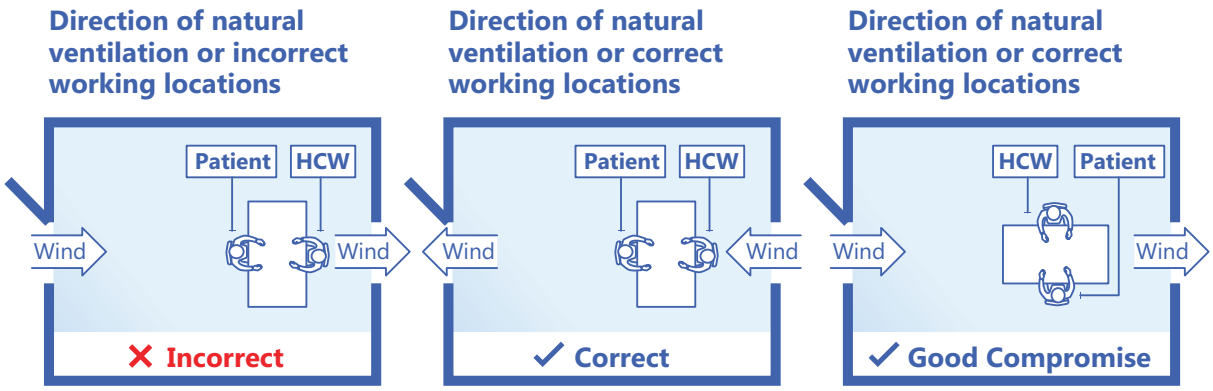
To achieve optimum ventilation and ACH with natural ventilation, it is necessary to ensure that:

- the area of doors and windows that can open constitutes more than 20% of the floor area (e.g. a room of 10 m^2 should have fixed, unrestricted openings of about 1 m^2 on two sites, giving a total of 2 m^2 of openings);
- there are openings on opposite walls for cross-ventilation;
- openings are unrestricted (e.g. doors and windows are kept open during patient visits); and
- upper levels of the building are better ventilated than lower levels.

Wind direction and the airflow rate should be considered when deciding on the seating arrangements for the patients and health care workers in consultation rooms. **Fig. 3.14** depicts a consultation room with the seating arrangements to use or avoid, based on the airflow direction. The officer in charge of the health facility should ensure that health care workers are closest to the source of clean air and

patients are closest to the point of air exhaust, to ensure that contaminated air does not blow towards the health care worker. The seating arrangement should be decided on after repeated observations and measurements at different times of the day (e.g. sunrise vs sunset) and in different seasons (e.g. hot and humid summer vs cold and dry winter).

Fig. 3.14. Incorrect, correct and neutral ways to locate the seating for health care workers and patients in a consultation room with natural ventilation *(12)*

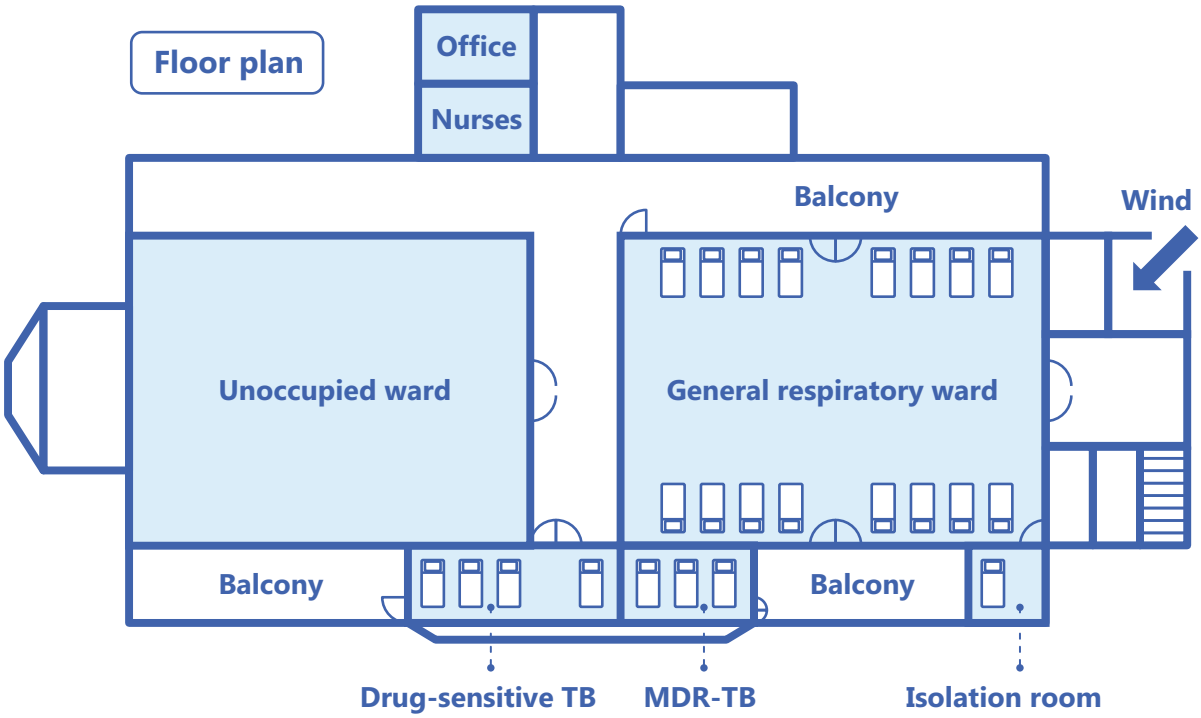


HCW: health care worker.

Source: Stop TB Partnership (2009) *(12)*.

Fig. 3.15 shows an example of a natural ventilation system in a TB referral hospital in Peru *(41)* and **Fig. 3.16** shows a naturally ventilated health centre in South Africa.

Fig. 3.15. Layout of natural ventilation system, Hospital Nacional Dos de Mayo, Lima, Peru





General respiratory ward



Drug sensitive TB ward



Drug resistant-TB ward



Drug resistant-TB ward

Source: WHO (2009) *(41)*.

Fig. 3.16. Example of natural ventilation at a health centre in South Africa

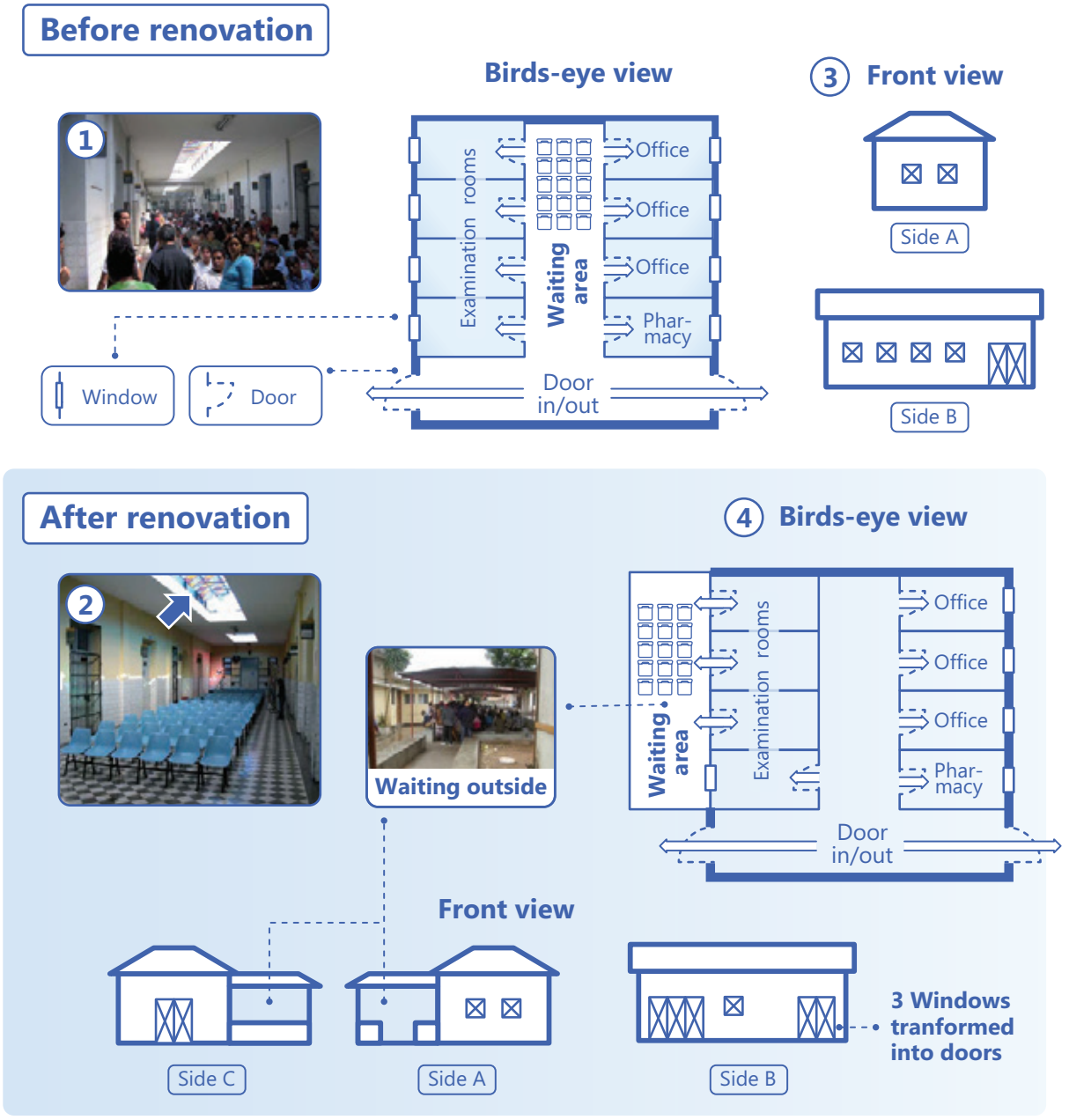


Source: Curry International Tuberculosis Center (2022) *(20)*.

The floor plan in **Fig. 3.15** shows that the ward for patients with DS-TB, with four beds, is well ventilated, given the high ratio of window and door area to the room volume, despite this ward being on the side of the building protected from prevailing winds. The MDR-TB ward has three beds and is adjacent to the DS-TB ward; however, it has separate access and its exposure to the prevailing winds is similar to that of the DS-TB ward. Smoke tube testing consistently demonstrated airflow in through the door and out through the windows. The isolation room is located off the main general respiratory ward. The door connects with the general respiratory ward, and three windows open to the outside. With the door closed, a mean of 23 ACH was measured with all three windows fully open. Opening the door produces cross ventilation and increased the mean to up to 49 ACH. Smoke testing consistently demonstrated that the direction of airflow was from the main ward into the isolation room and out of the windows.

Often, the waiting area in hospitals and clinics is poorly ventilated, increasing the risk of *M. tuberculosis* transmission for both health care workers and visitors. **Fig. 3.17** depicts an example of a hospital in Peru where renovation in the outpatient department helped to significantly reduce this risk. In the plan, the waiting area is located next to various consulting rooms (medical specialities, surgery and psychiatry). A front entrance leads in from the street, and doors at the other end lead into different parts of the hospital. On a typical day, up to 300 patients share the waiting space during the consulting hours. Originally, the roof in this space was sealed with four glass sections, two measuring 14 m × 2.4 m and two measuring 5 m × 2.4 m. The renovation involved raising the height of these sealed sections by 1 m, with openings allowing air entry into the waiting room (as shown by the arrow in picture 2 of **Fig. 3.17**). This improved the natural ventilation from about 6.5 to 15 ACH. Structural changes were also made from outside the building and some windows were converted into doors, creating additional air entry into the consulting rooms (the bottom right panel in **Fig. 3.17**). The waiting area was shifted outside with a simple covered roof for shade. This combination of measures helped to improve ventilation in the health facility and reduce the risk of infection transmission *(10)*.

Fig. 3.17. Improving natural ventilation in an outpatient clinic



Source: image supplied by GB Migliori.

The photos in **Fig. 3.18** present good examples of well-ventilated waiting spaces in and around health facilities.

Fig. 3.18. Examples of natural ventilation in the waiting areas of four outpatient clinics



Outdoor waiting area in Kibongoto Infectious Disease Hospital, Tanzania.

Source: Curry International Tuberculosis Center (2022) *(20)*.



Waiting area with natural ventilation in Ho Chi Minh City, Viet Nam.

Source: CDC/DGHT/GTB.



Waiting area constructed for DR-TB patients with open shed and improved ventilation, Urban Health Center, Dharavi, Mumbai, India.

Source: CDC/DGHT/GTB.



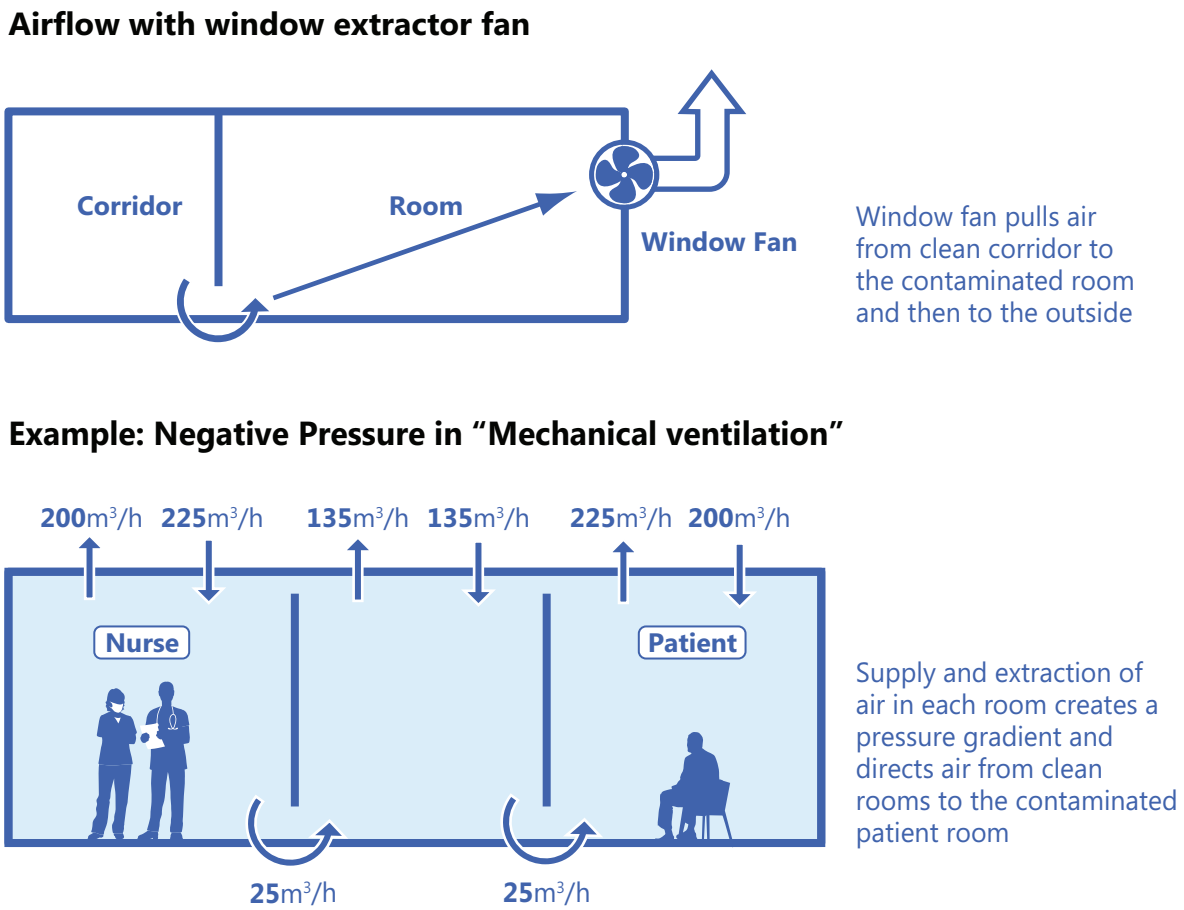
Waiting area for patient and visitors.

Source: Aurum institute, South Africa.

3.2.3 Mechanical ventilation

The use of mechanical ventilation, mixed-mode ventilation or HEPA filters may be feasible in settings where resources are available, or where natural ventilation is not suitable or is unreliable owing to the weather. Mechanical ventilation works by creating negative pressure (**Fig. 3.19**), which draws in air from higher pressure areas and uses the pressure gradient to create airflow between different rooms. The system is designed to enable air to move from "clean" areas to "dirty" areas.

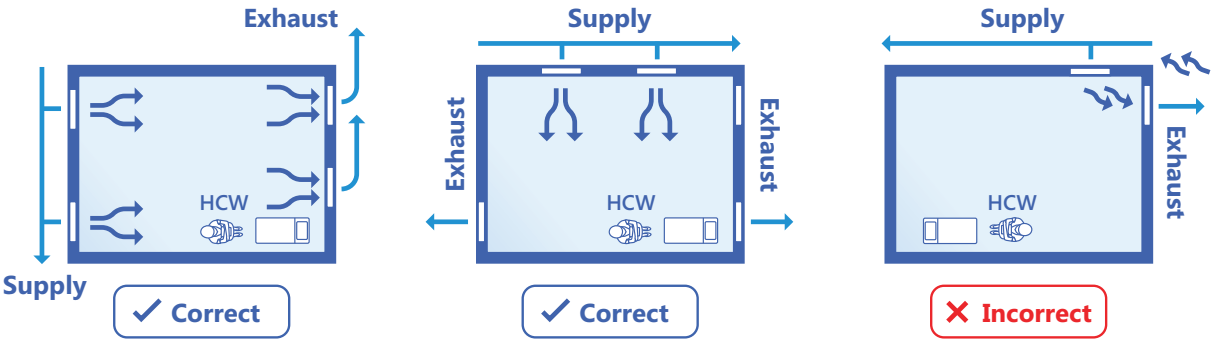
Fig. 3.19. Air pressure gradient with mechanical ventilation



Source: Stop TB Partnership (2009) *(12)*.

Airflow patterns are affected by the temperature and configuration of the space, and by physical barriers to airflow, such as furniture. The diagrams on the left in **Fig. 3.20** show two scenarios with appropriate location of the source of clean air supply and the exhaust, which allows for good air mixing. Conversely, the diagram on the right presents a scenario where the air supply and the exhaust are located in such a way that the clean air is removed before it can mix with the potentially contaminated air, thus prohibiting dilution of the contaminated air.

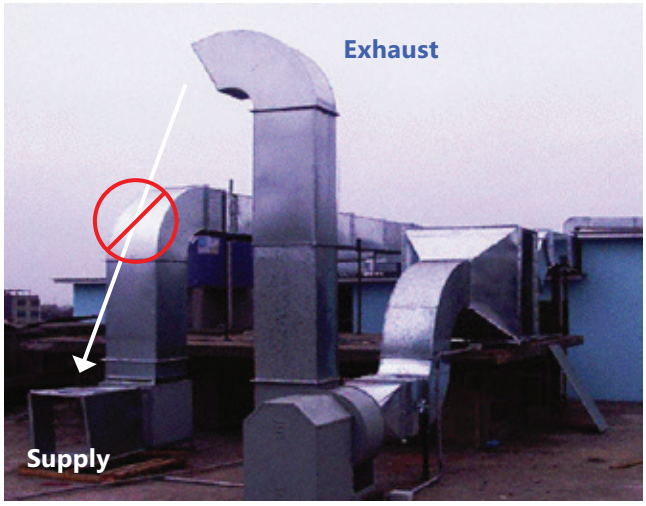
Fig. 3.20. Layout of rooms with good and suboptimal air mixing



Source: Jensen et al. (2005) *(40)*.

Sometimes, poor engineering design can increase the risk of contamination or produce short-circuiting, as shown in **Fig. 3.21.** In this example, the position of the exhaust air fan increases the likelihood of contaminated air being reintroduced through the supply inlet. Such short-circuiting can be avoided if the supply inlet is located at least 10 m away from the exhaust.

Fig. 3.21. Short-circuiting in a mechanical ventilation system, causing contaminated air to be recirculated



Source: image supplied by GB Migliori.

Mechanical ventilation can also be ensured through an entirely closed system (**Fig. 3.22)**, where air is recirculated and filtered using special filters (e.g. HEPA filters), and filtered air is reintroduced into the facility. In closed mechanical ventilation systems, maintenance of the HEPA filters is paramount because dirty filters can modify the airflow and reduce effectiveness. Mechanical ventilation systems should be professionally designed, installed and maintained, to allow good mixing of air and dilution of contaminated air, although this is usually costly.

Fig. 3.22. Example of mechanical ventilation equipment



MDR-TB ward, Radboud University Medical Centre, The Netherlands.

Source: Stop TB Partnership (2009) *(12)*.

3.2.4 HEPA filters

HEPA filters can be used as part of mechanical ventilation systems to filter out infectious particles from recycled air, or as part of a compact in-room-air cleaner. They should always be considered as an adjunct to other ventilation measures; used alone, they do not provide outside air for the occupant's comfort, nor do they enhance ventilation.

HEPA filters are composed of a mesh of randomly arranged fibres. The fibres typically comprise polypropylene or fibreglass with diameters of 0.5–2.0 µm. Often, these filters are tangled bundles of fine fibres that create a narrow, winding pathway through which air passes. When the largest particles are passing through this pathway, the bundles of fibres behave like a sieve and physically block the particles from passing through. However, when smaller particles pass through the pathway, as the air twists and turns, they cannot keep up with the air's motion and they collide with the fibres. The smallest particles have little inertia and move around the air molecules as they are bombarded by these molecules. Because of their movement, the smaller particles also end up crashing into the fibres. Key factors affecting filter functions are the fibres' diameter, the filter thickness and the face velocity; that is, the rate of air movement at the face of the air filter (airflow rate divided by face area). The air space between HEPA filter fibres is typically much greater than 0.3 µm. However, the design is such that a range of particle sizes are trapped through a combination of the following mechanisms:

- **diffusion** – particles below 0.3 µm in size are captured by diffusion resulting from the collision of the smallest particles with air molecules; the small particles are effectively blown or bounced around and collide with the filter fibres;
- **interception** – mid-size particles are intercepted when they are in a line of flow with the air stream and come within one radius of a fibre and adhere to it; and
- **impaction** – larger particles are unable to avoid fibres by following the curving contours of the airstream and are forced to embed directly in a fibre.

The HEPA filters can be used to clean air before it is extracted from a room to the outside via an exhaust fan, recirculated to other areas in a health care facility, or recirculated into an airborne infection control or negative-pressure room. To ensure adequate functioning, HEPA filters should be installed carefully, and the filters should be maintained in accordance with the manufacturer's instructions. Improper design, installation or maintenance of HEPA filters can allow infectious particles to circumvent filtration and escape into the general ventilation system. A manometer or other pressure-sensing device should be installed in the filter system to provide an accurate and objective way to determine the need for filter replacement. The filters can also degrade over time with exposure to humidity and ambient aerosols; hence, in general they should not be used in systems that recirculate air back into the general ventilation system from negative-pressure rooms and treatment rooms. If filters are used in that way, the filter manufacturer should be consulted regarding the performance of the filter, to ensure that it maintains the desired filtration efficiency over time. There should be written records of all HEPA filter maintenance and monitoring *(42)*.

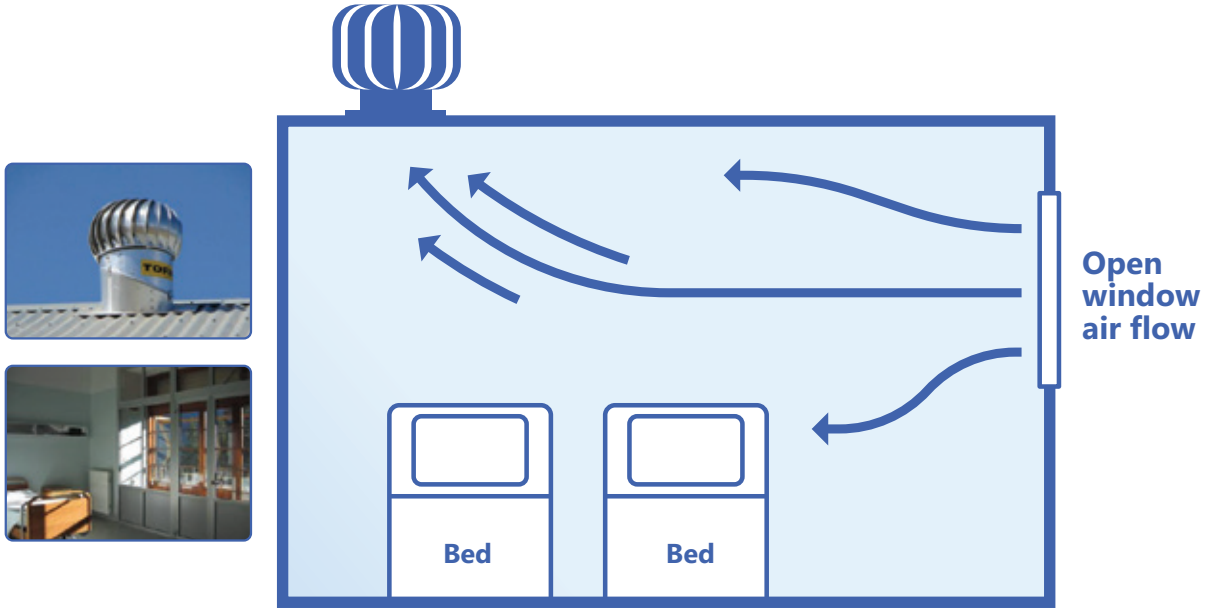
3.2.5 Mixed-mode ventilation

Ventilation systems that combine the use of mechanical and natural ventilation are called hybrid or mixed-mode systems. Propeller fans may be used to increase air circulation, along with exhaust fans, to generate areas of negative air pressure that will draw in air. This may increase air movement from the outside, enhancing ACH in the room when the system is appropriately designed. Such systems can be designed where natural ventilation is not suitable (e.g. owing to very cold weather) or fully mechanical ventilation is not available. Evaporative coolers or desert coolers may be an effective solution in hot weather to achieve both comfort and adequate ventilation. In cold weather, doors and windows may need to be closed; hence, high ventilation rates are difficult to achieve and air exhaust fans may be needed to enhance ventilation. Propeller fans placed on a desk, floor or ceiling may not be able to ensure an adequate supply of fresh air or to expel room air to the outdoors, to achieve

the required number amount of ACH. Regular measurements of ACH should guide the choice of equipment and its placement to enhance ventilation.

In scenarios where there is only one window and that window may need to be closed, the amount of air entering the room is curtailed. In such situations, turbines could be used as the exhaust system and to enhance natural ventilation (**Fig. 3.23**).

Fig. 3.23. Turbine-driven natural ventilation



Source: image supplied by GB Migliori and Paul Jensen.

Key point: Given the cost and the high risk of design or maintenance failures, ventilation systems that recirculate air may not be suitable for settings with a high risk of *M. tuberculosis* transmission, such as TB inpatient wards. In such settings, natural or hybrid mechanical ventilation without recirculation or upper-room GUV systems may be more suitable.

4. Respiratory protection

Respiratory protection should be implemented as a part of a package of TB IPC interventions. However, inappropriate implementation of respiratory protection measures, or reliance on these measures alone, may create a false sense of security and increase the risk of TB *(13)*. The available studies assessing the effectiveness of respiratory protection in reducing the risk of *M. tuberculosis* transmission are highly heterogeneous. The absolute reduction in TST conversion ranged from 4.3% to 14.8% *(13)*. However, since the studies usually test a package of TB IPC interventions, direct evidence on the role of respiratory protection is lacking *(13)*. The WHO GDG noted that the overall protection depends on whether respirators have been properly fit-tested and maintained, and on the quality of training and the way the respirators are used.

WHO recommends using particulate respirators, within the framework of a respiratory protection programme, to reduce *M. tuberculosis* transmission to health workers, individuals attending health care facilities or other people in settings with a high risk of transmission. The recommendation that health care workers should use particulate respirators applies to all health care and nonhealth congregate settings (e.g. correctional facilities), and other settings where health services are provided to individuals with presumed and confirmed TB (e.g. refugee and asylum centres). The introduction of particulate respirators for health care workers should be part of a more comprehensive respiratory protection programme that is in line with occupational safety and health measures. Particulate respirators are effective only if people know how to use them. Respiratory protection should be offered to all personnel entering high-risk areas, particularly health care workers living with HIV or those who are exposed to people with infectious TB and DR-TB. Respirators may also be used by community workers or family members caring for patients with TB who are infectious.

A comprehensive respiratory protection component of a programme has the following elements:

- a TB IPC focal person at the health facility or congregate setting to coordinate the implementation of the respiratory protection programme;
- allocation of dedicated funding and human resources to ensure availability of commodities such as medical masks and respirators;
- funds for the development of education material and training of staff in appropriate application, use and disposal of respirators;
- a choice of appropriate respirators that meet global standards for protection (e.g. N95, FFP2 or FFP3) in different settings; the procurement team should consider different sizes to fit the range of staff members in the facility;
- written SOPs that are made available to all users and displayed at strategic locations;
- a plan for respirator fit-testing for all users, including fit-testing after every change of brand or make of the respirators; as a minimum, all health care workers must do a seal check before wearing a respirator, as shown in **Fig. 4.1** (see Sect 4.1.1 for more details on conducting seal and fit test) *(43)*, and systematic records of fit-testing must be maintained;
- mechanisms to ensure that respirators are used by all personnel entering high-risk areas, health care workers living with HIV and care providers for infectious TB patients; and
- general health screening of those using respirators, to assess whether they can perform duties for long hours wearing a respirator – those with impaired lung function (e.g. asthma or chronic obstructive pulmonary disease) may be unable to perform duties with respirators and should be assigned to different tasks.

4.1 Particulate respirators

TB was the first disease proven to be transmitted by the airborne route. More recently, viable *M. tuberculosis* have been isolated from cough and exhaled aerosols from persons with TB. Most of the particles in these aerosols are small and can be inhaled and deposited deep in lung tissues, where they can establish infection and progress to disease among those who are vulnerable. Respirators reduce the risk of inhaling such infectious particles and can help to mitigate the occupational risk of TB among health care workers. Although not all individuals with TB are infectious, there is currently no accurate way to determine which people are most infectious. Further, the range of infectious aerosol production from individuals with TB varies more than 1000-fold, which may explain why some people are "super-spreaders" whereas others are not infectious *(44)*. From an TB IPC stand point, the most infectious individuals with TB are those who are not yet on appropriate TB treatment *(20)*.

The use of respirators in health care settings is relatively new; they were first implemented in the early 1990s for the protection of health care workers managing MDR-TB outbreaks in the United States of America (USA). The respirators contain a filter with tiny pores that can block infectious droplets, thus protecting the user from inhaling them when the respirator is fitted closely to the face. Standards used for respirators differ between the USA and Europe. In the USA, N95 respirators are recommended, where the "N" refers to its approval for use against non-oil aerosols, and the "95" means that the filter material is at least 95% efficient at removing the particles of the most penetrating size (0.3 µm). The equivalent respirators in the European standard are FFP2 and FFP3. FFP2 filters out more than 94% of the particles (0.4 µm) and FFP3 filters out more than 98%. This filtration capability, however, does not directly translate into, for example, 95% protection with N95. The protection depends on the respirator being worn properly and fitting well. Although N95 or FFP2 are adequate for protection for general use for TB IPC, a higher grade of protection (e.g. FFP3) may be needed in specific settings (e.g. when undertaking aerosol-generating procedures on infectious TB patients).[20]

[20] Tracheal intubation, noninvasive ventilation (e.g. bilevel positive airway pressure and continuous positive airway pressure), tracheotomy, cardiopulmonary resuscitation, manual ventilation before intubation, bronchoscopy, sputum induction by using nebulized hypertonic saline, dentistry and autopsy procedures.

Fig. 4.1. Examples of particulate respirators[21]



Source: Curry International Tuberculosis Center (2022) *(20)* (top two images; images supplied by Pexels/CDC and GB Migliori (bottom two images).

Fig. 4.2. Use of respirators by health care workers



Source: Aurum Institute, South Africa.

Respirators have a substantial cost, considering the volumes that may be required for programmatic implementation. Disposable respirators do not need to be discarded at the end of each task; however, they should be discarded when they are no longer in their original working condition because of contamination, structural defects or wear.[22] They can be reused for 6–10 hours by the same person (or as indicated by manufacturer). The respirators should not be touched while being worn, hand

[21] Similar examples of respirators certified for use in different countries include KN95 in China, P2 in Australia and New Zealand, Korea 1st class (or KF94) in the Republic of Korea, DS2 in Japan and PFF2 in Brazil.

[22] US Department of Labor, Occupational Safety and Health Administration (OSHA).

hygiene should be performed when a used mask is touched or disposed of, and a respirator should be stored in a paper or tissue container (not plastic) to allow it to dry between each use. Users should not try to clean or decontaminate a disposable respirator (except in the case of elastomeric respirators (not depicted in **Fig. 4.2**), which can be cleaned and disinfected after removing filters). It is important to dispose of the respirators correctly, following the national requirement for contaminated medical waste disposal.

4.1.1 Respirator fit-testing

The major limitation in the protection offered by respirators is the potential for excessive air leakage between the respirator and the face. Fit-testing is required to assure a tight fit of the respirator assigned to the user. A key complaint of users is that respirators are less comfortable than medical masks because of the increased effort required to inhale air through the filter material. Hence, if a particulate respirator feels as comfortable as a medical mask, it may not be providing adequate protection. Fit-testing of respirators is essential when they are newly introduced in the facility, or when a new batch of respirators is received. Fit-testing provides a way to determine which respirator model and size fits the wearer best; it also provides an opportunity to assess whether the wearer can use the respirator properly. Periodic fit-testing can thus serve as an effective, hands-on training opportunity, including on other IPC interventions included in the employee training and retraining curriculum. Fit-testing should be offered to all new employees and repeated annually for all health care workers. The frequency of fit-testing may also be determined by:

- the risk of transmission of *M. tuberculosis* (e.g. high TB prevalence or high-risk settings);
- changes in facial features of the wearer or medical conditions that would affect respiratory function;
- changes in the physical characteristics of the respirator (size, type, model or make); and
- national policy on frequency of fit-testing.

Fit-testing[23] may be carried out using a test agent for qualitative detection, assessed by the wearer's sense of taste or smell, or involuntary cough (irritant smoke); it may also be done using quantitative measurement with an instrument (i.e. ratio of the aerosol concentration outside the respirator to the aerosol concentration inside) to verify the respirator's fit.[24] **Fig. 4.3** provides an example of a qualitative respirator fit-testing kit that typically includes a hood with collar, bottles with sensitivity and challenge test solutions, and two nebulizers for injection of the test solutions.

Fig. 4.3. Example of a qualitative respirator fit-testing kit



Source: Stop TB Partnership (2009) *(12)*.

[23] Additional information on fit-testing may be found in *(40)* and on the OSHA website (https://www.osha.gov/).

[24] A sample video is available, describing both quantitative and qualitive fit-testing *(45)*.

Test solutions for fit-testing

There are four methods for testing, using four different types of test solution: isoamyl acetate, irritant aerosol, saccharin and BitrexTM (denatonium benzoate). Tests using saccharin or BitrexTM are relatively easy to implement and can be used to test all types of disposable and elastomeric negative-pressure respirators (N95, 99 and 100 series, and FFP2 and FFP3). These tests use the subject's sense of taste and involve the use of a small test hood, as shown in **Fig. 4.4**.

Example of fit-testing procedure

The subject is expected to avoid eating or drinking anything (except water) for 15 minutes before the test, to avoid anything that has been eaten or drunk being confused with the taste of the test solution. The fit-testing is completed in two steps – a sensitivity test followed by a challenge test – and results are systematically documented.

Fig. 4.4. Fit-testing using a test hood



Source: Curry International Tuberculosis Center (2022) *(20)*.

Sensitivity test

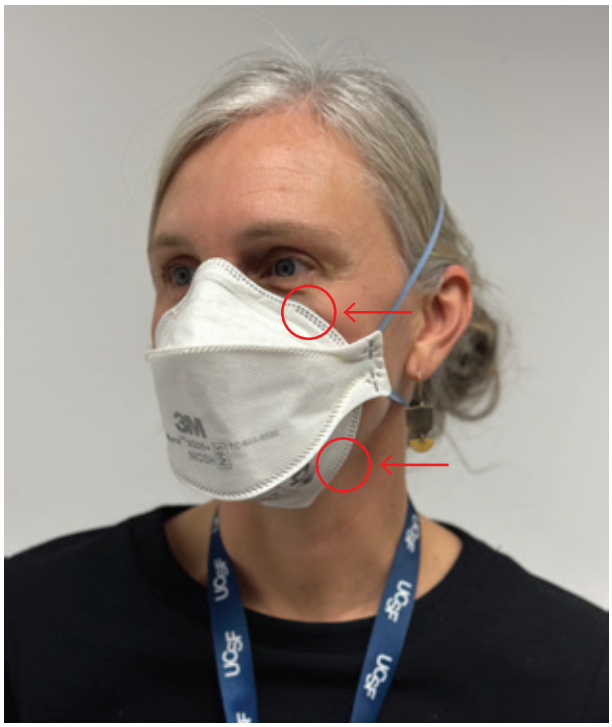
A sensitivity test is performed without the respirator. The tester injects 10 squeezes of the sensitivity test solution through a hole in the transparent visor of the hood. If the subject can taste the solution, the sensitivity test is complete. If the subject cannot taste the solution after 10 squeezes, an additional 10–20 squeezes are injected, until the subject detects the taste. The hood is then removed, and the subject is given a few minutes for the taste of the test solution to fade. This sensitivity test allows the subject to become familiar with the test solution. The number of squeezes needed for the subject to taste the solution during the sensitivity test is recorded (10, 20 or 30), and the same number of squeezes is used for the challenge test.

Challenge test

The aim of the challenge test is to understand whether a specific model of respirator used close to the face fits perfectly and prevents leakage around the edges. The subject puts the respirator on and is then asked to wear the hood. Several squeezes of the fit test solution (10, 20 or 30 – the same number as used in the sensitivity test) are injected under the hood. If the respirator is correctly placed and fits the subject's face well, the previously recognized test solution cannot be detected, despite injection of the test solution. The subject is then asked to complete seven actions: breathe normally,

breathe deeply, move the head from side to side, move the head up and down, talk nonstop, jog or walk on the spot, and return to breathing normally *(10)*, to mimic the practical actions performed by health care workers during patient care. Each of these seven steps is continued for 1 minute. If the subject completes the series without detecting the taste of the solution, the test is passed (i.e. the respirator is an appropriate fit for the subject). If the taste is detected during any of the seven steps, the fit test has failed, meaning that the subject may not be protected by the respirator. In cases of test failure, the tester should wait for 15 minutes and then perform the test again. A second failure indicates the need for a different size or model of respirator. **Fig. 4.5** depicts the points where air leakage frequently occurs *(11)*.

Fig. 4.5. Points on a particulate respirator where air leakage is likely to occur



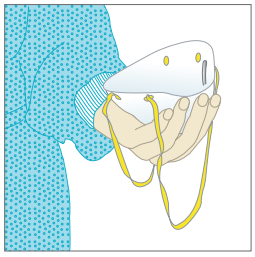
Source: Curry International Tuberculosis Center (2022) *(20)*.

Seal check on a particulate respirator

It is important to implement the plan for respirator fit-testing for all users, including fit-testing after every change of brand or make of the respirators. As a minimum, all health care workers must do a seal check before wearing a respirator, as shown in **Fig. 4.6** *(43)*.

Fig. 4.6. How to perform a seal check on a particulate respirator

WHO/CDS/EPR/2007.8b



Step 1

- Cup the respirator in your hand with the nosepiece at your fingertips allowing the headbands to hang freely below your hand.



Step 2

- Position the respirator under your chin with the nosepiece up.



Step 3

- Pull the top strap over your head resting it high at the back of your head. Pull the bottom strap over your head and position it around the neck below the ears.



Step 4

- Place fingertips of both hands at the top of the metal nosepiece. Mould the nosepiece (USING TWO FINGERS OF EACH HAND) to the shape of your nose. Pinching the nosepiece using one hand may result in less effective respirator performance.



Step 5

- Cover the front of the respirator with both hands, being careful not to disturb the position of the respirator.

Step 5a: Positive seal check

- Exhale sharply. A positive pressure inside the respirator = no leakage. If leakage, adjust the position and/or tension straps. Retest the seal. Repeat the steps until the respirator is secured properly.

Step 5b: Negative seal check

- Inhale deeply. If no leakage, negative pressure will make respirator cling to your face.
- Leakage will result in loss of negative pressure in the respirator due to air entering through gaps in the seal.

Epidemic and Pandemic Alert and Response © World Health Organization 2008. Design and layout by Engage Write & Design. www.engage-geneva.ch

Reproduced from "Infection prevention and control of epidemic- and pandemic-prone acute respiratory diseases in health care - WHO Interim Guidelines" available at *http://www.who.int/csr/resources/publications/WHO_CD_EPR_2007_6/en/index.html*

Source: WHO (2007) *(43)*.

4.2 Medical masks

Medical masks are traditionally used for keeping the surgical field or environment sterile. They are also used in health care settings as personal protection from infection spread via the droplet route. However, medical masks offer minimal protection against airborne *M. tuberculosis*. They consist of gauze or tissue without any filter to block infectious droplets. Hence, they are best suited to simply reducing the release of infectious aerosols into the room air by individuals with infectious TB. The

use of medical masks by individuals with TB has been shown to decrease transmission to guinea pigs by over 50% *(46)*.

Fig. 4.7. Medical mask used to reduce the release of infectious aerosols



Source: WHO / *Blink Media – Ricci Shryock.*

If an individual is bacteriologically positive or not responding to TB treatment, the person should wear a medical mask when in contact with other people, particularly in areas that are poorly ventilated. The mask should have a nasal bar that can fit around the user's nose, and it should completely cover their nose and mouth. The mask must be replaced at least once a day, or if it becomes wet or damaged. Given the increased work of breathing associated with pulmonary TB, it may not be appropriate to force an individual with TB to wear a respirator, but it may be reasonable to ask them to wear a medical mask. The individual may be able to remove the medical mask for large portions of the day (e.g. when they are alone, outside or sleeping); this is important because the mask restricts air movement and is often not comfortable.

Medical masks are part of the standard medical supplies procured by health services. Hence, the provision of medical masks to patients and the related education programme may incur minimal additional costs in health care and in congregate settings.



Source: WHO / Khalil Ashawi

5. TB IPC in special situations

5.1 TB IPC in congregate settings

Congregate settings are places where people reside in close proximity to each other, but which are not primarily meant to provide health care. Examples of such settings are prisons, homeless shelters, refugee camps, army barracks, hospices, dormitories, nursing homes and workplaces (e.g. factories and mines). TB can spread rapidly in congregate settings, sometimes even more rapidly than in health facilities, given the long duration of exposure, crowded environment, poor ventilation, delayed diagnosis and treatment, and (sometimes) limited access to health services. Individuals living in such settings should be protected against the risk of acquiring potentially life-threatening infections such as TB. Therefore, TB IPC measures should apply in these congregate settings as they do in health care facilities. However, it may be challenging for the MoH to access these facilities or services, particularly prisons and army hospitals, because they are managed by other public entities, such as the ministries of defence or justice. In the spirit of Pillar 2 of the End TB Strategy, a strong all-government approach to TB prevention should be established, to pave a way for collaboration and the provision of systematic access to TB services including chest X-ray, rapid TB diagnostics and TB IPC interventions. Possible steps for implementing TB IPC interventions in congregate settings are as follows *(12)*:

- establish appropriate mechanisms for the implementation of administrative, environmental and respiratory protection measures;
- undertake TB risk assessment and identify areas with a higher risk for *M. tuberculosis* transmission, then prioritize those areas for stringent IPC actions;
- develop and provide access to educational materials and TB IPC interventions for residents, and train the facility staff and supervisors on TB IPC;
- promote cough etiquette and ensure supplies of PPE for both residents and staff;
- create a culture within the institution that encourages people who have a cough to seek health care; support prompt identification of such individuals through systematic TB screening at entry and at regular intervals during their stay;
- ensure that residents or inmates who are diagnosed with TB are started on TB treatment promptly and are separated from others and isolated in a well-ventilated space until they achieve bacteriological conversion; if eligible, individuals who have been in contact with these inmates should be screened for TB and offered TPT; and
- offer HIV testing to staff and residents, and counsel them, then link them to the package of HIV prevention, care and treatment services, as needed.

Key point: Collaboration between the Ministry of Health and other public and private authorities is necessary for the systematic implementation of TB IPC measures in congregate settings, as it is in health care facilities.

5.2 TB IPC in households

TB IPC measures in patient households are important to minimize transmission of both DS-TB and DR-TB to family members, given their high risk of acquiring *M. tuberculosis* infection or developing TB disease. Prompt initiation of appropriate TB treatment for the index patient is the critical first step towards cutting the chain of *M. tuberculosis* transmission. Contacts of those with DR-TB are at higher risk than contacts of those with DS-TB because an index case with DR-TB may take longer to access effective treatment and become noninfectious. In addition, morbidity and mortality are greater if the contacts are living with HIV. Thus, rapid implementation of IPC measures within the households of TB patients is important after the diagnosis of TB or DR-TB. Patients' residences should be adequately ventilated, particularly the room where the person with infectious TB spends most of their time. Some basic enhancements to the living space to improve natural ventilation may substantially lower the risk to others. Patients should be educated on cough etiquette and should follow such practices at all times. If feasible, the bacteriologically positive TB patients should spend as much time as possible outdoors; sleep alone in a separate, adequately ventilated room; and spend as little time as possible in public places or on public transport.

Ideally, health care providers should wear respirators when attending bacteriologically positive TB patients in enclosed spaces. Once the patient is bacteriologically negative, respirators are no longer necessary. Family members living with HIV should not be directly involved in the care of infectious TB or DR-TB patients, but if there is no alternative, HIV-positive family members should wear respirators. Children aged below 5 years and pregnant women should spend as little time as possible in the same living spaces as patients with bacteriologically positive TB or DR-TB. All family contacts, and particularly children, should be screened regularly for TB disease and TB infection; if they test positive for TB disease, they should be offered DST and TB treatment. All contacts of patients with bacteriologically positive TB should be considered for TPT once TB is ruled out.

Implementation steps

Considerations for implementing TB IPC are as follows:

- Key stakeholders who could support effective implementation of TB IPC in households include staff at the health care facility, members of community-based organizations providing health services, community health workers or volunteers, as well as TB patients themselves and their close contacts.
- NTPs should build the capacity of the health workers to educate and counsel the TB patients and household members. Health education should start even before the patient is discharged from the hospital or referred for TB treatment after TB diagnosis and should continue during the course of treatment and follow-up.
- Community health workers and volunteers should be trained on how to implement TB IPC when a patient is discharged from the hospital, or referred for TB treatment, or during patient home visits.
- Household members should be educated on IPC measures, the importance of adherence to TB treatment, cough etiquette, natural ventilation and safe disposal of sputum. **Annex 10** provides a country example of a tool used for imparting education to patients and families.
- Additional precautions are required for caregivers of DR-TB patients. NTPs should facilitate the provision of targeted counselling and tools for respiratory protection, preferably respirators, for as long as the DR-TB patient remains infectious.
- The use of rapid TB diagnostic tests and the prompt start of treatment for TB or DR-TB should be assured.
- HIV testing and counselling should be offered to all household members, and TB screening and TPT to all contacts of the TB patient.
- The TB patient should be encouraged to follow cough etiquette, sleep in a well-ventilated room and minimize travel to public places or on public transport.
- Community leaders and representatives should be engaged to implement risk reduction strategies in communities with a high TB burden; such strategies include keeping windows open and providing TPT for contacts, particularly children and people living with HIV.

6. Monitoring and evaluation

Monitoring and evaluation are key factors in the success of a TB IPC intervention because they allow progress to be reviewed and plans to be adapted. In contrast to other TB programme interventions, which focus on patient coverage and outcome, much of the monitoring of TB IPC relies heavily on process indicators relating to the enhancement of facilities and changes in behaviour and practices. Monitoring and evaluation addresses questions such as: Is an IPC committee in place? Is triage being performed? Is equipment for mechanical ventilation in place? Has training been conducted?

Programme managers at national, subnational and facility level need to consider how the recording of data on IPC is done; for example, through systematic recording and reporting up to the national level using standard forms or data collected during supervision visits. The monitoring frequency should be annual at least, although some data may only need to be recorded as part of special surveys or implementation research.

Table 6.1 provides a set of five quantifiable indicators for the routine monitoring of key TB IPC measures at national level. It also shows the respective data sources for assessment. The indicator "Time from diagnosis to start of appropriate TB treatment" provides some measure of health system delays that can prolong infectiousness but that could be mitigated through administrative controls. The result would be presented as a mean or median (with ranges) for all patient records. The rate of TB in health care workers, when compared with the TB notification rate in the adult population, should be close to 1 if TB IPC measures are being effectively implemented in health care facilities, exposure is minimized and the risk of acquiring TB is reduced (more details on how to generate and interpret this indicator are given in **Annex 1**).

Table 6.1. Indicators of TB IPC measures for routine reporting at national level

Indicator	Source of information
Proportion of health facilities that have a valid and updated TB IPC plan	Policy document from the NTP, field visits and survey data
Proportion of health facilities that have appointed a TB IPC focal person as a part of facility IPC committee	Policy document from the NTP, field visits and survey data
Time from diagnosis to start of appropriate TB treatment	Surveillance data (should be available in most case-based records)
Proportion of health care workers involved in the care of DS-TB or MDR-TB, or in the collection of sputum samples, who are provided with at least one respirator per week	Supervisory visits
Relative risk of TB disease among health care workers compared with the TB notification rate in the adult population of the same area in the same year	Surveillance data

DS-TB: drug-susceptible TB; IPC: infection prevention and control; MDR-TB: multidrug-resistant TB; NTP: national TB programme; TB: tuberculosis.

Key points

- Consider which IPC indicators should be routinely monitored at national level for management by the NTP.
- Consider what data should be collected at the subnational and facility level for a useful interpretation of the IPC situation in TB programmes.

A sample checklist of measures that should be in place at national, subnational or facility level to consider alignment with WHO policy guidelines for TB IPC is given in **Annex 9**; it can be adapted for supervision visits and programme reviews. **Annex 1** includes a comprehensive list of variables that may be collected to assess compliance with each of the WHO recommendations given in the guidelines for TB IPC. Data to evaluate such an extensive set of indicators may require separate surveys or implementation research.

References

1 Global tuberculosis report 2022. Geneva: World Health Organization; 2022 (https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022).

2 WHO consolidated guidelines on tuberculosis. Module 1: Prevention – tuberculosis preventive treatment. Geneva: World Health Organization; 2020 (https://www.who.int/publications/i/item/9789240001503).

3 WHO operational handbook on tuberculosis. Module 1: Prevention – tuberculosis preventive treatment. Geneva: World Health Organization; 2020 (https://www.who.int/publications/i/item/9789240002906).

4 WHO consolidated guidelines on tuberculosis. Module 4: Treatment – drug-resistant tuberculosis treatment. Geneva: World Health Organization; 2020 (https://www.who.int/publications/i/item/9789240007048).

5 WHO operational handbook on tuberculosis. Module 4: Treatment – drug-resistant tuberculosis treatment, 2022 update. Geneva: World Health Organization; 2022 (https://www.who.int/publications/i/item/9789240065116).

6 Migliori GB, Nardell E, Yedilbayev A, D'Ambrosio L, Centis R, Tadolini M et al. Reducing tuberculosis transmission: a consensus document from the World Health Organization Regional Office for Europe. Eur Respir J. 2019;53. doi: https://doi.org/10.1183/13993003.00391-2019.

7 Migliori GB, D'Ambrosio L, Centis R, Van Den Boom M, Ehsani S, Dara M. Guiding principles to reduce tuberculosis transmission in the WHO European region. Geneva: World Health Organization; 2018 (https://apps.who.int/iris/bitstream/handle/10665/342227/9789289053419-eng.pdf?sequence=1&isAllowed=y).

8 Estebesova A. Systematic review of infection prevention and control policies and nosocomial transmission of drug-resistant tuberculosis. Georgia State University: Thesis; 2013 (https://scholarworks.gsu.edu/cgi/viewcontent.cgi?article=1332&context=iph_theses).

9 Implementing the End TB Strategy: the essentials. Geneva: World Health Organization; 2015 (https://apps.who.int/iris/handle/10665/206499).

10 Granich R, Binkin NJ, Jarvis WR, Simone PM, Rieder HL, Espinal MA et al. Guidelines for the prevention of tuberculosis in health care facilities in resource-limited settings. Geneva: World Health Organization; 1999 (https://apps.who.int/iris/handle/10665/66400).

11 WHO policy on TB infection control in health-care facilities, congregate settings and households. Geneva: World Health Organization; 2009 (https://pubmed.ncbi.nlm.nih.gov/24432438/).

12 Tuberculosis Coalition for Technical Assistance, Centers for Disease Control and Prevention, US Agency for International Development. Implementing the WHO policy on TB infection control in health-care facilities, congregate settings and households. Geneva: Stop TB Partnership; 2009 (https://stoptb.org/wg/tb_hiv/assets/documents/tbicimplementationframework1288971813.pdf).

13 WHO guidelines on tuberculosis infection prevention and control, 2019 update. Geneva: World Health Organization; 2019 (https://apps.who.int/iris/handle/10665/311259).

14 Tuberculosis laboratory biosafety manual. Geneva: World Health Organization; 2012 (https://apps.who.int/iris/bitstream/handle/10665/77949/9789241504638_eng.pdf?sequence=1).

15 Infection prevention and control [website]. Geneva: World Health Organization; 2023 (https://www.who.int/teams/integrated-health-services/infection-prevention-control).

16 Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level. Geneva: World Health Organization; 2016 (https://apps.who.int/iris/handle/10665/251730).

17 Minimum requirements for infection prevention and control programmes. Geneva: World Health Organization; 2019 (https://www.who.int/publications/i/item/9789241516945).

18 A guide to monitoring and evaluation for collaborative TB/HIV activities – 2015 revision. Geneva: World Health Organization; 2015 (https://www.who.int/publications/i/item/9789241508278).

19 WHO consolidated guidelines on tuberculosis, Module 4: Treatment – tuberculosis care and support. Geneva: World Health Organization; 2022 (https://www.who.int/publications/i/item/9789240047716).

20 Tuberculosis infection control: a practical manual for preventing TB. San Francisco, CA: Curry International Tuberculosis Center; 2022 (https://www.currytbcenter.ucsf.edu/products/tuberculosis-infection-control-practical-manual-preventing-tb).

21 WHO consolidated guidelines on tuberculosis. Module 2: Screening – systematic screening for tuberculosis disease Geneva: World Health Organization; 2021 (https://www.who.int/publications/i/item/9789240022676).

22 Consolidated guidelines on HIV testing services: 5Cs: consent, confidentiality, counselling, correct results and connection. Geneva: World Health Organization; 2015 (https://apps.who.int/iris/handle/10665/179870).

23 Silva DS, Citro B, Volchenkov G, Gonzalez-Angulo L. Ethics and human rights considerations regarding involuntary isolation of people with TB. Int J Tuberc Lung Dis. 2020;24:15–20. doi: https://doi.org/10.5588/ijtld.17.0879.

24 Ethics guidance for the implementation of the End TB Strategy. Geneva: World Health Organization; 2017 (https://apps.who.int/iris/handle/10665/254820).

25 WHO consolidated guidelines on tuberculosis. Module 4: Treatment – drug-susceptible tuberculosis treatment. Geneva: World Health Organization; 2022 (https://www.who.int/publications/i/item/9789240048126).

26 Nardell EA. Preventing transmission of *Mycobacterium tuberculosis* – a refocused approach. Clin Chest Med. 2019;40:857–69. doi: https://doi.org/10.1016/j.ccm.2019.07.010.

27 Maher D, Boldrini F, Pathania V, Alli B, Gabriel P, Kisting S et al. Guidelines for workplace TB control activities: the contribution of workplace TB control activities to TB control in the community. Geneva: World Health Organization; 2003 (https://apps.who.int/iris/handle/10665/42704).

28 Visca D, Ong CWM, Tiberi S, Centis R, D'Ambrosio L, Chen B et al. Tuberculosis and COVID-19 interaction: a review of biological, clinical and public health effects. Pulmonology. 2021;27:151–65. doi: https://doi.org/10.1016/j.pulmoe.2020.12.012.

29 TB/COVID-19 Global Study Group. Tuberculosis and COVID-19 co-infection: description of the global cohort. Eur Respir J. 2022;59. doi: https://doi.org/10.1183/13993003.02538-2021.

30 Stop TB poster [website]. Atlanta, GA: United States Centers for Disease Control and Prevention; 2022 (https://www.cdc.gov/tb/publications/posters/stoptb.htm).

31 Dokubo EK, Odume B, Lipke V, Muianga C, Onu E, Olutola A et al. Building and strengthening infection control strategies to prevent tuberculosis – Nigeria, 2015. MMWR. 2016;65:263–6. doi: https://doi.org/10.15585/mmwr.mm6510a3.

32 Upper-room ultraviolet germicidal irradiation (UVGI). Atlanta, USA: United States Centers for Disease Control and Prevention; 2021 (https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation/uvgi.html).

33 Maintenance of upper-room germicidal ultraviolet (GUV) air disinfection systems for TB transmission control. Geneva: End TB Transmission Initiative, Stop TB Partnership; 2017 (https://stoptb.org/wg/ett/assets/documents/MaintenanceManual.pdf).

34 Ahne CJ, Lemire N, Lindahl PA, Marks PC, Patton MP, Comstock WS. Humidifiers, ASHRAE Handbook – HVAC Systems and Equipment. New York: American Society of Heating, Refrigerating, and Air-Conditioning Engineers; 2016 (https://www.ashrae.org/file%20library/technical%20resources/covid-19/si_s16_ch22humidifiers.pdf).

35 Department of Health and Human Services, United States Centers for Disease Control and Prevention. Environmental control for tuberculosis: basic upper-room ultraviolet germicidal irradiation guidelines for healthcare settings. Washington, DC: DHHS; 2009 (https://www.cdc.gov/niosh/docs/2009-105/default.html).

36 Guidelines for design and construction of hospital and health care facilities. The American Institute of Architects Academy of Architecture for Health; 2001 (https://www.fgiguidelines.org/wp-content/uploads/2015/08/2001guidelines.pdf).

37 Nardell EA. Transmission and institutional infection control of tuberculosis. Cold Spring Harb Perspect Med. 2015;6:a018192. doi: https://doi.org/10.1101/cshperspect.a018192.

38 Disinfecting room air with upper-room (UR) germicidal UV (GUV) systems. Geneva: Stop TB Partnership's End TB Transmission Initiative (ETTi); 2018 (https://www.stoptb.org/file/10924/download).

39 Guidelines on airborne infection control in healthcare and other settings. New Delhi: Ministry of Health and Family Welfare; 2010 (https://tbcindia.gov.in/WriteReadData/l892s/4830321476Guidelines_on_Airborne_Infection_Control_April2010Provisional.pdf).

40 Jensen PA, Lambert LA, Iademarco MF, Ridzon R. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care settings. MMWR Recomm Rep. 2005;54:1–141. doi: https://pubmed.ncbi.nlm.nih.gov/16382216/.

41 Natural ventilation for infection control in health care settings. Geneva: World Health Organization; 2009 (https://apps.who.int/iris/handle/10665/44167).

42 Guidelines for environmental infection control in health-care facilities: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. Atlanta, GA: United States Centers for Disease Control and Prevention; 2019 (https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf).

43 How to perform a respirator seal check. Geneva: World Health Organization; 2007 (https://apps.who.int/iris/bitstream/handle/10665/70064/WHO_CDS_EPR_2007.8b_eng.pdf?sequence=1&isAllowed=y).

44 Melsew YA, Gambhir M, Cheng AC, McBryde ES, Denholm JT, Tay EL et al. The role of super-spreading events in *Mycobacterium Tuberculosis* transmission: evidence from contact tracing. BMC Infect Dis. 2019;19:244. doi: https://doi.org/10.1186/s12879-019-3870-1.

45 Respiratory fit testing [website]. Washington, DC: Occupational Safety and Health Administration; 2023 (https://www.osha.gov/video/respiratory-protection/fit-testing).

46 Dharmadhikari AS, Mphahlele M, Stoltz A, Venter K, Mathebula R, Masotla T et al. Surgical face masks worn by patients with multidrug-resistant tuberculosis: impact on infectivity of air on a hospital ward. Am J Respir Crit Care Med. 2012;185:1104–9. doi: https://doi.org/10.1164/rccm.201107-1190OC.

Annex 1. Data elements for monitoring implementation of tuberculosis infection prevention and control

This annex provides two tables:

- Table A1.1 lists indicative data elements that may be monitored using periodic surveys or through implementation research studies, to complement the indicators that are routinely collected indicators (described in **Chapter 6**); and
- Table A1.2 provides an example of country evaluation of the tuberculosis (TB) infection prevention and control (IPC) activities at 6 months compared with baseline.

Table A1.1. Data element that may be monitored using periodic surveys or implementation research studies

Recommendations	Indicative date elements
Administrative controls	
Recommendation 1: Triage of people with TB signs and symptoms, or with TB disease, is recommended to reduce *M. tuberculosis* transmission to health workers (including community health workers), persons attending health care facilities or other persons in settings with a high risk of transmission.	• Number of outpatients, inpatients or individuals attending the health facility or living in a congregate setting. • Number of individuals identified as having cough at the reception or in the waiting areas among those attending the health facility or the congregate setting.
Recommendation 2: Respiratory separation / isolation of people with presumed or demonstrated infectious TB is recommended to reduce *M. tuberculosis* transmission to health workers or other persons attending health care facilities.	• Number of individuals having cough fast-tracked for TB evaluation. • Number of individuals having cough placed in isolation area for evaluation or admitted for care and treatment.
Recommendation 3: Prompt initiation of effective TB treatment of people with TB disease is recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission.	• Number of individuals having cough who were evaluated for TB and diagnosed with TB disease. • Number of individuals diagnosed with TB disease who started TB treatment within 7 days.

Recommendations	Indicative date elements
Recommendation 4: Respiratory hygiene (including cough etiquette) in people with presumed or confirmed TB is recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons **in settings with a high risk of transmission.**	• Medical mask or respirators (or both) are available for use by health care workers, visitors at health care facilities and other persons in settings with a high risk of *M. tuberculosis* transmission. (Yes/No) • Number (%) of health care workers and persons attending the health facilities or other persons in settings with a high risk of transmission of *M. tuberculosis* found to be using medical masks or respirators appropriately. • Number (%) of health care workers or staff using the respirators in the health facility or other settings with a high risk of transmission of *M. tuberculosis* who received fit testing during the reporting period. • Mechanism for respirator fit testing is in place for all users when a new batch of respirators is received. (Yes/No) • Number (%) of health care workers serving in health facilities or settings with a high risk of transmission of *M. tuberculosis* who underwent respirator fit testing during the reporting period.
Environmental control	
Recommendation 5: Upper-room GUV systems are recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission.	• Number (%) of upper-room GUV systems installed in health facilities or congregate settings found to be optimally functional. • Number (%) of upper-room GUV systems installed in health facilities or congregate settings cleaned during the reporting period. • Number (%) of upper-room GUV systems installed in health facilities or congregate settings where tests for effectiveness and safety of the fixtures was conducted during the reporting period.
Recommendation 6: Ventilation systems (including natural, mixed-mode, mechanical ventilation, and recirculated air through high-efficiency particulate air [HEPA] filters) are recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission**.**	• Natural ventilation is optimal in, patient waiting areas or consultation rooms in health facilities. (Yes/No) • Cross ventilation is optimal in waiting areas and medical consultation rooms. (Yes/No) • Record of measurement made for ACH with the use of mechanical or mixed mode ventilation is available. (Yes/No) • Record of maintenance or replacement of HEPA filters during the reporting period is available. (Yes/No)

Recommendations	Indicative date elements
Respiratory protection	
Recommendation 7: Particulate respirators, within the framework of a respiratory protection programme, are recommended to reduce *M. tuberculosis* transmission to health workers, persons attending health care facilities or other persons in settings with a high risk of transmission	• Number (%) of health care workers or other staff working in high-transmission settings who are trained in the application, use and disposal of particulate respirators.
Core components of IPC	
	• The NTP collaborates with national bodies having overall responsibility for IPC (e.g. for the prevention of health care associated infection or combating antimicrobial resistance). (Yes/No) • TB IPC is incorporated within the mandate of IPC committees at all levels. (Yes/No) • A focal person to monitor TB IPC is identified in IPC committees at all levels. (Yes/No) • Number (%) of health care workers or other staff at health facilities or congregate settings trained on TB IPC. • Number (%) of health care facilities or congregate settings with a high risk of *M. tuberculosis* transmission where an annual TB risk assessment survey is conducted.

ACH: air changes per hour; GUV: germicidal ultraviolet light; HEPA: high-efficiency particulate air; IPC: infection prevention and control; *M. tuberculosis*: *Mycobacterium tuberculosis*; NTP: national TB programme; TB: tuberculosis.

Table A1.2. Example of a country evaluation of TB IPC activities at baseline and 6 months[a]

Baseline of Phase	District 1		District 2		District 3			District 4		TBIC measures Evaluation (Baseline vs 6 months later)	**Evaluation of Phase I (6 months after)**	District 1		District 2		District 3			District 4	
Hospitals/ Clinics	**H**	**CI**	**CI**	**CI**	**H**	**H**	**C**	**CI**	**CI**		**Hospitals/ Clinics**	**H**	**CI**	**CI**	**CI**	**H**	**H**	**CI**	**CI**	**CI**
IPC focal person assigned											IPC focal person assigned									
IPC committee formed											IPC committee formed									
Written TB IPC plan available											Written TB IPC plan available									
TB IPC training for all staff done											TB IPC training for all staff done									
TB IPC information available for all patients and visitors											TB IPC information available for all patients and visitors									
Patients asked about cough when entering the facility											Patients asked about cough when entering the facility									
Coughing patients separated and "fast tracked"											Coughing patients separated and "fast tracked"									
Signage for cough etiquette present											Signage for cough etiquette present									
Tracking mechanism to monitor patient turn-around time											Tracking mechanism to monitor patient turn-around time									
Staff receive evaluation for TB at least annually											Staff receive evaluation for TB at least annually									
Confidential log is kept of all staff diagnosed with TB											Confidential log is kept of all staff diagnosed with TB									
Signage in place to keep doors and windows open											Signage in place to keep doors and windows open									
Functional extractor or UV lighting											Functional extractor or UV lighting									
Patient waiting areas outdoors or with cross-ventilation											Patient waiting areas outdoors or with cross-ventilation									
Medical masks available and worn by coughing patients											Medical masks available and worn by coughing patients									
N-95 or FFP2 respirators readily available and used by staff											N-95 or FFP2 respirators readily available and used by staff									
Staff trained on proper fit of respirator											Staff trained on proper fit of respirator									

FFP2: filtering facepiece 2; IC: infection control; TB: tuberculosis; UV: ultraviolet.

[a] Green: the measure implementation is in place; yellow: the measure implementation is at draft stage or planned; and red: the measure is not implemented.

Source: table supplied by GB Migliori.

Annex 2. Facility tuberculosis risk assessment tool

This annex is based on a tool produced by Médecins Sans Frontières (MSF) *(1)*.

Instructions: This tool helps to give an idea of the risk of transmission of *Mycobacterium tuberculosis* in health care facility or congregate settings. The results should be completed by the infection prevention and control (IPC) focal person and interpreted by the IPC committee. For the Yes/No questions, a Yes answer indicates good tuberculosis (TB) IPC practices. Any pertinent information on No answers is noted in the Comments section below each table.

Overview of the facility (interview with the health facility manager)

Name, address and telephone number of the facility	
Name of assessor	
Name of facility manager	
Date of current TB IPC assessment	
Date of last TB IPC assessment	
Type of facility (e.g. primary health care or prison)	
Medical services offered (e.g. OPD consultation, VCT or antenatal care)	
Size of the population served by this facility	
Facility TB case notification rate per 100 000 per year	
National TB case notification rate per 100 000 per year	
Number of DR-TB patients in care	
Number of people living with HIV in care	
Average number of cases of TB reported per month in the facility	
Is there a functional IPC committee in the facility or a committee at which TB IPC is discussed?	
Is there a written facility-specific infection prevention and control plan (that includes TB IPC)?[a]	
Is there a budget allocated for TB IPC activities?	
Is there a person in charge or a focal person for TB?	
Is the TB focal person a member of the facility IPC committee?	
How often does IPC committee meet? [a]	
Did all the clinical staff receive documented TB IPC training or refresher training within the past 2 years? [b]	

[a] If possible, obtain a copy of the minutes of the last IPC meeting and TB IPC plan.

[b] Review and note number (%).

Comments _____

Administrative measures

Risk identification and segregation

	Yes	No
Are high risk areas (e.g. TB ward, ART centre or sputum collection corner) properly identified?		
If yes, is there a SOP to be followed in high-risk areas (e.g. wear respirators)?		
Are presumptive TB cases separated from other patients?		
Are persons segregated based on bacteriological status (positive/negative)?		
If treating DR-TB patients, is segregation by resistance pattern implemented?		
Is ambulatory treatment for patients with DR-TB encouraged in the intensive phase?		
Is access to high-risk areas limited or restricted for visitors?		

Comments _____

Waiting areas (observe behaviour for 1 hour, ideally in the main (or in the specific TB) waiting area during the busy early morning hours

	Yes	No
Are patients given health education on TB through talks or use of audiovisual aids while they wait?		
Is there educational content on display regarding TB and cough hygiene?		
Are visitors told to cover their nose and mouth when they cough or sneeze?		
Are presumptive TB cases separated in any way from other patients?		

Comments _____

Management of persons with presumptive or confirmed TB (interview health care workers)

	Yes	No
Is fast tracking or accompanied referral implemented to minimize waiting time in crowded spaces?		
Are symptomatic individuals offered medical masks?		
Are results of sputum smear microscopy available in less than 48 hours?		
Is TB treatment started immediately after TB diagnosis? (Note the average duration between date of diagnosis and date of starting TB treatment)		

Comments _____

Sputum specimen collection and preparation (witness a sputum sample collection and preparation)

	Yes	No
Is sputum collection performed in a designated, well-ventilated area?		
Is sputum collected in labelled, screw-top sterile plastic containers?		
If sputum is induced, are the mask and tube replaced or decontaminated between patients?		

Comments _____

Staff measures (interview facility manager)

	Yes	No
Are educational sessions on TB risk for health care workers conducted annually?		
Do staff members involved in patient care receive annual TB evaluation?		
Do staff members involved in patient care receive annual chest X-ray?		
Have staff members received TPT at least once?		
Number of employees notified with TB disease in the past 12–24 months		
Are staff aware of national occupational health and safety regulations when diagnosed with TB?		

Comments _____

Environmental measures (If possible, make rough estimates of ventilation using a vaneometer and smoke tube or incense stick)

	Yes	No
Is natural ventilation possible?		
If yes, are windows open during busy hours?		
Are health care workers positioned "up-wind" from patients during consultation and counselling?		
Are waiting areas in outdoor or open areas?		
Is measurement of ACH possible?		
Are there at least 12 ACH in all waiting areas?		
Are there at least 12 ACH in consultation rooms and wards?		
Are there at least 20 ACH in the sputum collection area (or in open air)?		
Is a mechanical ventilation system used?[a]		
Are GUV fixtures used in areas frequented by patients with infectious TB?[a]		

[a] If a mechanical system or GUV fixtures are used, explain their functioning and maintenance in detail in a separate sheet.

Obtain a scale drawing of the floor plan of the whole facility including doors and windows (if this is not available, make a sketch). Shade the different areas according to the level of risk based on the observations on environmental measures:

- high risk of TB transmission – dark grey
- limited risk of TB transmission – grey
- low risk of TB transmission – white

Include patients and staff flow, and environmental measures (e.g. fans and GUV fixtures).

Comments _____

Personal protective measures (Walk unannounced around the facility and observe, then discuss with staff)

	Yes	No
Are medical masks for patients with presumptive TB available in sufficient quantity?		
Are respirators that meet FFP2 or N95 standards available for staff?		
Are respirators available in sufficient quantities for all health care workers?		
Are respirators of more than one size, model or brand available?		
Are respirators available in sufficient quantities for care providers of patients with bacteriologically confirmed TB?		
Do health care workers use respirators when assisting sputum collection or induction?		
Do health care workers wear respirators before entering the room of a person with presumed TB or a patient with bacteriologically confirmed TB?		
Do health care workers perform a seal check before wearing a respirator?		
Does the facility have a fit-test programme for health care workers using respirators?		
Do health care workers who use respirators undergo fit-testing at least once?		

Comments _____

ACH: air changes per hour; ART: anti-retroviral therapy; DR-TB: drug-resistant TB; GUV: germicidal ultraviolet light; HIV: human immunodeficiency virus; IPC: infection prevention and control; OPD: outpatient department; SOP: standard operating procedure; TB: tuberculosis; TPT: TB preventive treatment; VCT: voluntary counselling and testing.

Conclusions (debrief health facility manager after completing assessment)

According to the assessor and the facility manager, what are the current main issues and barriers in the implementation of TB IPC?

According to the assessor and the facility manager, what are the priority actions for the implementation of TB IPC in this facility for the next 6–12 months?

Reference for Annex 2

1 Varaine F, Rich ML. Appendix 16. Basic TB infection control risk assessment tool, Tuberculosis: Médecins Sans Frontières, Partners In Health; 2023 (https://medicalguidelines.msf.org/sites/default/files/TB-Appendix%2B16.pdf).

Annex 3. Example of an outline of facility tuberculosis infection prevention and control plan

The facility tuberculosis (TB) infection prevention and control (IPC) plan given in this annex is based on a publication from the United States Centers for Disease Control and Prevention (CDC) *(1)*.

- Name of facility:
- TB IPC committee chair:
- TB IPC focal person:
- IPC committee members (e.g. nursing services, radiology, laboratory, medical records, community representative, TB clinical lead and HIV clinical lead):
- Schedule of IPC committee meetings (e.g. first Wednesday of each month), updates on TB IPC will be a standing agenda item:

Background

- Type of health facility:
- Patient visits per year (outpatients, inpatients):
- Type of health services available (e.g. outpatient, HIV and anti-retroviral therapy [ART], TB screening and follow-up, prenatal, maternity, paediatric and laboratory services including rapid TB diagnostics and X-ray):
- Estimated TB burden in the catchment area of the health facility:
- Type of TB services available (e.g. screening, diagnosis, treatment and TB preventive treatment [TPT]):

Purpose

An infection prevention and control programme requires a plan for identifying and separating patients, providing appropriate treatment and other measures to reduce the risk for TB transmission to patients and health care workers. The plan should be based on the findings from the facility risk assessment and be consistent with the national TB IPC policy and latest guidelines from the World Health Organization (WHO).

Authority statement

The designated TB IPC focal person should have the authority to assess, implement and ensure compliance with this plan, including the authority to use measures to minimize the risk of TB transmission to patients, visitors and health care workers.

Responsibilities

The facility IPC committee has the authority to adapt the plan as needed to maintain the safety and health of patients, visitors and staff members. The TB IPC focal person, with the support of the facility administration and IPC committee, will ensure implementation of the plan as outlined in the following sections for administrative and environmental controls, and respiratory protection.

Administrative controls

The TB IPC focal person will monitor the implementation of activities such as the following:

- TB IPC training of staff;
- educating staff on the TB IPC plan;
- providing educational information on TB IPC to patients, visitors and staff;
- performing TB IPC risk assessment and analysis, and developing a performance improvement plan at least annually;

To reduce the risk of TB transmission, the facility will be responsible for ensuring that:

- visitors are routinely asked about cough upon the entering facility;
- individuals who cough will be separated and fast-tracked for diagnosis;
- all patients diagnosed with TB are started on TB treatment immediately;
- signage for cough etiquette is displayed at strategic locations;
- all staff are trained to provide education on cough etiquette;
- a confidential log is maintained of staff members diagnosed with TB;
- all staff members receive evaluation for TB at least annually, HIV test and ART when positive and TPT as per national guidelines; and
- HIV-infected staff are reassigned if they request reassignment.

Environmental controls

Engineering and maintenance department staff are responsible for ensuring compliance with the following measures:

- monitoring of natural and mechanical airflow daily in the waiting room, consultation rooms and wards;
- conducting regular maintenance, and keeping a log kept on all directional and extractor fans, and any other special equipment (e.g. germicidal ultraviolet light [GUV] lamps);
- preventing overcrowding in hallways or waiting areas and providing alternative seating arrangements, as required; and
- installing signage directing health care workers to keep doors and windows open.

Respiratory protection

Personal protective equipment (PPE), when used in tandem with other TB IPC measures, can reduce the risk of TB transmission. Apart from making sure that appropriate PPE is available to staff, the clinic will budget for and ensure uninterrupted availability of items such as:

- tissues and medical masks for coughing patients;
- N-95 or FFP2 respirators for staff working in high-risk areas;
- fit-testing kits; and
- educational material.

Signature and date Administrator	Signature and date IPC committee chairperson

Annex 4. Health care worker tuberculosis screening form

This tuberculosis (TB) infection screening form is based on a publication from the United States Centers for Disease Control and Prevention (CDC) *(1)*. It is intended for screening health care workers periodically for TB. Other health screening (e.g. for diabetes, HIV, hypertension or malnutrition) can be added to this form as needed.

Demographics			
Date:	ID:	Age:	Sex: ☐ Male ☐ Female
Occupational category:		Department:	
TB symptom screening			
Do you have any of the following symptoms or risk factors? (Check if present)			
General symptom screen (people without HIV)		Four-symptom screen (people with HIV)	
☐ Cough >2 weeks		☐ Cough (any duration)	
☐ Fever >2 weeks		☐ Fever (any duration)	
☐ Loss of weight in last 3 months		☐ Loss of weight in last 3 months	
☐ Drenching night sweats		☐ Drenching night sweats	
☐ Sputum production			
☐ Coughing up blood			
☐ Lymphadenopathy (e.g. neck swelling)			
☐ TB contact in the past year			
Is there a X-ray chest result? ☐ Yes ☐ No		**Abnormality detected:** ☐ Yes ☐ No	
TB screening result ☐ Positive ☐ Negative			
Referred for TB diagnosis? ☐ Yes ☐ No		**If yes, referred where?**	
Referred for test for TB infection? (TB negative) ☐ Yes ☐ No		**If yes, referred where?**	
Started TB preventive treatment? (TB negative) ☐ Yes ☐ No		**Date of start of TPT:**	

HIV: human immunodeficiency virus; ID: identity; TB: tuberculosis; TPT: TB preventive treatment.

Annex 5. Health care worker TB screening register

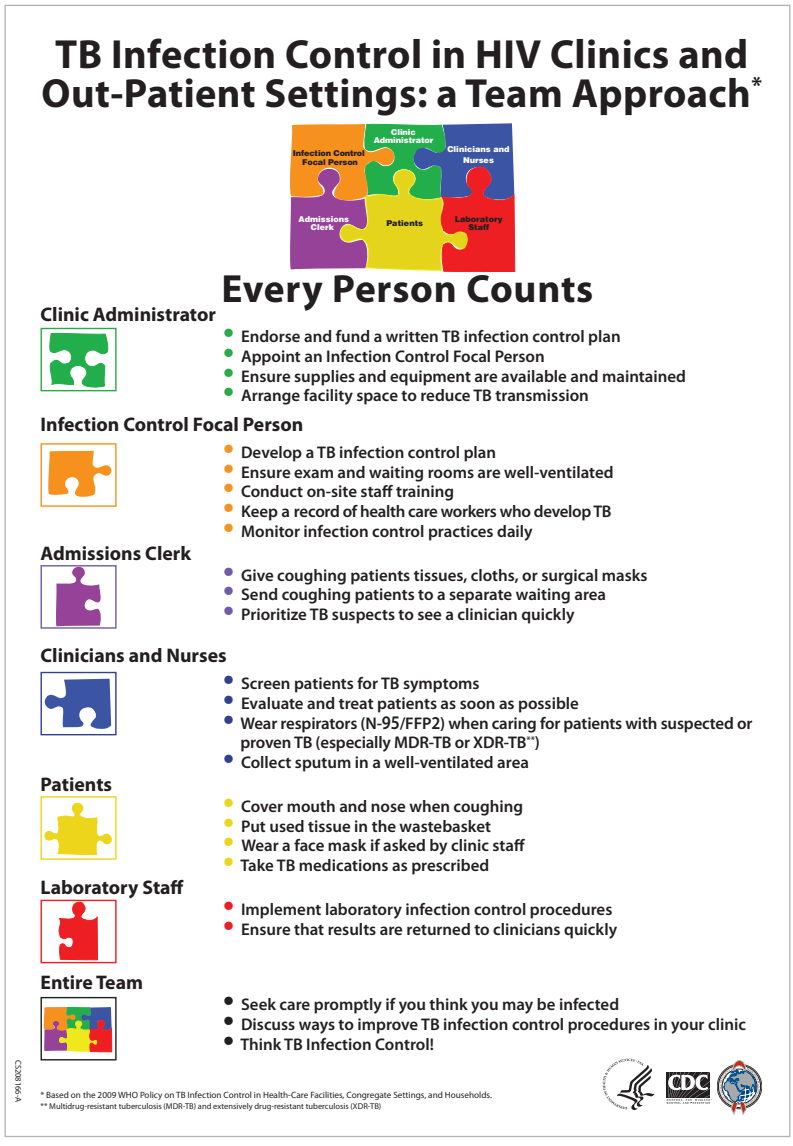
This register is based on a publication from the United States Centers for Disease Control and Prevention (CDC) *(1)*. It is intended to be used to list the progress of health care workers being screened for tuberculosis (TB). It may also be used to derive performance indicators for screening, initiation of treatment and TB preventive treatment (TPT).

No	Demography						TB screening					TB preventive treatment (TPT)			TB diagnosis and treatment				Comments
	Health care worker identity no.	Date	Age	Sex	Occupational category	Department	Date	Screening result	Referred for TB diagnosis	Referral location	Chest X-ray result	TPT start date	TPT regimen	TPT outcome	Diagnostic test	Test date	Test result	TB Treatment start date	
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			

TB: tuberculosis; TPT: TB preventive treatment.

Annex 6. Sample posters for health education

This annex provides sample posters for health education from different countries.







Source: CDC, TB BASICS toolkit.(1)

Protect Others. Protect Yourself.



Cough or sneeze into your arm



Use a tissue and then throw it away



For good hygiene wash your hands

CS221396-B

What You Need To Know About TB

Source: CDC, TB BASICS toolkit.(1)

What is Tuberculosis (TB)?

TB is an infectious disease that usually attacks the lungs, and, if left untreated can be deadly.

How do you get TB?

TB is spread person-to-person through the air when an infectious person coughs or sneezes. That is why everyone should cover their nose and mouth when they cough or sneeze. **You cannot get TB by shaking hands, hugging, or by sharing food, glasses, or cigarettes.**

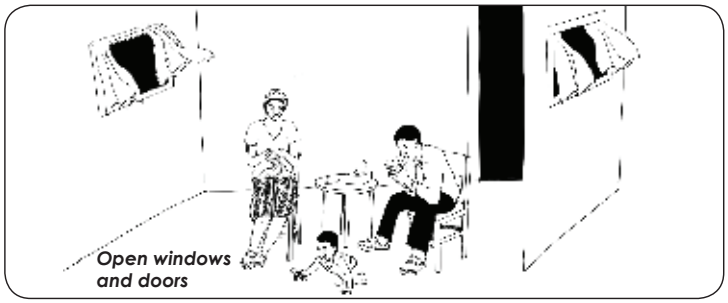
Can anyone get TB?

Yes, anyone can get TB but persons at increased risk are those with:

- HIV/AIDS
- Diabetes
- Cancer
- Or take certain medications that lower their ability to fight off infections

Can TB be cured?

Yes, TB can be cured with TB medicine prescribed by a healthcare provider. The person must take the medicine every day until the healthcare provider says he/she is cured. It usually takes many months to be cured. "Natural or alternative" therapies will not cure TB.



Open windows and doors

What are some of the signs of TB?

- A cough that persists
- Fever
- Night sweats
- Weight loss without trying to lose weight

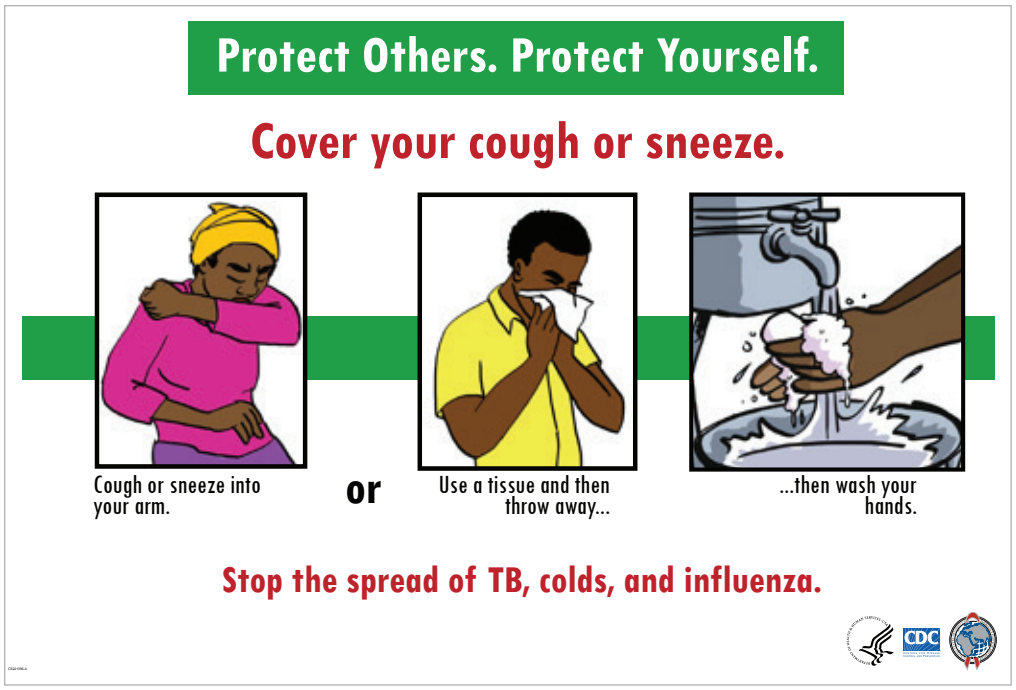
These signs left untreated, put you and your family at risk. Anyone with these signs should cover their cough and go to the clinic to seek care promptly. The sooner you are treated, the sooner you can be cured.

The best way to prevent TB is to encourage people with TB signs to go to the clinic for treatment.

If I or someone in my family has TB what can we do to protect others from TB?

- Cover all coughs and sneezes with a tissue, handkerchief, or inner arm.
- Dispose of tissues in a trash bin. Wash handkerchiefs after use.
- At home, open the doors and windows. The clean air flowing through the house can blow TB germs outside.
- Encourage persons on TB treatment to take all TB medications daily and not skip doses.
- Persons on TB treatment should check with the healthcare provider before stopping any TB medications.
- Tell your healthcare provider if you live with or are in close contact with someone who has TB. You may need to be screened for TB.

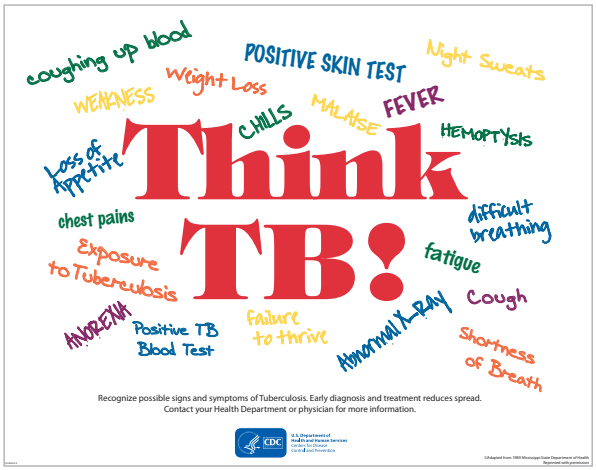
Source: CDC, TB BASICS toolkit.(1)



Source: CDC, TB BASICS toolkit.(1)

These posters are from the United States Centers for Disease Control and Prevention (the Stop TB poster is also available in Spanish) *(2, 3)*.







Source: Brihanmumbai Municipal Corporation, SHARE India, and CDC. Patient education material in Marathi, Mumbai India

References for Annex 6

1 TB BASICS toolkit, Atlanta, GA: United States Centers for Disease Control and Prevention (personal communication).

2 Think TB poster [website]. Atlanta, GA: United States Centers for Disease Control and Prevention; 2012 (https://www.cdc.gov/tb/publications/posters/thinktb.htm).

3 Stop TB poster [website]. Atlanta, GA: United States Centers for Disease Control and Prevention; 2022 (https://www.cdc.gov/tb/publications/posters/stoptb.htm).

Annex 7. How to choose upper-room germicidal ultraviolet light fixtures

The scenarios in this annex are designed to aid in choosing the most appropriate and cost-effective germicidal ultraviolet light features; that is, features using ultraviolet C (UVC) to create an effective upper-room UVC_{254} system. The effectiveness of the system depends on room shape and dimensions, type of fixtures available and how occupants will use the space. The three examples given demonstrate how these factors can influence final fixture choices for upper-room UVC *(1)*.

A. Low-ceiling room	Floor-to-ceiling height is too low to safely install upper-room UVC_{254}	Height 2.3 m	Width 3 m	Length 3 m
B. Standard office or examination room	1. Floor-to-ceiling height is **sufficient for upper-room UVC_{254}**	Height 2.6 m	Width 3 m	Length 3 m
	2. **Calculate room volume**: (V) = (h) x (w) x (l)	V = 23.4 m^3		
	3. **Calculate required room UVC_{254} output (mW)**: Required UVC_{254} dose = V (m^3) × 12 mW/m^3	Required UVC_{254} dose = 280–290 mW		
	4. Calculate type and number of UVC_{254} fixtures: a) If ceiling height is 2.4–3.0 m, use a **louvred or baffled style fixture** (ceiling not high enough to safely use an open design fixture). b) A manufacturer has louvred or baffled UVC_{254} fixtures with six different levels of UVC output. c) The goal is to have enough fixtures (based on UVC_{254} output) to meet the required room UVC_{254} dose for adequate disinfection for the room size. **Here the goal would be a total room UVC dose of 280–290 mW.** **Cost consideration**: In general, the cost of a UVC_{254} fixture with an output of 400 mW is *not* double the cost of a UVC_{254} fixture with an output of 200 mW. The cost of replacement lamps is nearly identical. In general, the greater the number of units, the greater is the UVC efficacy because it ensures coverage of a broader area from the source; however, multiple units cost more.	Manufacturer fixture options for louvred or baffled design (UVC_{254} output) 200 mW. . . . . (0.2 W) 400 mW. . . . . (0.4 W) 600 mW. . . . . (0.6 W) 800 mW. . . . . (0.8 W) 1000 mW. . . . . (1.0 W) 1200 mW. . . . . (1.2 W) **One 400 mW UVC_{254} fixture or two 200 mW UVC_{254} fixtures would meet required UVC_{254} dose for disinfection.**		

	5. Appropriate air mixing should be installed and verified.	
	6. Safety exposure for occupants should be considered during design and installation, then verified after installation.	
C. Large room, high ceiling (with decorative acoustic ceiling panels)	1. Floor-to-ceiling height is **sufficient for upper-room UVC_{254}** a) In this example, decorative acoustic architectural panels are hung from the ceiling. The panel bases (lowest points) are 3 m above the floor. b) The floor to panel height is used for UVC_{254} considerations and calculations.	Actual height 6.1 m Ceiling panel height 3 m Width 12.2 m Length 15.2 m
	3. **Calculate room volume**: (V) = (h) × (w) × (l)	V = 556 m^3
	4. **Calculate required room UVC_{254} output (mW)**: Required UVC_{254} dose = V (m^3) × 12 mW/m^3	Reqired UVC_{254} dose = 6672–6800 mW
	5. **Calculate type and number of UVC_{254} fixtures** In this case, the functional ceiling is 3 m and these values will be used for both the dosing calculations and UVC_{254} fixture selection: a) Because of the decorative ceiling panels, use **louvred or baffled fixtures** (if no panels were present, the 3 m high ceiling would have allowed open or semi-open UVC_{254} fixtures). b) A manufacturer has louvred or baffled UVC fixtures with six different levels of UVC254 output. c) The cost-effective choice would be to use as few fixtures as possible**. Six 1.2-W UVC_{254} fixtures would be a practical choice** if they can produce a relatively uniform distribution of UVC_{254} in the room. Depending on the room shape, a combination of fixture outputs may be needed. If there were no or very few obstructive items in the upper portion of the room, open or semi-open UVC_{254} fixtures could have been considered. Open UVC_{254} fixtures generally start at 3 W and higher in output. For this example, two or three open UVC_{254} fixtures would suffice.	Number of fixtures needed per UVC_{254} fixture output to reach required room UVC_{254} dose of 6800 mW: **No.** — **UVC_{254} output** 34 — 200 mW (0.2 W) 17 — 400 mW (0.4 W) 11 — 600 mW (0.6 W) 9 — 800 mW (0.8 W) 7 — 1000 mW (1.0 W) 6 — 1200 mW (1.2 W)
	5. Appropriate air mixing should be installed and verified.	
	6. Safety exposure for occupants should be considered during design and installation, then verified after installation.	

UVC: ultraviolet C.

Reference for Annex 7

1 Tuberculosis infection control: a practical manual for preventing TB. San Francisco, CA: Curry International Tuberculosis Center; 2022 (https://www.currytbcenter.ucsf.edu/products/tuberculosis-infection-control-practical-manual-preventing-tb).

Annex 8. Choosing a radiometer for measurement of ultraviolet C irradiation

The manufacturer's specifications should be checked to determine whether the radiometer has the appropriate characteristics for wavelength, irradiance measurement and accuracy, based on the ultraviolet C (UVC) source being used *(1)*.

Wavelength range

The radiometer chosen should be able to measure wavelengths of 220–280 nm with a peak response at 254 nm for standard UVC_{254} low-pressure mercury lamps.

- If measuring sources other than UVC_{254} low-pressure mercury lamps, look for a radiometer calibrated to the peak output of the concerned source.
- If using more than one type of UVC fixture with different wavelengths, consider purchasing a radiometer that can be programmed to measure multiple wavelengths (rather than using radiometers specific for individual wavelengths).

Irradiance measurement range

The radiometer chosen should be able to measure effective[25] irradiance within a recommended range of at least **0.1–2000 µW/cm²** for standard UVC_{254} low-pressure mercury lamps.

- The upper end of the range may need to be increased if high-output, unbaffled UVC fixtures are used.
- For wavelengths other than 254 nm, the range may need to be shifted up or down based on the peak output of the lamp (depending on the manufacturer's specifications).

Accuracy

Accuracy may be referred to as "measurement uncertainty" under specifications. The radiometer should have an accuracy (measurement uncertainty) for both of the following criteria:

- Accuracy for measurements of UV irradiance of more than 1 to 2000 µW/cm² should be ±10% of the reading (not ±10% of the upper end of the radiometer range), to measure irradiance and confirm performance of the source or lamp.
- Accuracy for measurements of UV irradiance of 0.05–1 µW/cm² should be ±0.05 µW/cm², to measure safety levels for occupants.

Some radiometers meet both of the accuracy criteria required; however, if a radiometer meets only one of the two criteria, a second radiometer that meets the other criterion will be needed. Reputable

[25] Safety and performance standards presume that dose measurements are calculated using effective irradiance. Most UVC_{254} radiometers measure total irradiance; total irradiance results should be multiplied by two (to convert to effective irradiance).

companies will disclose this information; if the information is not given on the company's website, then it is best to speak with a representative of the manufacturer.

- Calibration instructions: The radiometer should be calibrated according to the manufacturer's recommendations. If no recommendation is provided, then annual calibration is recommended.
- Field of view (FOV) cone: An FOV cone is a separate accessory for the radiometer that should be used for all safety measurements. It should be ±40 degrees (80 degrees total) and must be compatible with the radiometer model.

Reference for Annex 8

1 Tuberculosis infection control: a practical manual for preventing TB. San Francisco, CA: Curry International Tuberculosis Center; 2022 (https://www.currytbcenter.ucsf.edu/products/tuberculosis-infection-control-practical-manual-preventing-tb).

Annex 9. Checklist for the review of programmatic implementation of tuberculosis infection prevention and control

This checklist was prepared for the express purpose of national tuberculosis (TB) programme reviews for TB infection prevention and control (IPC) *(1, 2)*. Such reviews typically consider multiple programmatic components; thus, a checklist helps the reviewer to focus on the critical areas of any particular component.

Objectives

By the end of the review, experts should be able to comment on how TB IPC measures are implemented at different levels of the health services (with the measures being administrative controls, environmental controls, respiratory protection and the core components of IPC as they apply to TB).

Note: TB laboratory biosafety is generally dealt with separately from TB IPC, and this review needs to be coordinated with the experts reviewing the laboratory services.

Background

The End TB Strategy calls for a 90% reduction in TB deaths and an 80% decrease in the TB incidence rate by 2030. The strategy emphasizes the need for prevention across all approaches, including TB IPC at health care facilities and other settings where the risk of *Mycobacterium tuberculosis* transmission is high. TB IPC measures and practices are vital to reduce the risk of transmission, by reducing the concentration of infectious particles in the air and the exposure of susceptible individuals to such particles.

Stakeholders

Various personnel are involved in implementation of TB IPC and may be encountered as part of the programme review:

- managerial staff at national, subnational and health facility level contributing to the national TB programme (NTP) and national HIV/AIDS programme; and other individuals such as engineers, managers at hospitals and primary health care facilities and at long-term residential facilities, prison health services and migrant facilities; and
- health care workers and community health workers involved in TB and HIV care; evaluations of household contacts; implementation of IPC; diagnostic services in health care facilities, both in public and private primary and secondary health sectors; and other services

Key questions to answer

Note: Questions marked by an asterisk are those that are most relevant at the national level.

Policies and core components of IPC

- Are guidelines and institutional arrangements for IPC adequate in scope? Do they focus sufficiently on airborne infection prevention and control (e.g. is there an IPC committee at the health facility level and does its mandate include airborne infection and TB)?
- Are there IPC risk assessments and plans for selected high-risk settings?
- Have staff been trained or sensitized on airborne infection prevention and control in last year?

Administrative controls

Are the following administrative controls and measures in place to reduce the transmission of *M. tuberculosis* by patients with infectious TB at facilities?

- Staff designated to oversee IPC activities in the health facility.
- Staff designated to implement triage, separation and fast tracking of individuals with TB symptoms.
- Provision of respiratory protection equipment for staff and visitors (e.g. respirators for health workers and medical masks for patients).
- Policy in place to ensure early initiation of TB treatment among individuals diagnosed with TB.
- Provision of patient education material (e.g. audiovisual aids in the patient waiting area providing information on cough etiquette and respiratory hygiene, and posters and pamphlets providing key messages to reduce airborne infections).
- Are health care workers offered annual TB screening (e.g. chest X-ray and tests for TB infection) and provision of TB preventive treatment (TPT)?

Environmental controls

- Is the infrastructure of health care facilities adequate for the implementation of TB IPC?
- Are patient waiting areas well-ventilated?
- Is the seating arrangement in doctor or staff consulting rooms, hospital wards appropriate? Is there cross-ventilation?
- Does the facility use any form of mechanical ventilation (e.g. exhaust fans and high-efficiency particulate air [HEPA] filters) to ensure frequent air changes or does it use upper-room germicidal ultraviolet (GUV) systems?
- Is there a need for structural changes in the health facility to facilitate IPC for airborne pathogens? Who is responsible for health facility maintenance and renovation?

Respiratory controls

- Do staff use respiratory protection equipment appropriately (e.g. respirators and medical masks)?
- If respirators are used, is fit testing done before supply?

Indicators

Indicator	Source of information
The proportion of health facilities that have a valid (i.e. updated) TB IPC plan	Policy document from the NTP, field visits and survey data
The proportion of health facilities that have an appointed TB IPC focal person as a part of the facility IPC committee	Policy document from the NTP, field visits and survey data
Time to initiation of appropriate TB treatment after diagnosis	Surveillance data (should be available in most case-based records)
The proportion of health care workers involved in the care of patients with multidrug-resistant TB or in the collection of sputum samples who are provided with at least one respirator per week	Field visits
Rate of TB in health care workers compared with the TB notification rate in the adult population of the same area in the same year[a]	Surveillance data

IPC: infection prevention and control; NTP: national TB programme; TB: tuberculosis

[a] The table below presents more detail on the rationale and methodology for the calculation of this indicator *(3)*.

Definition: The relative risk of developing TB disease among health workers employed in facilities providing care for TB or HIV expressed as a ratio of the TB case notification rate among health workers to the TB notification rate in the general population during the same period, adjusted for age and sex if appropriate.

Numerator: The TB notification rate among health workers; that is, the total number of patients with TB registered among health workers per unit number of health workers in the reporting unit during the reporting period.

Denominator: The TB notification rate in the general adult population; that is, the total number of TB patients registered per unit number of adult populations in the reporting unit during the reporting period.

Purpose: To estimate the relative risk of developing TB among health workers compared with the general population, providing an indirect measure of the impact of TB IPC activities implemented in health care facilities.

Rationale: Health workers share the background risk of TB in the population. Additionally, due to involvement in patient care, their exposure to infectious TB is higher than that of the general population. If TB IPC measures are effectively implemented in health care facilities, exposure can be minimized and the risk of acquiring TB reduced, and the relative risk of TB disease should be close to 1.

Methodology: TB among health workers should be registered in the occupational health programme in the country, and the occupational health records should provide information on the number of health workers detected having TB during the reporting period. Alternatively, and in the absence of occupational health records, information on TB among health workers may be obtained from the NTP. Health workers having TB should be registered in TB registers maintained at the basic management unit, and it is desirable to indicate occupation in the register or indicate "health care worker" and workplace in the

remark's column of the TB register. The definition of "health care worker" may be country specific, and it needs to be clearly defined and used universally and consistently to compare trends over time. Depending on the country, it may include only medical and nursing staff or all health workers.

Numerator: Calculate the notification rate of TB among health workers by dividing the total number of health workers reported to have TB by the total number of health workers in the reporting unit during a chosen period (most commonly 1 year, given the relatively low numbers of health workers with TB).

Denominator: Calculate the TB notification rate among the adult general population by dividing the total number of adult patients with TB registered during the reporting period by the total adult population in the reporting unit during the chosen period. The data used in the numerator and denominator may be adjusted for age and sex for further analysis.

Periodicity: Data should be collected continuously and reported annually to the national and subnational level, and also to WHO.

Strengths and limitations: This indicator attempts to measure the adequacy of IPC measures in health care facilities, but it should be interpreted carefully because occupational health records or registration in NTP records by occupation may be lacking. The data may further be lacking if health workers prefer TB treatment from non-NTP providers. This may underestimate the overall risk of TB among health workers. On the other hand, the risk may be overestimated if the probability of health workers accessing TB screening and diagnostic services from the NTP in a country is high.

Source of information: Occupational health records, TB register at the basic management unit.

Responsibility: NTP.

HIV: human immunodeficiency virus; IPC: infection prevention and control; NTP: national TB programme; TB: tuberculosis; WHO: World Health Organization.

References for Annex 9

1 WHO guidelines on tuberculosis infection prevention and control, 2019 update. Geneva: World Health Organization; 2019 (https://apps.who.int/iris/handle/10665/311259).

2 Tuberculosis laboratory biosafety manual. Geneva: World Health Organization; 2012 (https://apps.who.int/iris/bitstream/handle/10665/77949/9789241504638_eng.pdf?sequence=1).

3 A guide to monitoring and evaluation for collaborative TB/HIV activities – 2015 revision. Geneva: World Health Organization; 2015 (https://www.who.int/publications/i/item/9789241508278).

Annex 10. Country example: education messages for tuberculosis and for tuberculosis infection prevention and control

This annex provides examples of posters from Myanmar with educational messages for tuberculosis (TB) and TB infection prevention and control (IPC) for community members.



Heath education message for TB patients and families

By

National Tuberculosis Programme, Department of Public Health, Ministry of Health

and

World Health Organization, Country Office, Myanmar



Collaboration between the TB patient and family members is important for successful treatment

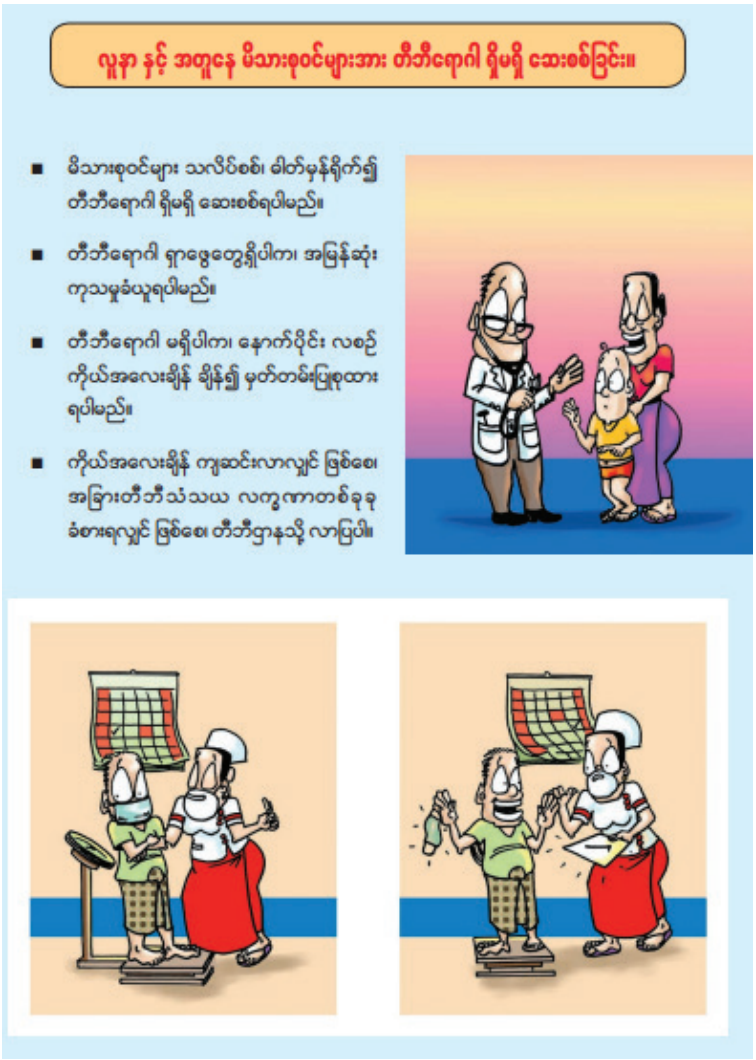
1. The patient must go to clinic on follow-up days and must not miss the appointment.
2. The patient must collect and submit good-quality sputum samples as directed by the doctor.
3. The patient must take medicines given by the doctor as prescribed.
4. She / he must complete the entire course of treatment (otherwise TB relapse may occur) and must come to the clinic twice a year for the next two years.



Patient must behave correctly each day to prevent infection transmission to family members and the community

The patient should:

1. **Wear a medical mask** at all times except when they are alone until the sputum is negative (the mask must cover both the nose and mouth).
2. **Keep windows open** except when it rains or during the night.
3. Collect sputum only into a spittoon with a lid and antiseptic solution (e.g. phenol mixed with water, as per instructions).
4. Keep the spittoon covered.
5. Each day, dispose of sputum properly (e.g. into latrine).
6. **Avoid visits to crowded places**.



TB screening and evaluation of household contacts

1. Family members must be **evaluated for TB** with symptoms, chest X-ray and sputum examination.
2. If someone has TB, they must be **started on TB treatment immediately**.
3. If she/he is not diagnosed with TB, the health worker or doctor should **evaluate for TB preventive treatment (TPT)** and start TPT.
4. **Body weight** should be regularly measured, if she/he has loss of weight or becomes unwell with TB symptoms, she/he must visit the health centre.



For further information, please contact:

Global Tuberculosis Programme
World Health Organization
20, Avenue Appia
CH-1211 Geneva 27
Switzerland
Website: www.who.int/tb

9789240078154