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GUIDELINES *for* THE PREVENTION *of* TUBERCULOSIS

IN HEALTH CARE FACILITIES IN RESOURCE-LIMITED SETTINGS

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GUIDELINES FOR THE PREVENTION OF TUBERCULOSIS IN HEALTH CARE FACILITIES IN RESOURCE-LIMITED SETTINGS

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EXECUTIVE SUMMARY

Presently, disease caused by *Mycobacterium tuberculosis (M. tuberculosis)* is the leading cause of mortality among adults in the world. Populations in resource-limited settings account for nearly 95% of *M. tuberculosis* infections, with the global burden due to infection of *M. tuberculosis* being approximately 1.1 billion people. In 1998, WHO reported an estimated two million deaths due to tuberculosis (TB).

The WHO strategy to control TB, Directly Observed Treatment, Short-Course Chemotherapy (DOTS), can cure nearly all cases of TB. One of the foundations of DOTS is the administration of standard short-course chemotherapy (SCC) under direct observation to TB patients via health care workers (HCWs). Recent studies performed in developing countries have shown that HCWs caring for infectious TB patients are at increased risk of *M. tuberculosis* infection and disease.

HCWs are essential in the fight against TB and they should be protected. Given the integral nature of HCWs in managing active cases and in preventing further transmission of *M. tuberculosis*, the World Health Organization (WHO) presents these guidelines to provide Member States with limited resources, with inexpensive and effective control strategies for prevention of *M. tuberculosis* transmission in HCWs. These guidelines serve not only to prevent patient-to-HCW transmission, but also to prevent patient-to-patient transmission.

These guidelines provide discussion and recommendations for the district and referral level (thus accounting for the wide variety of health care facilities) based upon three levels of infection control: administrative, environmental, and personal respiratory protection. The first priority in infection control is the use of administrative control measures to prevent the generation of infectious droplet nuclei, thereby reducing the exposure of the HCWs and patients to *M. tuberculosis*. Measures at the referral and district level include development of an Infection Control Plan, HCW training, patient education, sputum collection, triage and evaluation of suspect TB patients in outpatient settings, and reduction of exposure in the laboratory. Additional measures such as isolation of patients with multidrug-resistant TB (MDR-TB) and other isolation policies apply specifically to referral level facilities.

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

The third priority is to protect HCWs, via personal respiratory protection, from inhaling infectious droplets. Surgical masks prevent the spread of microorganisms from the wearer but do not provide protection to the wearer. Respirators provide protection to the wearer from inhaling infectious droplet nuclei. Respirators are expensive and they should be reserved for high-risk referral hospital settings.

Personal respiratory protection alone will not provide adequate protection for the HCW from infection of *M. tuberculosis*.

HCWs are vital resources in the fight against TB. These guidelines provide cost-effective interventions that can be directly implemented (or modified) within a facility at the district or referral level in any resource-limited setting. Efforts should be made to execute such control strategies to prevent nosocomial transmission of *M. tuberculosis*. Such measures serve not only to conserve resources in terms of direct costs due to treatment of HCWs and indirect costs in terms of loss of HCWs specialising in the management of TB patients, but also in reducing the burden due to tuberculosis.

GLOSSARY AND ABBREVIATIONS

Administrative controls: defined as the managerial or administrative measures (e.g., early diagnosis, prompt isolation or separation of infectious TB patients, prompt initiation of appropriate anti-tuberculosis treatment) to reduce significantly the risk of TB transmission by preventing the generation of droplet nuclei.

Aerosol: a collection of droplet nuclei that are expelled by an infectious person upon coughing, sneezing, shouting.

Acid-fast bacilli (AFB): rod-shaped bacteria that do not lose their stain when exposed to acid-alcohol mixture after the staining process, i.e. *Mycobacterium tuberculosis* and all mycobacteria.

Bacille Calmette-Guérin (BCG) vaccine: A live vaccine against TB derived from an attenuated strain of *Mycobacterium bovis*.

Biosafety Cabinets Class I (BSC I): cabinet that protects the worker and the work environment from exposure to an aerosol by drawing air into the cabinet. The air is either exhausted outside or filtered and recirculated into the room.

Biosafety Cabinets Class II (BSC II): cabinet that uses a laminar air flow in addition to exhaust to protect both the specimen /culture and the worker from contamination.

CDC: ***C****enters for* ***D****isease* ***C****ontrol and* ***P****revention*

District level health care facility: defined as aid posts, dispensaries, health centres, and hospitals.

DOTS: ***D****irectly* ***O****bserved* ***T****reatment,* ***S****hort-course chemotherapy*. World Health Organization strategy for TB control.

Infectious Droplet nuclei: microscopic particles which are an estimated 1-5 microns in diameter and are produced when a person coughs, sneezes, shouts or sings. Such particles may remain suspended in the air for hours.

Environmental control measures: measures that can be used in high-risk areas to reduce the concentration of droplet nuclei in the air (e.g., maximizing natural ventilation or controlling the direction of airflow).

Exhaust ventilation: an efficient environmental control technique (e.g., laboratory hoods, tents, booths, ventilation device) to contain airborne particles near the source before they can disperse widely into the air.

Face mask: cloth or paper mask (e.g., surgical mask) that prevents the spread of micro-organisms from the wearer to others by capturing the large wet particles near the source (mouth); it does not provide sufficient protection from inhaling airborne infectious droplet nuclei through.

Health care workers (HCWs): group of people that includes nurses, physicians, nursing and medical students, laboratory workers and others who work in health care facilities and may be exposed to patients with communicable diseases.

HIV: Human immunodeficiency virus, the causative agent of the acquired immunodeficiency syndrome (AIDS).

Infection with *M. tuberculosis*: the subclinical, latent infection with tubercle bacilli, manifested by a positive tuberculin skin test, but without clinical evidence of disease.

Infection control (IC): specific measures and work practices that reduce the likelihood of transmitting *M. tuberculosis.*

Isolation room: single patient room with negative pressure ventilation where infectious TB patients can be isolated from other patients.

IUATLD: ***I****nternational* ***U****nion* ***A****gainst* ***T****uberculosis and* ***L****ung* ***D****isease.*

Mechanical ventilation: methods used to direct airflow to dilute and remove air, and to produce negative pressure in isolation rooms (e.g., window fan, exhaust ventilation systems, etc).

Multidrug-resistant tuberculosis (MDR-TB): TB caused by strains of *M. tuberculosis* which are resistant to both isoniazid and rifampicin with or without resistance to other drugs.

Mycobacterium tuberculosis: the bacterium that causes TB.

Natural ventilation: defined as natural air movement to achieve dilution and air exchange in an area with free-flow of ambient air (e.g., through the open windows).

Negative pressure ventilation: ventilation system which permits the control of the air-flow direction in isolation or procedure rooms. So the room with negative pressure has a lower pressure than adjacent areas, which keeps air from flowing out of the room and into adjacent rooms or areas. It is the relative air pressure difference between two areas in a health-care facility.

Nosocomial: referring to an occurrence, usually acquisition of an infection, in a health care setting or as a result of medical care.

Personal respiratory protection: respiratory protective device which can be used by HCWs that fits over the mouth and nose to protect against transmission of *M. tuberculosis* by reducing the risk of inhaling infectious droplet nuclei.

Recirculation filtration system: more expensive option used in ventilation systems to remove droplet nuclei by a filtration system which then exhausts the air back into the room.

Referral level health care facility: defined as regional or national referral and university hospitals.

Respirators: special type of closely-fitted mask with the capacity to filter particles 1 micron in size to protect from inhaling infectious droplet nuclei.

Smoke tubes: devices used to monitor proper airflow direction and to determine the correct function of ventilation systems

Tuberculin skin testing (TST): intracutaneous injection of purified protein derivative (PPD) to identify persons who have been sensitised to mycobacterial antigens by infection with *M. tuberculosis*, environmental mycobacteria or administration of BCG.

Tuberculosis (TB): a clinically active, symptomatic disease caused by bacteria belonging to the *M. tuberculosis* complex (*M. tuberculosis*, *M. bovis*, *M. africanum*).

Ultraviolet germicidal irradiation (UVGI): an environmental control measure to kill or inactivate micro-organisms like *M. tuberculosis* through exposure to UVGI.

WHO: ***W****orld* ***H****ealth* ***O****rganization.*

INTRODUCTION

Recent increases in rates of tuberculosis (TB) among health care workers (HCWs), as well as hospital-based outbreaks of multidrug-resistant TB among HIV-infected patients, have led to greater concern about the risk of *Mycobacterium tuberculosis (M. tuberculosis)* transmission in health care settings (nosocomial transmission). Nosocomial transmission is of obvious concern because it affects not only other patients but also the personal health of HCWs and may result in either temporary or permanent loss of HCWs from the workforce.

Recent studies of the risk of nosocomial transmission of *M. tuberculosis* performed in developing countries have shown that HCWs caring for infectious TB patients are at risk of *M. tuberculosis* infection and disease. Nonexistent or ineffective TB infection control (IC) measures facilitate *M. tuberculosis* transmission in these health care settings. A review of the most common factors contributing to *M. tuberculosis* transmission in health care facilities at the district and referral levels in the developing world shows that many can be remedied with simple and, in many instances, inexpensive control measures. Many of the TB control measures that are likely to have the greatest impact on reducing *M. tuberculosis* transmission (e.g., rapid diagnosis and triage of infectious TB patients) can be implemented with minimal additional financial resources.

In low-income countries, the risk of patients and HCWs acquiring TB could be significantly reduced if governments, health authorities, and HCWs themselves make infection control a high priority. HCWs are a valuable and often scarce resource, and their expertise cannot be easily replaced. Commitment to reducing the risk of nosocomial *M. tuberculosis* transmission to HCWs is necessary to protect them from undue exposure, infection, disease, disability and death.

This document addresses IC guidelines designed to reduce the risk of nosocomial *M. tuberculosis* transmission within health care facilities in developing countries. The document focuses on the safety of HCWs and on the means to reduce the risk of patient-to-patient transmission. While probably infrequent, transmission from HCW to patients also will be reduced by implementing the measures outlined in this document.

Health care facilities and the populations they serve differ enormously depending on factors such as economic resources, the organization of health care services, referral patterns, climate, and geography. In an attempt to address the wide variety of health care facilities that are found in moderate to high TB prevalence areas, the discussion and recommendations are divided into two general levels:

- **district level,** including aid posts, dispensaries, health centers, and hospitals
- **referral level,** including regional or national referral and university hospitals.

In addition to the differences in size, patient volume, and patient complexity, these guidelines attempt to address differences in resources that may exist between the different levels. The vast majority of care provided to patients with TB occurs at the district level in the face of extremely limited resources. Consequently, IC guidelines for this level necessarily and appropriately focus on inexpensive

administrative (managerial) measures (e.g., patient identification, diagnosis, and the initiation of prompt treatment for TB) in lieu of expensive measures more appropriate for referral centers (e.g., exhaust ventilation for TB isolation rooms). Regardless of the level, most of the administrative controls are applicable. Of course, economic and human resource factors enter into decisions regarding IC measures; thus, these guidelines will have to be adapted according to the setting.

1 PATHOGENESIS AND TRANSMISSION OF TB

1.1 Review of transmission and pathogenesis of *Mycobacterium tuberculosis*

The following is a brief review of some important facts for understanding risk of nosocomial transmission of TB:

- *M. tuberculosis* is carried in airborne particles, or droplet nuclei, that can be generated when persons with TB sneeze, cough, or speak
- the infectious droplet nuclei are an estimated 1-5 microns in diameter, and normal air currents can keep them suspended and airborne for days
- infection, which is usually asymptomatic, occurs when a susceptible person inhales droplet nuclei containing *M. tuberculosis* and the organisms reach the alveoli of the lungs
- once in the lung, the organisms are taken up by the alveolar macrophages and may spread further throughout the body
- disease, which is usually accompanied by focal and generalized symptoms, may develop soon after infection; in most persons, however, an immune response is generated within 2-10 weeks after infection that limits further multiplication and spread of the tubercle bacilli
- some of the bacilli may remain dormant and viable for many years (i.e., latent infection with *M. tuberculosis*)
- persons with latent infection do not have symptoms of active TB and are not infectious

1.2 Factors affecting the risk of *Mycobacterium tuberculosis* infection

The probability that a person who is exposed to *M. tuberculosis* will become infected depends primarily on:

- the concentration of infectious droplet nuclei in the air, which is influenced by the number of organisms generated by the TB patient and the amount of ventilation in the area of exposure
- duration of exposure

Characteristics of the TB patient influence the number of organisms generated and thereby increase the risk of transmission. Such characteristics include:

- disease in the lungs, airways or larynx
- presence of cough or other forceful expiratory measures
- presence of acid-fast bacilli in the sputum

- presence and extent of cavitation on chest radiograph
- failure of the patient to cover the mouth and nose when coughing or sneezing

Patients with TB usually become noninfectious within a short period of time after initiating treatment. Thus, health providers may contribute to TB transmission by:

- delaying initiation of therapy
- failing to initiate treatment with an adequate regimen
- performing procedures that can induce coughing or cause aerosolization of *M. tuberculosis* (e.g., sputum induction)

1.2.1 Environmental factors

Environmental factors that enhance transmission include:

- exposure in relatively small, enclosed spaces
- lack of adequate ventilation to "clean" the environment through dilution or removal of infectious droplet nuclei
- re-circulation of air containing infectious droplet nuclei

1.2.2 Host characteristics

The characteristics of the persons exposed to *M. tuberculosis* that may affect the risk for becoming infected are not as well defined:

- persons who have been infected previously with *M. tuberculosis* are less susceptible to subsequent infection
- in high-prevalence countries, when the risk of infection is very low, the majority of new adult TB cases results from reactivation of remotely acquired infection; however, the higher the risk of infection is, the more important become the contribution of exogenous reinfection and progression from recent infection
- the effect of human immunodeficiency virus (HIV) infection on the risk of TB infection has not been clearly proven, although HIV is the strongest known risk factor for progression from TB infection to TB disease
- the risk of infection may be increased, as a result of changes in the immune response in the mucosa of bronchi and lung tissue that is affected [by silicosis, inhalation of smoke (e.g. tobacco, exposure to cooking fires, industrial exposure)]

1.2.3 *Bacille Calmette-Guérin (BCG) vaccination and TB infection*

BCG vaccination:

- does not reduce the risk for infection
- does decrease the risk for progression from latent TB infection to active TB, especially disseminated or central nervous system disease in children

There are several studies showing that the risk of TB among HCWs can be reduced to some extent by BCG vaccination. However, vaccination with BCG has not been shown consistently to provide protection in different settings.

1.3 Risk of disease following infection

In most persons who are infected with *M. tuberculosis:*

- the risk of progressing to active TB is estimated to be approximately 10%, if infection has occurred in childhood
- the risk of developing disease is greatest in the first years following infection
- the risk of developing disease among persons with a long-standing infection, with not other recognisable risk factor, is approximately 1 per 1,000 person-years

Factors affecting the risk of disease:

- recent infection with *M. tuberculosis*
- infection with HIV; persons with *M. tuberculosis* infection who are co-infected with HIV have approximately an 8%-10% risk *per year* for developing active TB
- persons with HIV infection who become newly infected with *M. tuberculosis* are at high risk for progression to active TB; such progression can occur very quickly after infection
- other conditions may pose a modest increase in the risk of progression (e.g., spontaneously healed TB with fibrotic residuals, diabetes, probably malnutrition, and, in certain settings, silicosis)

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2 RISK OF NOSOCOMIAL TRANSMISSION OF *MYCOBACTERIUM TUBERCULOSIS* TO HEALTH CARE WORKERS IN RESOURCE-LIMITED COUNTRIES

2.1 Documentation of nosocomial risk

Several studies in industrialized countries have shown that HCWs and medical and nursing students with patient contact are at increased risk for acquisition of TB infection and development of disease. Until recently however, data on the risk of TB infection and disease for HCWs in resource-limited country settings were limited. Available information is summarized in **Table 2.1**.

2.2 Who is at risk?

The assessment of occupational risk of TB for HCWs in resource-limited countries can be complicated by:

- the difficulty of collecting TB incidence data among HCWs
- a high prevalence of *M. tuberculosis* infection and disease in the general population
- the widespread use of BCG vaccination, which complicates interpretation of tuberculin skin testing
- the difficulty of collecting HIV prevalence data among HCWs

A variety of investigations have been conducted to assess the risk of active TB or risk of infection as measured by tuberculin skin test (TST) positivity in HCWs and students in the health professions. These studies (Table 2.1) were conducted in countries in Africa, Asia, and South America. To date, increased risk has been documented in a number of HCW groups including, but not limited to, nurses, physicians, nursing and medical students, and laboratory workers. Those at risk include any HCW in facilities that diagnose and treat TB patients. HCWs who have more frequent and direct patient contact, who have a longer duration of employment, who have contact with TB patients who have not yet been diagnosed and placed on therapy, who work in facilities with no IC measures in place, and who perform cough-inducing procedures on patients, are at increased risk.

A number of additional factors may contribute to nosocomial *M. tuberculosis* transmission in resource-limited countries. These include economic factors which may cause delays in patients seeking treatment or affect the health system's ability to provide timely and appropriate diagnosis and treatment, diagnostic delays, and an underestimation of risk by HCWs due to misconceptions about prior infection and BCG protection. In addition, patients may be hospitalized unnecessarily and may be cared for in crowded clinics and wards, increasing risk of transmission to both patients and HCWs.

2.3 Conclusion

Increased risk of nosocomial transmission has been documented in a variety of resource-limited country settings. A variety of factors contribute to nosocomial transmission. The greatest risk of transmission occurs when patients remain undiagnosed and untreated. The key, therefore, to the reduction of nosocomial risk is early diagnosis and prompt initiation of treatment of TB cases.

Table 2.1 Reported occupational acquired M. tuberculosis infection or disease among health care workers in resource-limited countries

Study	Site	Study period	TB outcome measured	Population	Results (rates)
Harries et al.	Malawi	1993 1994	Disease	Nurses (n=310)	Medical/TB ward nurses (13%) vs other nurses (3%)
Wilkinson et al.	South Africa	1993 1995	Disease	HCWs	15 cases of TB among nurses 1 case of nosocomial transmission documented by RFLP
Kassim et al.	Ivory Coast	1996	Infection Disease	HCWs (n=512)	HCWs with patient contact (70%) vs other HCWs (45%) HCWs working ≥1 year (80%) vs HCWs working <1 year (61%) 2 HCWs with active TB diseae
Do et al.	Thailand	1996	Infection Disease	HCWs (n=911)	HCWs with patient contact (72%) vs other HCWs (63%) HCWs working ≥1 year (69%) vs HCWs working <1 year (50%) 7 HCWs with active TB disease
Garrett et al.	Brazil	1997	Infection	HCWs (n=542)	HCWs with patient contact (49%) vs other HCWs (25%) Medical ward HCWs (51%) vs other HCWs (27%)
Kritski et al.	Brazil	1994 1997	TST conversion	HCWs (n=351)	HCWs (8%) vs general population (1%)
Perkins et al.	Brazil	1994	Infection	Medical students (n=411)	Classroom students (12%), pre-clinical students (16%), and clinical students (23%) vs engineering students (6-9%)
Kritski et al.	Brazil	1997	Infection	Medical students (n=455)	Classroom students (2%), pre-clinical students (6%), and clinical students (16%) vs engineering students (4-6%)

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3 AN INTRODUCTION TO INFECTION CONTROL STRATEGIES

3.1 Infection control strategies

There are three levels of infection control (IC) measures: administrative (managerial), environmental, and personal respiratory protection. Administrative controls are the most important since environmental controls and personal respiratory protection will not work in the absence of solid administrative control measures. Each level operates at a different point in the transmission process:

- Administrative controls reduce HCW and patient exposure
- Environmental controls reduce the concentration of infectious droplet nuclei
- Personal respiratory protection protects HCWs in areas where the concentration of droplet nuclei cannot be adequately reduced by administrative and environmental controls.

1st Priority	**Administrative Controls**
2nd Priority	**Environmental Controls**
3rd Priority	**Personal Respiratory Protection**

3.2 Administrative (managerial) controls

The first and most important level of control is the use of administrative controls to prevent droplet nuclei from being generated and thus **reducing the exposure of HCWs and patients to *M. tuberculosis***. Ideally, if the risk of exposure can be eliminated, no further controls are needed. Unfortunately, the risk usually cannot be eliminated, but it can be significantly reduced with proper administrative measures.

Important administrative measures include early diagnosis of potentially infectious TB patients, prompt separation or isolation of infectious TB patients, and the prompt initiation of appropriate anti-tuberculosis treatment. Other important measures include an assessment of the risk of transmission in the facility, the development of an IC plan that details in writing the measures that should be taken in a given facility, and adequate training of HCWs to implement the plan. It is essential that one individual be assigned responsibility and accorded authority to monitor the implementation of the IC plan. Administrative measures for the district and referral levels are more thoroughly presented in Chapter 4.

3.3 Environmental control measures

Since the exposure to infectious droplet nuclei usually cannot be eliminated, various environmental control methods can be used in high-risk areas to **reduce the concentration of droplet nuclei in the air**. Such measures include

maximizing natural ventilation and controlling the direction of airflow. Although many environmental control measures require resources that are not available in most situations (e.g., most district level health facilities), some (e.g., opening windows to increase natural ventilation and use of fans to control the direction of air flow) can be implemented in resource-limited settings. Environmental measures are discussed fully in Chapter 5.

3.4 Personal respiratory protection

The third recommended control measure is the **protection of the HCW from inhaling infectious droplets** through the use of personal respiratory protective devices which are designed to fit over the mouth and nose and filter out infectious TB particles. The type of surgical masks (cloth, paper) commonly used by HCWs do not filter out infectious droplet nuclei, although they may be of some use if placed on patients to prevent the generation of such nuclei. Personal respiratory protective devices for HCWs that are capable of adequately filtering out infectious particles are more expensive than surgical masks and are the least effective of the three IC measures. They should not supplant more effective, less expensive, IC measures. Therefore, they should only be used in specialized settings (usually at the referral level) when all other IC measures have been fully implemented (see Chapter 6).

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4 ADMINISTRATIVE CONTROL MEASURES

4.1 Administrative (Managerial) Control Measures

The development of administrative TB control measures should take precedence over all other interventions to reduce nosocomial *M. tuberculosis* transmission. Without effective administrative controls, environmental measures and personal respiratory protection are of limited value.

As mentioned in the introduction, these guidelines are written to address IC for two levels of health care facilities: district (aid posts, dispensaries, health centers, and hospitals) and referral (regional or national and university hospitals). In most situations, this categorization holds true, however, there may be some difficulties in classifying some health facilities. For example, a district hospital may actually be quite large, have specialized services and therefore more closely approximate a referral level health care facility. With this in mind, the critical elements of TB administrative controls for the two levels are presented. It should be noted, however, that each successive level of administrative control builds upon the level below (i.e., the referral level should implement the measures suggested for the district level in addition to referral level measures).

4.2 District level

4.2.1 *Assessment of settings at risk for M. tuberculosis transmission*

Regardless of the size of the health care facility, an assessment of HCWs risk of *M. tuberculosis* infection should be conducted as the first step in improving TB infection control. The risk of *M. tuberculosis* transmission should be evaluated for the facility and for areas within the facility where TB patients might receive care (e.g., examination rooms, laboratory, pharmacy, waiting areas, etc.).

Not all areas within a facility pose the same risk; a medicine ward containing patients with undiagnosed respiratory disease is likely to present a greater risk of TB exposure to HCWs and other patients than a pediatric or surgical ward. In some situations the risk on a medical ward may be higher than on a TB ward, where patients on adequate therapy are rendered non-infectious rapidly. This risk assessment should consider:

- the number of infectious TB patients seen per year
  - in the entire facility
  - in each specific area
- the amount of time that infectious TB patients spend in the area
- whether special procedures (e.g., sputum collection) that increase the number of infectious particles are performed in the area

The results of this risk assessment will guide the development of the IC plan, since interventions should focus initially on those areas that pose the highest risk.

4.2.2 Infection control plan

The next step is to **w**rite an IC plan and obtain the approval of appropriate authorities. The IC plan should then be implemented and adherence with its recommendations should be monitored. Together, the district TB control officer and the health post HCW or clinic director should assume the responsibility for writing and obtaining approval as well as implementing and monitoring the IC plan. For larger facilities (e.g., district hospital), a small committee can be formed with the responsibility to write and implement the IC plan. In certain settings, having an IC plan for TB alone might be not feasible. Thus, if the facility already has an IC committee, measures appropriate for the control of TB could also be part of the more general IC measures.
In general, the IC plan should include:

- identification of risk areas
- assessment of TB among HCWs (where feasible)
- assessment of HIV prevalence in the patient population (where feasible)
- assessment of HCW training needs
- area-specific infection control recommendations
- time-line and budget (e.g., material and personnel costs)

INFECTION CONTROL ASSOCIATION OF KENYA

In Kenya, the recently founded Infection Control Association of Kenya has developed a generic IC plan that is targeted for implementation at every health facility in the country. The elements of the IC plan include i) performing inventory of the facility; ii) establishing the IC structures including the IC committee, the IC team, continuing education, and the laboratory; and iii) developing a data handling and information system (Infection Control Bulletin 1998; 2:3-5).

4.2.3 HCW training

Infection control is effective only if each person working in a facility understands the importance of IC policies and his/her role in implementing them. As part of the training, each HCW should receive instruction appropriate for his/her job category. Ideally, training should be conducted before initial assignment, and continuing education should be provided to all employees. All HCWs working at the district level should receive ongoing education at least once a year regarding:

- the basic concepts of *M. tuberculosis* transmission and pathogenesis
- the signs and symptoms of TB
- the increased risk of TB disease in persons with HIV infection, and other immunosuppressive conditions, who also are infected with *M. tuberculosis*

- the importance of the IC plan and the responsibility that each HCW has to implement and maintain IC practices in order to reduce the risk of *M. tuberculosis* transmission
- which settings pose an increased risk of *M. tuberculosis* transmission (e.g., closed examination rooms)
- specific IC measures and work practices that reduce the likelihood of transmitting *M. tuberculosis*

4.2.4 Early identification and diagnosis

Prompt identification of patients with suspected TB is critical to initiate TB treatment, thus reducing the exposure of HCWs to infectious TB patients. A patient who makes several visits to a health facility without being correctly diagnosed with TB or spends time on a hospital ward for several days or weeks before the diagnosis of TB is suspected can pose a risk for HCWs and patients alike. Suspicion of TB should be high in:

- patients with persistent cough (i.e., ≥ 3 weeks)
- patients with other symptoms compatible with TB (e.g., bloody sputum, night sweats, fever, or weight loss)
- patients in whom the risk of TB is high (e.g., HIV-infected or immunocompromised persons)
- contacts of a person with infectious TB

Patients suspected of having TB should undergo prompt diagnostic evaluation. To ensure prompt laboratory evaluation, efforts should be made to make sure that the patient's sputum specimen reaches the laboratory in a timely fashion and results are returned promptly. The laboratory performing acid-fast bacilli (AFB) smears should be proficient at:

- methods of sputum specimen processing
- the administrative aspects of specimen processing (e.g., record-keeping, notification)
- maintaining quality control of diagnostic procedures (e.g., AFB sputum smears)
- ensuring adequate supplies for processing sputum samples

It is essential that sputum collection and delivery to the laboratory be done in a timely manner. Ideally, laboratory staff should be available seven days a week, so that AFB sputum smears can be performed and read in a timely manner, and results can be available within 24 hours of specimen collection. If seven day laboratory coverage is not possible, at least six days should be ensured.

4.2.5 Patient education

Patients should be educated about *M. tuberculosis* transmission and the importance of **cough etiquette**, i.e., to minimize the generation of infectious droplet nuclei, coughing patients should be instructed to turn their heads and cover their mouth and nose with their hands and preferably with a cloth or tissue when coughing. If patients do not have a cloth or tissue, these should be provided by the institution. Posters emphasizing cough etiquette should be placed in the waiting areas.

4.2.6 Sputum collection

Sputum collection always should be done **outside (open environment) and away from other people**, not in small rooms such as toilets or other enclosed areas. When outdoor sputum collection is not possible, sputum should be collected only in well-ventilated areas where the risk of exposing HCWs and other patients is low.

4.2.7 Triage and evaluation of suspect TB patients in outpatient settings

The outpatient evaluation and management of potentially infectious TB patients is an important TB control measure because it can potentially reduce the exposure of HCWs and hospitalized patients to infectious TB patients. Health posts, clinics, and hospital-based clinics may serve an important role in the outpatient management of these patients. In the outpatient setting:

- patient waiting areas should be open and well-ventilated; where weather permits, open-air shelters with a roof to protect patients from sun and rain are recommended
- patients who may have infectious TB should be triaged to separate clinics or waiting areas
- placing potentially infectious TB patients in waiting areas with other patients without TB, especially those who are immunocompromised (e.g., AIDS) or pediatric patients, should be avoided
- persons with cough of $\geq$ 3 weeks duration should be considered TB suspects. If a separate waiting area cannot be established for them, consideration should be given to providing expedited **priority service** to decrease the risk of exposure for other patients and HCWs. In other words, these patients should be moved to the front of the line to quickly provide care and reduce the time that others are exposed to them
- only one patient at a time should be allowed to be in the examination room to reduce the chance of transmitting *M. tuberculosis* to other patients

For patients with TB, treatment should be initiated promptly in accordance with established policy guidelines outlined by the National Tuberculosis Programme (NTP).

Consideration should be given to holding TB clinics to evaluate suspect TB patients during hours when the clinic is less congested (e.g., afternoons).

4.2.8 Reducing exposure in the laboratory

For district levels that perform sputum smear microscopy:

- access to the laboratory should be strictly limited to essential HCWs
- sputum collection should not take place in the laboratory area
- a pass-through window should be used to deliver sputum samples

Handling sample containers and making smears pose low risk to HCWs (barring breakage which could produce an aerosol). For more information, please consult chapter 7 and the WHO publication *"Laboratory services in tuberculosis control"*, and the IUATLD publication, *"The public health service national tuberculosis reference laboratory and the national laboratory network. Minimum requirements, role and operation in a low-income country"* (see references).

4.2.9 Evaluating infection control interventions

At a health post or district hospital it may be difficult to detect a change in TB rates among HCWs after the implementation of TB IC measures because of 1) the long time intervals that often occur between infection and disease and 2) the small number of HCWs working at the facility. However, it is usually possible to monitor the implementation of the interventions through periodic supervision of the measures outlined in the IC plan. Establishing surveillance of active TB rates among HCWs in the district may nonetheless provide a useful means of evaluation, although the complex relationship between infection and development of disease as well as other factors such as high HIV rates or high TB rates in the community may complicate the interpretation of trends.

One way to assess the impact of implemented IC practices is by reviewing the medical records of a sample of TB patients seen in the facility. The evaluation of outcome measures can then be used to identify the areas where improvement may be needed. Measures that can be examinated include:

- time interval from admission to suspicion of TB
- time interval from suspicion of TB to ordering sputum for AFB smears
- time interval from ordering to the collection of sputum
- time interval from the examination of the smear to the reporting of results
- time interval from the return of laboratory results to the initiation of treatment

Unnecessary delays in any of these can lead to increased nosocomial transmission of *M. tuberculosis*.

4.3 Referral level

Since the referral-level hospital is usually larger, provides service to a greater number of patients and has more resources, additional administrative IC measures to those proposed for district-level facilities are necessary. The recommendations for district-level measures outlined above also apply to referral-level facilities. Specifically, **measures regarding the IC plan, HCW training, patient education, sputum collection, triage and evaluation of suspect TB patients in outpatient settings, and reduction of exposure in the laboratory, are similar for both levels.** Several additional measures applicable to the referral level are detailed below as well as specific recommendations for some of the sections already covered for the district level.

4.3.1 *Assessment of at risk settings for M. tuberculosis transmission*

At the referral level, the assessment of HCW risk of exposure to *M. tuberculosis* should be conducted in both inpatient and outpatient settings. The risk of *M. tuberculosis* transmission should be evaluated for the entire hospital and for specific areas within the facility where TB patients might receive care (e.g., examination rooms, medical wards, HIV wards, radiology, emergency departments, bronchoscopy suites, spirometry rooms) or where HCWs otherwise may be at risk (e.g., in laboratories, autopsy suites). As outlined in 4.2.1., this information should be used to develop an IC plan, with interventions focusing initially on those areas at highest risk.

4.3.2 *Early identification and diagnosis*

Besides the measures outlined at the district level, it may be useful in referral facilities with a high volume of hospitalizations to appoint a Ward Cough Officer. In the absence of such a person, establishing a method for rapid communication of sputum smear results from laboratory personnel to clinicians is essential.

WARD COUGH OFFICERS

In Blantyre, Malawi, an innovative approach to ensuring prompt evaluation and diagnosis of suspect TB patients has been implemented. To avoid delays, a ward cough officer has been hired who is responsible for sputum collection, ensuring rapid transport of specimens to the laboratory, and the delivery of results to the ward medical team. With training, the ward cough officer also may be useful to identify patients in need of evaluation (e.g., chronic coughers) and help enforce TB infection control policies.

4.3.3 *Encourage outpatient TB management*

One of the most effective means to reduce the risk of nosocomial *M. tuberculosis* transmission at the referral level is to avoid hospitalization if possible and **manage**

TB patients in the outpatient setting (see section 4.2.7). Many patients can be managed entirely as outpatients, thereby avoiding hospitalization and the risk of exposing other patients and HCWs. Other patients can be discharged to outpatient care after a short initial hospitalization. If hospitalization is used, patients should be re-evaluated frequently for possible discharge with continuation of therapy as outpatients. Furthermore, discharge planning for patient follow-up and the continuation of therapy should be carried out according to the NTP recommendations.

Treatment of patients with tuberculosis

When a decision to treat the patient has been made, rational, proven regimens which are recommended by the NTP should be used. It is essential that health staff observe and assist as patients swallow their medicine. It is well documented that many patients may not take medicines, for various reasons, unless treatment is directly observed. Although direct observation is generally done on an outpatient basis, it is also essential that all doses of anti-tuberculosis medicines which are given to inpatients are directly observed. Anti-tuberculosis medicines should never be left in the patients room or at the patients bedside to be ingested later.

For patients with TB, treatment should be initiated promptly in accordance with established policy guidelines outlined by the NTP. It is of the utmost importance to ensure practical and realistic plans for continuation and completion of treatment following hospital discharge. In many settings, a large proportion of patients who are begun on anti-tuberculosis treatment in hospitals do not complete treatment, and many are re-admitted, again infectious. This results in unnecessary risk of further transmission of TB. Every patient who leaves the hospital on anti-tuberculosis treatment should have an appointment for follow-up care and, ideally, a hospital staff member should be assigned individual responsibility for ensuring that at least the first outpatient appointment is kept.

For outpatient treatment, follow-up should be done at a different time of the evaluation of TB suspects. However, it must be ensured that this is done at a convenient time for the patient. Otherwise, patients may discontinue treatment prematurely, become infectious again, and be re-admitted to the facility. Outpatient treatment should be directly observed by an individual who is accessible and acceptable to the patient and accountable to the health system. HCWs, community volunteers, and others can be effective treatment observers. Treatment observation by family members is often unsuccessful. Every dose of anti-tuberculosis treatment should ideally be directly observed; this is particularly important in the intensive phase of treatment and whenever rifampicin is used.

4.3.4 Inpatient management: separation and isolation policies

Ideally, infectious TB patients should be isolated from other patients so that others are not exposed to the infectious droplet nuclei that they generate. In settings where separate facilities do not exist for TB patients, this is often difficult to achieve because it usually requires sophisticated and expensive environmental controls. However, separation of TB patients from others is usually far less costly than isolation and can potentially contribute to reduction of nosocomial transmission. At the referral level, an attempt should be made to:

- limit the number of areas in the facility where exposure to potentially infectious TB patients may occur
- establish separate wards, areas, or rooms for confirmed infectious TB patients. If possible, these wards/areas should be located away from wards with non-TB patients, especially wards with high-risk patients (e.g., pediatric, immunosuppressed patients). Ideally, these wards should be in separate buildings

The optimal arrangement in a larger health facility would include two wards, housed in separate buildings if at all possible:

- a medical ward with no TB suspects
- a known TB ward (only patients on TB therapy)

Finally and least effective, if only one ward is available, a separate area within the ward can be established for patients with TB (preferably in a better ventilated portion of the ward). Whatever arrangement is used, patients with and without TB should be physically separated from each other and the wards should be well-ventilated. At a minimum, windows of opposing walls should be kept open whenever possible to ensure optimal cross-ventilation. The direction of air flow should always be away from uninfected patients (See chapter 5).

The difficulty of ensuring effective separation of patients reinforces the need to avoid hospital admission, or rapidly discharge patients, with suspected or confirmed TB.

4.3.5 Isolation and Multidrug-Resistant (MDR) TB

In general, patients with MDR-TB require specialized management at a referral center. Because of the prolonged period that such patients are infectious and the consequent increased risk of nosocomial transmission, whenever possible, patients suspected of having MDR-TB should be placed in a separate area or building in the facility, preferably in well-ventilated individual patient rooms where the possibility of contact with other patients who do not have TB or do not have

MDR-TB is minimal. If this is not feasible and there is a large number of patients suspected of having MDR-TB, then ward for MDR-TB or area of a ward should be established. It should be acknowledged that in many cases it is impossible to predict or to detect MDR-TB, and in many countries this information never becomes available.

MDR-TB AND HIV

It is essential that patients with TB, especially MDR-TB, be separated from patients who have HIV infection. In many countries, outbreaks of MDR-TB have spread very rapidly on wards for AIDS patients.

4.3.6 *Enforcing isolation policies*

Isolation policies should be strictly enforced:

- Except for when infectious TB patients must undergo essential diagnostic procedures outside their rooms, they should not be allowed to leave their rooms or wander the hospital grounds (a designated area outside for confirmed infectious TB patients can be used for fresh air and exercise)
- a disposable surgical mask should be placed on infectious and suspect TB patients whenever they leave the isolation areas (i.e., for a medically essential procedure or diagnostic examination).
- if possible, visitation hours should be held in a designated area outdoors

4.3.7 *Discontinuing isolation*

Patients in the isolation/separation area should be frequently re-evaluated to determine if isolation is still required. In settings where MDR-TB is uncommon, those with a diagnosis of sputum-positive pulmonary TB can be considered to be noninfectious and eligible for transfer from isolation or discharge for outpatient management when two criteria are met:

- they have received appropriate anti-tuberculosis chemotherapy directly observed for a minimum of two weeks

and

- they have shown clinical improvement

Patients with MDR-TB may remain infectious for prolonged periods, and discontinuing isolation after two weeks could contribute to nosocomial MDR-TB outbreaks. In hospitals or geographic areas known to have a high rate of MDR-TB, consideration should be given to adding sputum smear negativity to the above criteria.

4.3.8 Evaluating infection control interventions

In many referral hospitals, monitoring TB disease among HCWs to evaluate the effectiveness of IC interventions may not be practical. However, the monitoring of the implementation of the interventions should be performed on a routine basis (see section 4.2.9).

4.3.9 Surveillance for TB disease/infection among HCWs

HCWs should be educated about the signs and symptoms of TB and instructed to report promptly for evaluation should these develop. Consideration may be given to active screening for symptoms on a periodic basis if resources permit, with further evaluation of those found to have symptoms compatible with TB. In larger referral facilities, consideration should be given to collecting data on the number of HCWs from the facility who are diagnosed with TB in a HCW TB registry. Surveillance should include information about the main risk factors:

- workplace (e.g., outpatient clinic, medical ward)
- occupation (e.g., nurse, nurses aid, physician, cleaning person)
- history of recent exposure to TB patients at work or outside the workplace
- history of treatment for TB
- history of HIV testing and results

Chest radiographs are used in some countries to periodically evaluate HCWs for TB. However, radiographs are costly and inefficient since the yield is usually very low. Instead, active screening for symptoms of TB may be more cost-effective

HCW tuberculin skin test screening:

- is very resource-intensive
- results may be difficult to interpret in settings where BCG vaccination use is common
- should only be used in the context of a research study or in settings where preventive therapy is offered

CONFIDENTIALITY

Maintaining patient confidentiality is a key component in preventing nosocomial *M. tuberculosis* among HCWs. In the case of HCWs, confidentiality means that only the HCW and the physician and staff directly involved in their medical care know the HCWs' medical status.

HCWs may be afraid of being diagnosed with TB because of concerns that their medical status will be divulged to the rest of the staff and community. This will delay diagnosis and treatment which may lead to nosocomial transmission. Punitive policies regarding TB in HCWs (e.g., suspension with reduced pay, breach of confidentiality) should be avoided to reduce practices that delay diagnosis and treatment. Confidentiality also should be ensured for HIV counselling and testing.

4.4 Special Areas and Topics

In addition to wards and outpatient clinics, there are a number of settings where risk of TB transmission to HCWs and patients may be increased. In addition, special consideration should be given to reducing nosocomial TB transmission in settings where patients, HCWs, or both have HIV infection.

4.4.1 *Radiology*

Radiology departments in referral-level facilities often provide services to a variety of patients many of whom may be at particularly high risk of TB (e.g., young children or immunocompromised patients). Therefore, radiology departments should attempt to:

- schedule inpatient chest radiographs on infectious and suspect TB patients for non-busy times, such as the end of the afternoon
- provide coughing patients with a surgical mask to wear; alternatively provide tissues or cloth
- provide expedited priority service to potentially infectious TB patients to minimize the length of time spent in the department
- restrict access to the radiology suite during operating hours to patients and essential personnel only (e.g., post signs, enforce the policy)
- use the room with the best ventilation for taking images of potentially infectious TB patients

QUEUES

In many facilities, there are hundreds of patients waiting to be seen every day. Often hallways and waiting areas are crowded with patients, their families, and HCWs. Due to the high demand, there are often lines that form outside of various departments (e.g., radiology, pharmacy, outpatient). Since people do not want to lose their place in line they often need to crowd together to make sure that others do not "move ahead of them" in the line. HCWs should take responsibility to help alleviate the stress of waiting in line and also to reduce the risk of nosocomial *M. tuberculosis* transmission. One way to do this is to use a number system. Patients can be given numbers in the order that they arrive and then are asked to wait outside or in a better ventilated area until their number is called.

4.4.2 Sputum induction and cough-inducing procedures

Cough-inducing procedures (e.g., sputum induction or bronchoscopy) should be done only when absolutely necessary on patients who may have TB. Sputum induction should only be done if the patient is unable to produce an adequate specimen without induction. Likewise, bronchoscopy should be used as a last resort after other less risky diagnostic measures have been taken. Bronchoscopy on patients with an established TB diagnosis should be avoided. Administrative measures in such settings are essential, although strong consideration should be given to implementing environmental measures and personal respiratory protection, as described in Chapters 5 and 6.

4.4.3 Surgical and autopsy suites

Surgery and autopsy suites are often poorly ventilated and may pose considerable risk of *M. tuberculosis* infection to HCWs if procedures are performed on TB patients. In general, elective surgery on potentially infectious TB patients should be postponed**.** Efforts should be made to establish adequate environmental controls (Chapter 5). In addition, personal respiratory protection should be used by all personnel working in the operating room or autopsy suite when procedures are performed on suspected or known TB patients (Chapter 6).

4.4.4 Intensive care areas

Intensive care areas also may be high risk areas especially when potentially infectious TB patients are intubated:

- intubation and management of a patient's airway (e.g., suctioning) can create aerosols
- intensive care units are often small and poorly ventilated

To decrease the risk of nosocomial TB transmission:

- avoid intubation on potentially infectious TB patients
- "think TB" in intensive care patients
- improve ventilation in intensive care areas (see Chapter 5)
- use personal respiratory protection for procedures that are likely to create aerosols in potentially infectious TB patients

4.4.5 Immunosuppression and TB

HCWs as well as patients who are immunosuppressed are at increased risk of :

- reactivation of previous TB infection
- rapid progression to disease after infection

Suspect or known infectious TB patients pose a special threat to other immunosuppressed patients and HCWs. Therefore, it is especially important to prevent the exposure of immunocompromised HCWs to patients who are known or suspected of having TB, particularly MDR-TB. Serious outbreaks of MDR-TB have occurred among immunocompromised patients and HCWs exposed to infectious MDR-TB patients. Immunocompromised HCWs should be given opportunities to work in areas with a lower risk of exposure to *M. tuberculosis*. In most areas of the world, TB should be strongly considered as part of the differential diagnosis for immunocompromised HCWs with respiratory complaints. Immunocompromised HCWs suspected of having TB should be promptly evaluated and treated, preferably on an outpatient basis. As with all HCWs, they should be removed from work until infectiousness is ruled out or until their sputum has become smear-negative.

Table 4.1. Administrative Infection Control Measures for District and Referral Level Health Care Facilities

DISTRICT LEVEL MEASURES (aid posts, dispensaries, health centers, and hospitals)	**REFERRAL LEVEL MEASURES These additional measures apply to referral-level facilities**
Assessment of at-risk settings for *M. tuberculosis* infection	Encourage outpatient TB management
IC plan	Inpatient management and isolation policies
HCW training	Isolation of multidrug-resistant (MDR) TB
Early identification and diagnosis	Enforcing isolation policies
Patient education	Specific policies for discontinuing isolation
Sputum collection	Evaluating infection control interventions
Triage and evaluation of suspect TB patients in the health post or clinic	Surveillance for TB disease/infection among HCWs
Reducing exposure in the laboratory	**Special Areas and Topics in Infection Control**
Evaluating infection control interventions	Radiology
	Sputum collection and cough-inducing procedures
	Surgical and autopsy suites, intensive care areas
	Immunosuppression and TB

Suggestions for Further Reading

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5 ENVIRONMENTAL CONTROL MEASURES

5.1 General comments

Environmental controls are the second line of defense for the prevention of nosocomial *M. tuberculosis* transmission to HCWs. In the face of inadequate administrative controls, environmental measures **will not** eliminate the risk. Although some environmental controls do not require a large expenditure of resources, many are expensive and technically complex. Therefore, most of the following recommended measures are more appropriate for referral hospitals with adequate resources. When employed in conjunction with administrative controls (e.g., prompt triage, diagnosis, and treatment of infectious TB patients), environmental controls can be used effectively to reduce the concentration of infectious droplet nuclei to which HCWs or patients may be exposed.

5.2 Environmental controls

A variety of simple to complex environmental controls can be used to reduce the number of aerosolized infectious droplet nuclei in the work environment:

- the simplest and least expensive technique is to remove and dilute the air from TB patient areas away from patients without TB by maximizing natural ventilation through open windows
- more complex and costly methods involve the use of mechanical ventilation (e.g., window fans, exhaust ventilation systems) in isolation rooms or wards to produce negative pressure and prevent contaminated air from escaping into hallways and other surrounding areas
- additional complex and costly methods include air filtration to remove infectious particles and ultraviolet germicidal irradiation (UVGI) to kill *M. tuberculosis* organisms

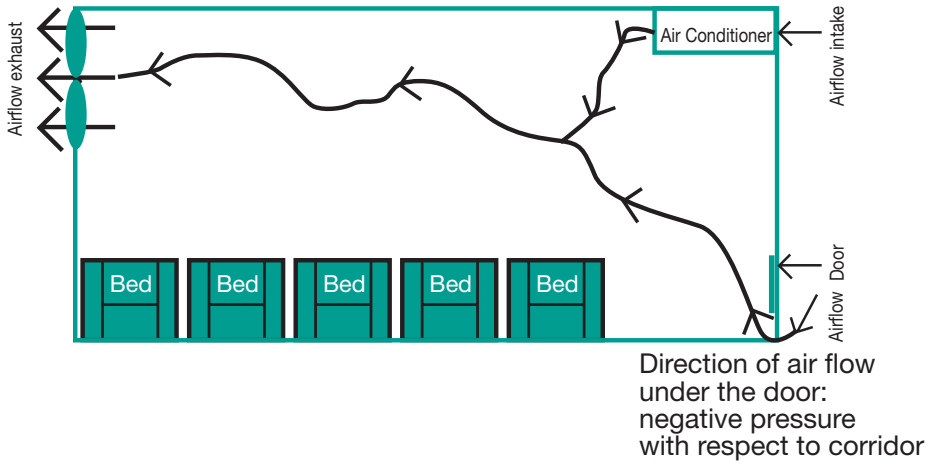
The design of the facility, climate of the area, type of patient population served, number of TB patients cared for in the facility, and resources available will dictate the type of environmental controls for each facility. To maximize benefit, efforts to improve ventilation should involve consultation with an expert in environmental control. Whatever environmental controls are in place, their adequate functioning should be evaluated regularly.

5.3 Ventilation patterns

Ventilation is the movement of air to achieve dilution and air exchange in a specific area. This process reduces the concentration of aerosolized droplet nuclei. To reduce nosocomial risk, the most ideal situation would be one in which fresh air is constantly pulled into a room and the contaminated air is exhausted to the outside, such that the air in the room is changed several times every hour **(figure 1)**. The most common way in such ventilation can be established is through the use of negative pressure ventilation, in which a room is kept at negative pressure

relative to the surrounding area and air is drawn into the room from the corridor and exhausted directly outside. Establishing such rooms can be highly costly, however, and the equipment needed requires ongoing maintenance. More feasible in most settings is the use of natural ventilation or of mechanical ventilation in which the movement of air is facilitated by the use of fans.

Figure 1. Negative pressure room; diagram illustrating airflow from outside a room, across patients's beds and exhausted out the far side of the room.



5.4 Methods to maximize natural ventilation

Natural ventilation can be used in medical wards or other sites in health facilities in temperate or tropical climates where windows can be left open. Natural ventilation can occur when a room or ward is of open construction with free flow of ambient air in and out through open windows **(figure 2)**. Maximizing natural ventilation patterns for the hospital, clinic, ward or room is the simplest approach to achieving better ventilation. Whenever possible:

- waiting areas, sputum collection areas, examination rooms, and wards should be "opened" to the environment (e.g., established in covered open areas or in areas with open windows). Additionally, windows or other openings may be installed that would allow for more ventilation. Windows and openings should be placed on outer walls such that air moves to the outdoors, not into other wards or waiting areas
- when ceiling fans are used, windows should also be left open since diluting **and** exchanging rather than just mixing the air is the objective

The risk of *M. tuberculosis* transmission is greatest in a closed room that contains air with aerosolized infectious droplet nuclei. A room with an open window at one end provides air exchange near the window; however, little air is exchanged a short distance from the window. Thus, the minimum acceptable condition is openings on opposite ends of a room (windows, window-door, etc.).

Figure 2. Natural ventilation; free flow of ambient air in and out through open windows

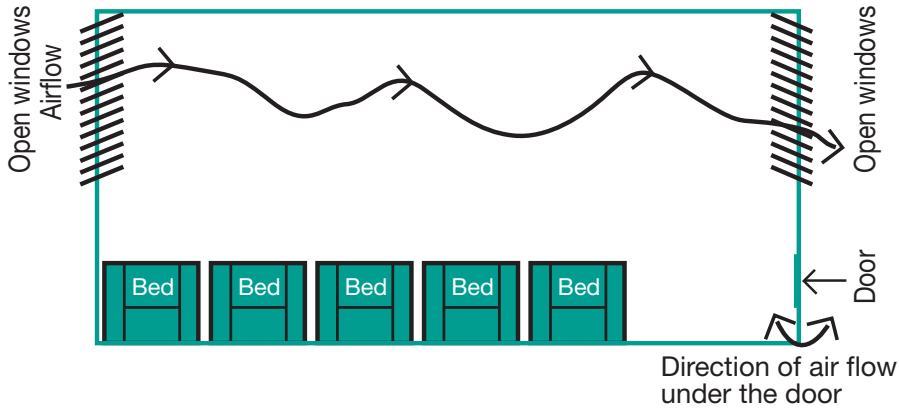


Figure 3 shows a typical clinic in an African country where patients, family members, visitors, and HCWs are in close proximity. The waiting area is actually a hallway with benches or chairs, and there is little air movement. Figure 4 shows a simple, cost-effective alternative which is a covered area that is open on the sides. The windows to the out-of doors have been replaced with doors leading to a patio, which serves as a new waiting room.

Figure 3. Poorly ventilated waiting area in an outpatient TB clinic

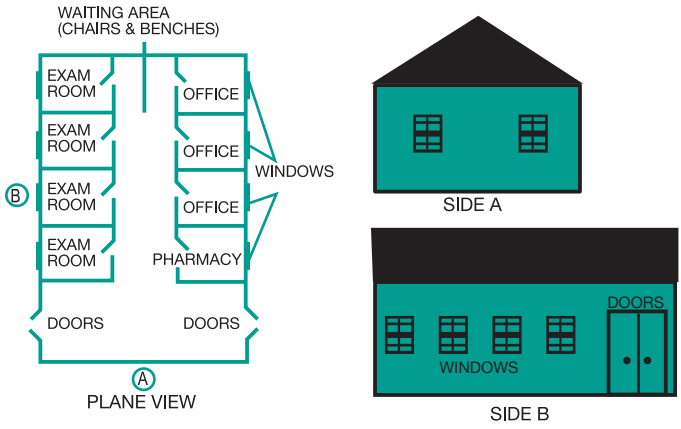
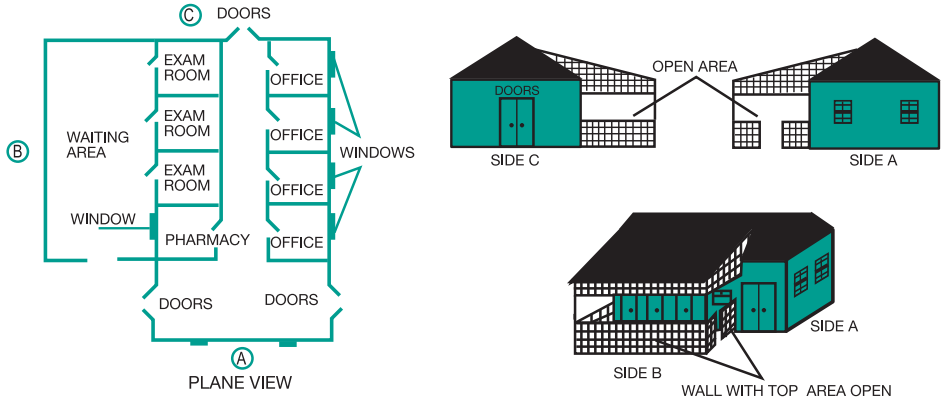


Figure 4. Proposed alternative for waiting area in an outpatient clinic that maximizes natural ventilation



5.5 Mechanical ventilation

In situations where natural ventilation is not feasible or is inadequate, mechanical ventilation can be used to reduce the concentration of infectious droplet nuclei in selected areas or rooms in the health care facility (e.g., patient rooms, waiting rooms, or examination rooms). It is important to use equipment with sufficient power to facilitate air entry into, and exhaust from, the room or area. In other words, if no air is allowed to enter the area, then it will be impossible to exhaust air. It is also important to attempt to direct air movement so that infectious droplet nuclei produced by coughing patients are exhausted *away* from others. Directional air flow should be maintained from a "clean" area, across the HCW, across the patient, and to the outside **(figure 1)**. The area where air is entering should be located away from the exhaust area to avoid re-entry of contaminated air ("short-circuiting").

Window fans are the least expensive and most feasible method of providing mechanical ventilation to direct air flow in most low-resource settings. However, it is important to ensure that air flows across the room (i.e., under a door and out a window, not in and out the same window or vent). Additional methods of mechanical ventilation, which require more resources, include mechanical exhaust systems that pump clean outside air into the building and then exhaust the contaminated room air back outside. Closed recirculation filtration systems, which take room air, filter it to remove infectious droplet nuclei, and then exhausts it back into the room, are effective but expensive and require considerable maintenance. For further information on mechanical exhaust systems and recirculation filtration systems, see readings at the end of the chapter.

5.6 Monitoring of ventilation and ventilation systems

Ventilation systems should be evaluated regularly to determine if they are functioning properly. The most simple evaluation includes the use of smoke (e.g., smoke tubes) to monitor proper airflow direction. If window fans are being used to produce negative pressure, they should be checked frequently to ensure air movement is directional and adequate. Evaluations should be documented in a maintenance record.

Monitoring Ventilation Systems

Using a carton box and flow velometer to monitor air flow in TB patient isolation room with mechanical ventilation system, Chiang Rai Hospital, Chiang Rai, Thailand

Using a smoke tube to monitor air flow in sputum collection booth at a TB facility in Riga, Latvia

5.7 Special areas

Certain areas of the health care facility should be considered high risk and a priority if environmental controls are implemented. These include TB isolation rooms, TB wards, or other areas such as intensive care units where TB patients may be housed. Unless natural ventilation is excellent in these areas, mechanical ventilation with window fans to generate directional air flow should be strongly considered.

Other high-risk areas may include sputum induction rooms, bronchoscopy suites, operating rooms, and autopsy suites **(see table 5.1)**. These areas should be considered high risk before, during and after procedures. Since large rooms may have little or no air movement and may be difficult to ventilate, a smaller, well-

ventilated room should be considered for bronchoscopies or other high risk procedures. As previously discussed, environmental controls should only be implemented as a supplement to effective administrative controls.

5.8 Ultraviolet germicidal irradiation

In some climates or in certain high-risk areas of a facility, use of natural and mechanical ventilation may not be feasible. In these situations, ultraviolet germicidal irradiation (UVGI) or portable HEPA filter units may provide a less expensive alternative to more expensive environmental measures that require structural alterations of a facility. These measures may be particularly useful in larger wards, TB clinic waiting areas or inpatient areas such as television or recreation rooms where TB patients congregate.

Studies show that *M. tuberculosis* is killed if the organisms are exposed sufficiently to UVGI. The major concerns about UVGI have been adverse reactions (e.g., acute and chronic cutaneous and ocular changes) in HCWs and patients from overexposure if the UVGI is not installed and maintained properly. If UVGI is to be used, guidelines provided in the readings at the end of this chapter as well as manufacturer's instructions regarding installation, cleaning, maintenance, and ongoing monitoring should be carefully consulted.
UVGI may be applied in several forms:

- in sputum collection booths, bare bulbs can be used to irradiate the entire booth when it is **not** occupied
- if HCWs and patients are in the room, continuous upper air irradiation can be used in which shielding placed below the UVGI sources prevents injury to occupants
- portable UVGI floor units also may be used
- an additional more expensive option involves the use of UVGI in combination with a closed mechanical system

Continuous upper air irradiation is the most applicable of the above methods in most resource-limited countries. The advantage of this technology is that the upper air is continuously being irradiated; thus, it provides some protection to the HCW while the infectious patient is in the room. This requires good air mixing to be effective. Furthermore, structural features such as ceiling height may limit the feasibility and usefulness of UVGI. If portable UVGI floor units are used, attention should be paid to lamp placement, since corners may receive inadequate radiation. The quality of UVGI lamps is very important. Usually a good one will last 5,000 to 10,000 hours (7-14 months). After that, the irradiance drops off rapidly. Responsibility should be assigned to ensure the lamps are cleaned and monitored properly to avoid adverse HCWs and patients exposure, that air flow patterns maximize *M. tuberculosis* UVGI killing, and that UVGI output is adequate.

5.9 HEPA Filtration

In small rooms with a limited number of patients or in other small, enclosed areas, HEPA filter units may be a useful alternative to mechanical ventilation requiring structural changes or to UVGI. HEPA filtration units may be free-standing or may be permanently attached to floors or ceilings to minimize tampering. If possible, the units can be exhausted outdoors, thereby creating a negative pressure isolation room.

If portable units are used, unrestricted airflow is essential; placing the unit close to furniture or putting items on top of the units may compromise their function. Careful regular monitoring is essential. Further information on HEPA filtration units and their monitoring and maintenance can be found in the readings at the end of this chapter.

Table 5.1. High Risk Areas for Nosocomial M. tuberculosis Transmission

TB patient isolation areas/rooms
Areas/rooms where sputum is collected or induced
Bronchoscopy suites
Surgical suites
Intensive care units
Autopsy suites

Suggestions for Further Reading

Centers for Disease Control and Prevention. Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care facilities, 1994. Morb Mortal Wkly Rep 1994; 43(RR13): 1-132.

NIOSH. Criteria for a recommended standard in occupational exposure to ultraviolet radiation. Cincinnati, Ohio: USDHEW, PHS, NIOSH. DHEW (NIOSH) Publication No. 73-11009.

6 PERSONAL RESPIRATORY PROTECTION

6.1 The role of respiratory protection

Personal respiratory protection (respirators) is the last line of defense for HCWs against nosocomial *M. tuberculosis* infection. Without appropriate administrative and environmental controls, respirators will **NOT** adequately protect the HCW from infection. However, respirators may serve as a valuable complement to administrative and environmental IC measures. Since personal respiratory protection may not be always affordable, it is most appropriate for use in high risk areas in the referral hospital setting. Because widespread **and** constant use of respirators is impractical, they should be used on a limited basis in specified high risk areas in conjunction with other administrative and environmental control measures:

- isolation rooms for patients with TB or MDR-TB
- during sputum induction or other cough-inducing procedures
- bronchoscopy suites
- autopsy areas
- spirometry rooms
- during emergency surgery on potentially infectious TB patients (elective surgery should be always postponed)

6.2 The role of surgical masks and respirators in respiratory protection

6.2.1 *Surgical masks*

There are important differences between a face mask and a respirator. Face masks, such as surgical masks (cloth or paper):

- do prevent the spread of microorganisms from the wearer (e.g., surgeon, TB patient) to others by capturing the large wet particles near the nose and mouth
- **do not** provide protection to the wearer (e.g., HCW, patient, family member) from inhaling infectious droplet nuclei in the air

6.2.1.1 *Use of surgical masks for patients*

In many settings the resources for disposable/cloth surgical masks for potentially infectious TB patients are not available. Although not the highest priority intervention, disposable/cloth masks can be used to reduce aerosols generated from potentially infectious TB patients:

- disposable/surgical masks should be considered for suspect and known infectious TB patients leaving isolation rooms for medically-essential procedures

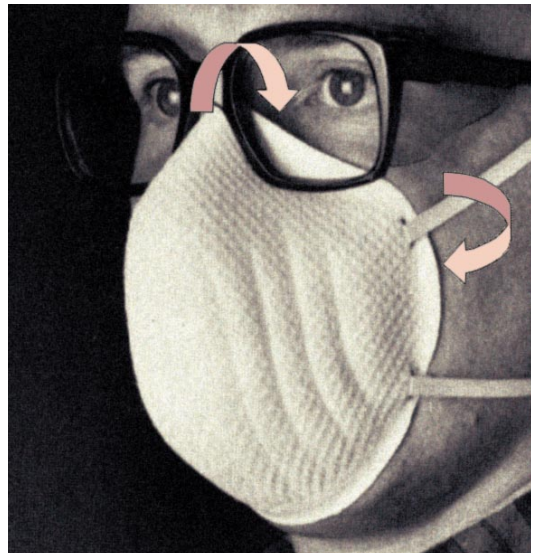
Because surgical masks may also serve to identify TB patients the risk of stigma also needs to be considered. Patient and HCW education regarding the importance and appropriate use of wearing masks should accompany their distribution. It is important to remember that a mask **does not** protect HCWs or other wearers from inhalation of air contaminated with *M. tuberculosis* and should not be used for that purpose. Masks usually have limited filtration capacity and are loosely fitted over the nose and mouth, allowing free entrance of aerosolized *M. tuberculosis*. Other devices, such as respirators **do** provide protection. Cloth surgical masks can be sterilized and reused.

6.2.2 Respirators

To protect HCWs from *M. tuberculosis* airborne droplet nuclei, a respiratory protective device with the capacity to filter a 1 micron particle is needed. Respirators are a special type of mask that provide such a level of filtration and are closely fitted to the face to prevent leakage around the edges. If the respirator is not fitted correctly, infectious droplet nuclei can easily enter a person's airways, potentially resulting in infection (see photo):

- respirators manufactured with at least 95% filter efficiency for particles of 0.3 micron in diameter are usually recommended for use by HCWs
- respirators are disposable but can be re-used repeatedly for several months if they are properly stored

The main factors responsible for the deterioration of respirators are humidity, dirt, and crushing. Respirators should be stored in a clean dry location. One method is to fold a light towel around the respirator (being careful not to crush the respirator). Plastic bags should never be used since they retain humidity.



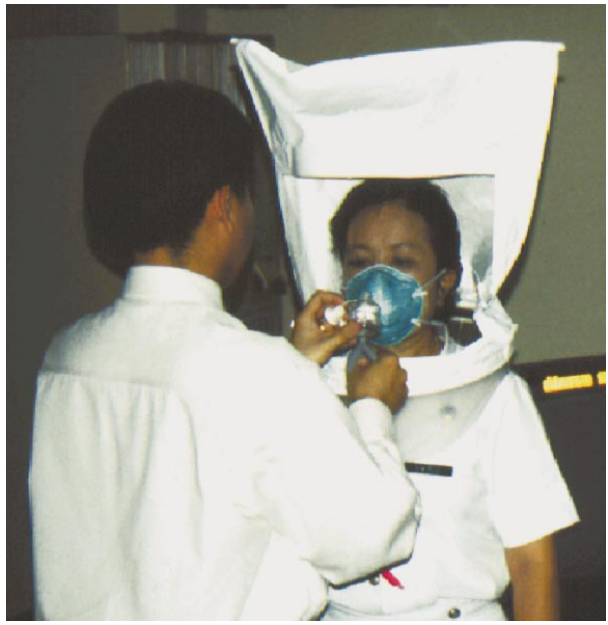
Wearing and fitting a respirator properly

6.2.3 Respirator fitting

Respirators are available in different sizes. It is recommended that HCWs be "fit tested" to ensure selection of the appropriate respirator. Fit testing of respirators should be performed to ensure that the appropriate respirator (size and shape) for each HCW is used. Qualitative fit testing involves the use of an aerosol which may be "tasted" (see photo). If the HCW "tastes" the aerosol (usually saccharin or a bitter-tasting material), the respirator must be adjusted (i.e., the nose clip) and retested. If the HCW fails the test a second time, a different size or brand respirator should be tested. Beards and facial hair do not allow proper sealing of respirators to the face. Any leak between the face and the mask is a potential entry point for infectious droplet nuclei. Should time and resources permit (financial and staff), a respirator testing program should be incorporated into the IC plan. For further details on fit testing, see suggested readings at the end of this chapter.

6.2.4 Protection in high risk areas

Respirators should be worn by all personnel entering high risk areas such as bronchoscopy rooms, sputum induction rooms, and autopsy suites. If a large volume of high risk procedures are performed, investment in a hooded positive pressure respirator (PAPR) may be cost-effective as these are re-usable and can be used by all personnel including those with facial hair or beards. Furthermore, fit testing is not necessary with the use of PAPRs.



Fit Testing in Thailand

Suggestions for Further Reading

Centers for Disease Control and Prevention. Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care facilities, 1994. Morb Mortal Wkly Rep 1994; 43(RR13):1-132.

NIOSH. Protect yourself against tuberculosis— A respiratory protection guide for health care workers. Cincinnati, Ohio: USDHHS, PHS, CDC, NIOSH. DHHS (NIOSH) publication No. 96-102.

NIOSH. Guide to the selection and use of particulate respirators certified under 42CFR84. Cincinnati, OhioL USDMMS, PHS, NIOSH. DHHS (NIOSH) publication No.96-101.

Adal KA, Anglim AM, Palumbo L, Titus MG, Coyner BJ, Farr BM. The use of high-efficiency air-filter respirators to protect hospital workers from tuberculosis. A cost-effectiveness analysis. N Engl J Med 1994; 331:169-73.

7 LABORATORY SAFETY

7.1 Laboratory safety

Laboratory safety is a complex topic. A thorough discussion of the issues involved is beyond the scope of these guidelines. For more details on laboratory safety issues, consult the WHO publication *Laboratory Services in Tuberculosis Control*.

7.2 AFB Smear preparation

Many laboratories which process infectious sputum in resource-limited countries perform only direct smear microscopy:

- performing direct smear microscopy has not been documented to result in the transmission of *M. tuberculosis* (assuming centrifugation is not being used)
- direct smear microscopy can be safely performed on the open bench
- neither environmental controls nor personal respiratory protection are necessary during the preparation of smears

In laboratories performing only smear preparation without the use of a centrifuge, perhaps the greatest threat to the personnel is contact with coughing patients. Administrative controls should be used to limit this exposure (see section 4.2.8).

7.3 Preparation of liquid suspensions of *Mycobacterium tuberculosis*

Laboratories which process liquid preparations of suspended *M. tuberculosis* (e.g., centrifugation, cultures, and drug susceptibility testing) should be considered at higher risk for nosocomial *M. tuberculosis* transmission. Safety can be improved by:

- enhancing ventilation in areas where culture and susceptibility testing of *M. tuberculosis* isolates is performed
- reducing the number of laboratories handling concentrated specimens containing *M. tuberculosis*
- only allowing laboratories with appropriate biosafety cabinets (BSC I or BSC II) and experienced staff to work with liquid suspensions of *M. tuberculosis*

7.4 Biosafety Cabinets (BSCs)

BSCs are relatively expensive and are designed to contain airborne microorganisms in laboratories working with liquid suspensions of *M. tuberculosis*. When used with appropriate laboratory practices, the spread of aerosolized microorganisms can be minimized through the use of a biosafety cabinet.
There are two general types of BSCs. BSC Class I protects the worker and the

work environment from exposure to an aerosol by drawing air into the cabinet. It does not protect the specimen from contamination. Air is exhausted outside or filtered and re-circulated into the room. Since the filters require maintenance, the most practical and safest cabinets simply exhaust air outside, away from windows, people, or areas where the air may be brought back into the building. Exhausting air to the outside produces negative pressure in the laboratory relative to the surroundings. The BSC should be designed such that the velocity into the cabinet is 0.35-0.45 m/sec. Too much velocity will induce turbulence and the potential for contaminated air to flow out of the BSC. Too little velocity may not be sufficient to carry out of the cabinet the aerosolized microorganisms. A simple technique to monitor airflow and rate is to hold a thin strip of tissue paper at various positions around the opening of the cabinet. In a well-functioning cabinet, the strip should float gently inward when placed anywhere around the opening. Ideally, air velocity should be measured periodically using a velometer, also known as hot-wire anemometer. This is the type of BSC needed in most laboratories.

BSC Class II is more expensive, since it uses laminar air flow in addition to exhaust. This type of cabinet protects both the specimen/culture and the HCW from contamination. However, without proper maintenance, the laminar air flow in Class II cabinets may actually increase the risk to HCWs by pushing contaminated air from the BSC into the breathing zone of the HCW.

For more details and proper selection of BSC, please consult the WHO Manual, *"Laboratory services in tuberculosis control"* and the IUATLD Manual, *"The public health service national tuberculosis reference laboratory and the national laboratory network"* (see references).

7.5 Personal respiratory devices in the laboratory

In laboratories where only smear microscopy is performed, personal respiratory protection (e.g., respirators) is not needed. Laboratories working with liquid suspensions of *M. tuberculosis* should be equipped with a BSC class I. Personal respiratory protection is not recommended if the BSC is functioning appropriately and all work with liquid suspensions is carried out in the cabinet.

Suggestions for Further Reading

World Health Organization. Laboratory services in tuberculosis control. Edition I. Geneva: World Health Organization, 1998.

Rieder HL, Chonde TM, Myking H, Urbanczik R, Laszlo A, Kim SJ, et al. The Public health service national tuberculosis reference laboratory and the national laboratory network. Minimum requirements, role and operation in a low-income country. Edition 1. Paris: International Union Against Tuberculosis and Lung Disease, 1998.

Collins CH, Grange JM, Yates MD. Tuberculosis bacteriology. Organization and practice. Edition 2. Oxford: Butterworth-Heinemann, 1997.

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