Reviews / Analyses

Practical and affordable measures for the protection of health care workers from tuberculosis in low-income countries

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With the global upsurge in tuberculosis (TB), fuelled by the human immunodeficiency virus (HIV) pandemic, and the increase in multidrug-resistant TB, the condition has become a serious occupational hazard for health care workers worldwide. Much of the current understanding about nosocomial TB transmission stems from the USA; however, little is known about the risk of such transmission in low-income countries. The focus of this review is on sub-Saharan Africa, since this is the region with the highest TB incidence, the highest HIV incidence, the worst epidemic of HIV-related TB, and where the risk to health care workers is probably greatest.

Measures used in industrialized countries to control nosocomial TB transmission (ventilation systems, isolation rooms, personal protective equipment) are beyond the resources of low-income countries. Protecting health care workers in these settings involves practical measures relating to diagnosis and treatment of infectious cases; appropriate environmental control; and relevant personal protection and surveillance of health care workers. Research needs to be carried out to examine the feasibility and cost-effectiveness of measures such as voluntary HIV-testing of health care workers (to enable known HIV-positive health care workers to avoid high-risk settings) and isoniazid preventive therapy for workers in high-risk settings. More resources are also needed to ensure full implementation of currently recommended measures to decrease the risk of nosocomial and laboratory-acquired TB.

Risk of TB infection among health care workers in industrialized countries

Background

Before the advent of effective antituberculosis medication, the risk of tuberculosis (TB) among health care workers, particularly those who worked in TB sanatoria, was high. After 1950, this risk declined substantially in industrialized countries because of the decreasing incidence of the disease and the availability of effective antituberculosis chemotherapy. However, since 1985 there have been a number of reported outbreaks of nosocomial TB, particularly in the USA, and the disease has once again become a serious occupational hazard for health care workers.

In 1993, a total of 3.2% of TB cases in the USA occurred among such workers (1), and many of these cases were occupationally acquired.

There are several reasons for the upsurge of nosocomial TB in industrialized countries (Table 1). Over the last decade there has been a resurgence of the disease in Europe and the USA. The incidence of TB increased by 20% in the USA over the period 1985–92, by 20% in Denmark over the period 1986–92, by 27% in Italy over the period 1988–92 and by 28% in Spain over the period 1990–92 (2). Many medical staff with working experience of TB have retired from the health service, leaving a new generation of physicians for whom it is an uncommon disease and low on the list of differential diagnoses. Infection control practices were therefore relaxed or

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Table 1: Reasons for the increase in nosocomial TB transmission in industrialized countries

- Resurgence of TB
- Poor hospital infection control practices
- Multidrug-resistant TB
- HIV infection

simply not followed in many hospitals because of the perception that TB was no longer important. The advent of multidrug-resistant TB, particularly in the USA, encouraged its spread within hospitals — not because patients with multidrug-resistant TB are more infectious than those with the drug-sensitive disease, but because first-line antituberculosis drugs are inadequate for its treatment, and patients infected with multidrug-resistant strains may remain infectious longer. Currently, the greatest risk of nosocomial TB transmission is to immunocompromised patients or staff, especially those infected with the human immunodeficiency virus (HIV). Health care workers and patients infected with HIV are more susceptible to TB, and once infected may not be able to contain the infection and may rapidly develop overt disease (3, 4).

The “at risk” health care worker

Nurses were the first occupational group who were identified to be at increased risk for TB and probably have the highest rate of infection and disease of all health care workers (5). This is not surprising, in view of the prolonged and often close contact between hospital nurses and patients. Physicians, particularly those aged 20–35 years and specialists in internal medicine, experience substantial rates of tuberculous infection and disease (6, 7). Specialists in respiratory medicine have higher rates of infection than those in other areas (8), probably because of the extra risk associated with performing bronchoscopy or caring for ventilated patients in intensive care units. Pathologists represent a further risk group. A study in Japan found a high incidence of TB among pathologists and pathology technicians, with the highest rates being among those who performed or assisted at autopsies (9).

Laboratory staff may become infected with TB either through accidental inhalation or inadvertent inoculation. In a review of the global literature, TB was reported to be the sixth most common occupationally acquired infection among laboratory workers (10), and it has been estimated that laboratory workers have a two to nine times higher risk of contracting TB than the general public (11). Although all these categories of health care worker are at risk regardless of their immune status, those infected with HIV are at much higher risk; for example, one review reported that 8 of 17 health care workers with multidrug-resistant TB were HIV positive (12).

Factors associated with nosocomial TB transmission

Common factors associated with TB transmission in recent reports of nosocomial outbreaks are shown in Table 2 (12). Rates of nosocomial transmission appear to be highest when the diagnosis of TB in hospitalized patients is delayed, when patients are not receiving adequate therapy, or when there is unrecognized drug resistance. In the USA, the delay in diagnosis in hospitals may relate to lack of awareness of TB by physicians, atypical clinical manifestations (particularly in the setting of HIV infection), or inadequate diagnostic facilities. The most infectious TB patients are those with smear-positive pulmonary disease, and sputum smear examination should be performed as quickly as possible on all TB suspects. However, according to one report, sputum smears for acid-fast bacilli were not performed in 16% of 641 hospitals in the USA caring for patients with TB, and routine sensitivity testing of isolates was not performed in 80% of these hospitals (13).

Measures to reduce nosocomial TB transmission in industrialized countries

Guidelines issued in 1990 by the Centers for Disease Control and Prevention (CDC) to prevent the

Table 2: Factors associated with TB transmission to health care workers in industrialized countries (12)

- Delay in diagnosis of TB
- Procedures associated with aerosolization of tubercle bacilli:
  - Intubation
  - Bronchoscopy
  - Sputum induction
  - Mechanical ventilation
  - Jet irrigation of tuberculous abscesses
  - Change of dressings of tuberculous ulcers
  - Autopsies
- Multidrug-resistant TB
- Poor personal protection:
  - Underuse of masks
- Poor ventilation processes:
  - TB isolation-room doors left open
  - Poor ventilation in wards or TB isolation rooms
  - Positive pressure in TB isolation rooms
  - Positive pressure in rooms dispensing aerosolized pentamidine
  - Recirculating ventilation
spread of TB in health care facilities in the USA (14) have been used successfully to control several outbreaks of nosocomial multidrug-resistant TB in the USA (15–19). The control measures that were effective in one nosocomial outbreak are summarized in Table 3. In 1993 CDC published further draft guidelines proposing new measures to prevent nosocomial TB (20). These guidelines have sparked controversy and debate because they include the wearing of respirator masks with high-efficiency particulate air filters (HEPA respirators) by health care workers in isolation rooms for patients with suspected TB. HEPA respirator masks are expensive, and their addition to the other measures recommended by CDC in 1990 offers negligible protective efficacy at great cost (21).

Nosocomial TB control must also include the protection of laboratory workers. It is recommended that laboratories which handle specimens containing mycobacteria must provide clear guidelines to laboratory workers for the safe testing of specimens, e.g. guidelines issued for laboratory safety in Europe and the USA (22–24). Table 4 shows recommended guidelines for laboratory safety in low income countries (25). In industrialized countries failure to adhere to guidelines for preventing spread of TB in health facilities has led to nosocomial transmission to patients and health care workers (17, 18, 26, 27) and to laboratory-acquired TB (23).

**Risk of TB infection among health care workers in developing countries: the example of sub-Saharan Africa**

**Impact of AIDS and tuberculosis**

In July 1996, an estimated 21.8 million adults and children worldwide were living with HIV/acquired immunodeficiency syndrome (AIDS), of whom 20.4 million (94%) were in developing countries (28). Sub-Saharan Africa is the region that has been hardest hit by the HIV/AIDS pandemic, with an estimated 14 million persons living with HIV infection. The HIV epidemic is also escalating in Asia, and by mid-1996 there were an estimated 4.8 million persons in Asia living with HIV infection. Worldwide during 1995, a total of 2.7 million new cases of adult HIV infection occurred; and of these, about 1.4 million infections were in sub-Saharan Africa and 1 million in South-east Asia (28). Since the beginning of the pandemic up to July 1996, more than 6 million adults have developed AIDS; and of these, 4.5 million have been in sub-Saharan Africa (28).

In sub-Saharan Africa HIV-seroprevalences in antenatal clinics doubled in several countries between 1990 and 1994, and in some cities are currently >30% (29). In some countries HIV-related disease

<table>
<thead>
<tr>
<th>Table 3: Interventions that were effective in reducing nosocomial transmission of multidrug-resistant TB in an HIV ward in the USA (15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative</td>
</tr>
<tr>
<td>Establish a TB control office</td>
</tr>
<tr>
<td>Staff the TB control office with a director, public health advisor, and outreach workers</td>
</tr>
<tr>
<td>Diagnostic measures</td>
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<tr>
<td>Increase awareness about TB among HIV-positive patients with respiratory illness</td>
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<tr>
<td>Introduce a policy to “rule out TB”</td>
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<tr>
<td>— Place patients with suspected TB or pneumocystis carinii pneumonia or with an abnormal chest radiograph in a TB isolation room</td>
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<tr>
<td>— Restrict sputum induction procedures and aerosolized pentamidine treatments to TB isolation rooms</td>
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<tr>
<td>— Increase staff numbers in mycobacterial laboratories and make routine and urgent acid-fast bacilli smears available every day</td>
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<tr>
<td>Therapeutic measures</td>
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<td>Expand initial anti-TB treatment to include four drugs</td>
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<tr>
<td>Allow patients in TB isolation rooms to leave only when medically necessary and ensure that such patients always wear a surgical mask when outside the room</td>
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<tr>
<td>Place automatic closing devices on all TB isolation room doors</td>
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<tr>
<td>Install negative pressure in all TB isolation rooms</td>
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<tr>
<td>Continue isolation of TB patients until at least three negative acid-fast bacilli sputum smears are obtained</td>
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<tr>
<td>Health care worker protection</td>
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<tr>
<td>Forbid immunocompromised staff from working on medical wards</td>
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<tr>
<td>Ensure that all health care workers entering a TB isolation room wear a surgical submicron mask and subsequently a dust-mist particulate respirator mask</td>
</tr>
<tr>
<td>Perform tuberculin skin tests on health care workers every 4 months</td>
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and AIDS are responsible for $\geq 50\%$ of hospital admissions (30). AIDS is the leading cause of adult death in Abidjan, Côte d'Ivoire (31), and in rural communities in Uganda (32).

Globally, in 1994 more than 4.8 million people were thought to be dually infected with *Mycobacterium tuberculosis* and HIV, with over 75% of them living in sub-Saharan Africa (33). The strong association between TB and HIV in this region has led to a large upsurge in the incidence of TB in several sub-Saharan African countries (34) and the region now has the highest TB case notification rate (96.8 per 100,000) (34). TB is one of the major causes of adult morbidity and mortality in the region (35), being responsible for large numbers of adult hospital admissions (30) and hospital deaths (36). Primary drug resistance levels in sub-Saharan Africa vary considerably; such resistance is high and continues to increase in some countries, such as Sierra Leone (37), but is low and remains stable in countries with good TB control programmes such as United Republic of Tanzania (38) and Malawi (39). Fortunately, the phenomenon of multidrug-resistant TB has not yet emerged as a significant threat in sub-Saharan Africa, and despite high HIV-seroprevalences multidrug-resistant TB has not been associated with HIV infection (39–41).

**Nosocomial TB transmission and risk to health workers**

Information is limited about the risk of TB transmission to health care workers in sub-Saharan Africa; however, the risk is likely to be substantial among such workers from a high HIV prevalence population, and therefore with increased susceptibility, related to HIV. A study carried out in a central hospital in Blantyre, Malawi, found that 4% of the nurses were diagnosed and treated for TB over the 2-year period 1993–94 (42). Over this 2-year period spent working in a particular hospital department, the proportion of nurses who developed TB was significantly higher among those in the medical and TB wards than among those in other hospital departments (13% versus 3%; odds ratio = 5.74). Potential confounding variables were age and HIV status; however, there was no significant difference in age between nurses working in different departments. The nurses’ HIV status was not assessed, although it is unlikely that HIV seroprevalence differs sufficiently among nurses working in different departments. Extrapolation of these findings to an annual case notification rate indicates that the rate of TB infection among nurses working in medical and TB wards was 6600 per 100,000 — nearly forty times higher than the case notification rate among the general population in Malawi in 1994 (180 per 100,000) (source, Malawi National TB Programme). The relative risk of health workers acquiring TB is not known in the absence of data comparing them with a similar group of the general population (excluding health care workers) matched for age and sex; however, health care workers are aged 15–59 years, the age group which accounts worldwide for 70% of all TB cases (43). Therefore, the relative risk of HCWs acquiring TB is likely to be

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**Table 4: Laboratory guidelines in low-income countries for safe testing of specimens containing mycobacteria (25)**

<table>
<thead>
<tr>
<th>Item</th>
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<tr>
<td>• Efforts should be made to avoid, minimize or control those laboratory operations which create potentially infectious aerosols</td>
</tr>
<tr>
<td>• For maximum protection of laboratory workers, a laboratory safety cabinet should be available for use in the preparation and fixing of smears or for processing specimens for culture</td>
</tr>
<tr>
<td>• Each time on entering the laboratory, the laboratory technician should put on a laboratory coat and wash his/her hands with soap and water. Similarly, each time on leaving, the technician should wash his/her hands and leave the coat hanging in the wardrobe</td>
</tr>
<tr>
<td>• It is forbidden to smoke or eat in the laboratory or to sit on the tables or benches</td>
</tr>
<tr>
<td>• All manipulations for preparing a smear should be completely standardized and the arrangements of the material on the table should always be the same to ensure maximum safety</td>
</tr>
<tr>
<td>• The opening of the sputum containers and the preparation of the smears must be done carefully to prevent the formation of aerosols</td>
</tr>
<tr>
<td>• Items such as the slide holder, the dryer, and the work surface should be flamed or soaked in a TB germicidal solution, e.g. 5% phenol or a phenol-derivative soap mixture</td>
</tr>
<tr>
<td>• All infectious wastes must be decontaminated on disposal</td>
</tr>
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**Notes:**


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close to forty times greater than that of the general population.

During this 2-year period, over 500 patients admitted to the general medical wards had smear-positive pulmonary TB, and there were long delays in diagnosing and treating these high-risk patients. The HIV-serostatus of the nursing staff was not determined; however, they are likely to experience the same prevalence of HIV infection as the rest of the adult population, and in 1993, 32% of pregnant women attending antenatal clinics in Blantyre were HIV-seropositive (44). It was not possible to determine whether the development of TB in the study nurses arose because of reactivation of latent infection or from new infection. However, epidemiological studies in the USA have shown that nearly two-thirds of TB cases among HIV-infected patients arise because of recent transmission, and this is likely also to be the case among nurses working in medical wards containing large numbers of untreated, smear-positive pulmonary TB patients (45, 46).

Morbidity and absenteeism among hospital staff in sub-Saharan Africa are high, much of it probably because of HIV-related infections (47), of which TB is one of the predominant conditions. A study in Zambia showed that mortality in nurses rose from 2 per 1000 in 1980–85 to 26.7 per 1000 in 1989–91, the increase being attributed to HIV-related disease (48).

There is almost no data on the risk of hospital laboratory workers in sub-Saharan Africa developing TB. In industrialized countries, such workers are at increased risk of acquiring TB compared with the general population (11), and inadequate compliance with the recommended safety regulations (22–24) has led to laboratory-acquired TB (23). Since resources to implement such regulations are inadequate in sub-Saharan Africa (25), it is likely that laboratory workers there are also at increased risk of TB infection. For example, safety cabinets for the handling of specimens containing mycobacteria are not available in most district hospital laboratories, and district hospital laboratories are usually multipurpose with no separate area for performing mycobacterial work.

Reduction of transmission of TB to health care workers in developing countries: the example of sub-Saharan Africa

The recommendations for controlling nosocomial TB transmission in industrialized countries are not, in general, applicable to low-income countries because of the high cost of implementing some of them and because some are inappropriate to the epidemiology of TB in such countries. Nevertheless, because of the need for practical advice that is reasonably effective and which can be implemented in low-income countries WHO provided guidelines in 1993 for the control of TB transmission in health care settings (49). These guidelines together with practical measures that have been implemented in some African hospitals where there is concern about nosocomial TB transmission are discussed below.

Diagnosis and treatment of infectious TB patients

The most cost-effective method of interrupting the chain of TB transmission is the rapid diagnosis and treatment of infectious TB patients, i.e. those with smear-positive pulmonary TB. As outlined below, there are several ways of ensuring as early a diagnosis as possible with the least possible risk of transmission of infection to others.

Adherence to criteria for suspected pulmonary TB. In areas where the prevalence of TB is high, which includes virtually all of sub-Saharan Africa, any patient with a cough that lasts >3 weeks should be investigated for pulmonary TB (25). This is particularly important if the patient has lost weight and has not responded to a course of antibiotics. It is also recommended that patients with haemoptysis, whatever the duration of symptoms, be investigated for pulmonary TB.

Investigation of TB suspects as outpatients. Many smear-positive TB patients are ambulant up until the time of their treatment (50). Admitting TB suspects to hospital to investigate the possibility of the pulmonary form of the disease may be convenient for the health care staff and possibly the patient; however, ambulant patients should be investigated whenever possible in the outpatient setting. Ensuring that all suspects are screened through one office (usually the district TB office), the use of an outpatient cough register, and a laboratory sputum register facilitate the tracing of suspects who are sputum smear-positive. A cough register is used to record the name and address of TB suspects, the date when sputum specimens are submitted, the date when sputum smear results are returned to the cough register personnel, the results of the sputum smear examination, and the date when the TB suspects return to collect the results. Smear-positive pulmonary TB patients who do not return to collect their results can be actively followed up.
Decreasing delays in sputum collection and delivery of results to hospital wards. Many TB suspects are still admitted to medical wards because of late presentation and serious illness. In most African countries, a patient with suspected pulmonary TB is asked to submit three sputum specimens for smear microscopy, which increases the chances of finding tubercle bacilli (51). In the past, the standard practice was to request three early morning sputum samples since secretions build up in the airways overnight. However, current recommendations are for the patient to provide three sputum specimens, collected within 24 hours, as follows: “on the spot”, early morning, and “on the spot” (see Table 5). Under routine conditions this method is as sensitive as collecting three early morning specimens (52). Even using the 24-hour method of sputum collection, significant delays can still occur: medical personnel may not request sputum specimens until several days after the patient is admitted; patients may not receive sputum containers, despite requests for sputum examination; patients may not understand how to submit sputums; collection and delivery of filled sputum containers to the laboratory as well as delivery of smear results back to the wards may be slow (53).

One possible solution to these delays is to appoint a ward “cough officer”. The salary of such an individual will be low in most sub-Saharan African countries, and the appointment is likely to be cost-effective. The cough officer can be made responsible for all aspects of sputum collection and delivery of results back to the ward and can ensure that smear-positive pulmonary TB patients are registered and started on treatment as soon as the diagnosis is made (see Table 6). This system has been implemented in the medical wards of one of the central hospitals in Malawi, and preliminary evaluation shows that it can significantly reduce the delays in diagnosis and in the initiation of treatment of infectious TB cases (A.D. Harries, personal observations, 1996).

### Table 5: Recommended procedure for 24-hour collection of sputum samples (52)

- **Sample 1**: Patient provides an “on the spot” sample under supervision when he/she is admitted to the ward
- **Sample 2**: Patient provides an early morning sample the following morning
- **Sample 3**: Patient provides another “on the spot” sample under supervision about 2 hours after the early morning sample

All three sputum specimens are then taken to the laboratory for sputum smear microscopy

### Table 6: Duties of a ward “cough officer”

- Identification of TB suspects on the ward on a daily basis, morning and afternoon with help of nursing and clinical staff
- Giving sputum containers promptly to suspected TB patients and educating them about sputum specimens, i.e. “on the spot”, early morning, and “on the spot”
- Taking sputum specimens with the completed sputum request forms every morning to the laboratory
- Collecting sputum results every morning from the laboratory and filing these in patients’ case notes
- For smear-positive pulmonary TB patients, taking the file, sputum result form, and patient for registration and start of treatment with the district TB officer as soon as the diagnosis is made
- Giving formal education sessions on a daily basis to all TB suspects in the medical ward
- Recording in a dedicated ward “cough register” the patient’s name, age, sex, address, date of sputum containers given to patient, date of filled sputum containers sent to laboratory, date and results of sputum smear examination, and date of smear-positive patients being started on antituberculosis treatment

Decreasing delays in laboratory smear microscopy. Most hospital laboratories in resource-poor countries stain sputum smears using the Ziehl–Neelsen method and examine for acid-fast bacilli (AFB) using light microscopy. Central hospitals with busy laboratories can speed up the diagnosis of pulmonary TB by investing in a fluorescent microscope using a auramine-phenolic or auramine–rhodamine stain; this has the advantage that smears can be scanned under low magnification and more smears can be examined in a given period of time compared with the Ziehl–Neelsen stain (51). All laboratories should try to perform smear microscopy and dispatch the results on the same day that sputum specimens are received.

Improving the safety of sputum smear microscopy for laboratory workers. The exterior of sputum containers may be contaminated at the time of expectoration (54), and laboratory workers should clean the outside of such containers with a suitable disinfectant before opening and processing them. A method to improve the sensitivity of sputum smear diagnosis that has been successfully tested in Ethiopia involves dissolving the sputum in household bleach (aqueous solution of sodium hypochlorite) and concentrating the bacteria by centrifugation (55); household bleach is a potent disinfectant and rapidly kills tubercle bacilli. This method may have the added advantage of lowering the risk of laboratory infection, especially in hospitals that do not have safety cabinets.
Protection of health care workers from TB in low-income countries

Isolation of infectious TB patients. Ideally, patients suspected to have pulmonary TB should be isolated from other patients without TB. Isolation rooms are not usually available in busy medical wards; however, since close proximity to an infectious case is a risk factor for acquiring tuberculous infection (56), patients with suspected pulmonary TB can be kept together in one area of the ward that is screened off from other sections, particularly those occupied by patients with known or suspected HIV/AIDS infection.

Once hospitalized patients are diagnosed to have smear-positive pulmonary TB, they should be isolated, during the initial phase of treatment, from those without TB. It is particularly important that infectious patients are isolated from those most susceptible to TB, i.e. immunosuppressed patients and infants. In institutions with large numbers of patients (most hospitals in Africa), this is best done by establishing a TB ward. Immunocompetent patients with drug-sensitive tubercle bacilli rapidly become noninfectious following a short-course of chemotherapy (this occurs in about 2 weeks). The bacillary response to treatment is at least as good for HIV-positive as for HIV-negative patients (57). However, this may not apply to TB patients with drug-resistant bacilli, and since most hospitals have no facilities for mycobacterial culture and drug sensitivity analysis it is preferable to continue to isolate all smear-positive patients until they have become sputum-smear negative.

Use of short-course chemotherapy for smear-positive pulmonary TB. Standard chemotherapy of 12 months’ duration using cheap drugs such as streptomycin,isoniazid, and thioacetazone or ethambutol is still employed in a number of countries in sub-Saharan Africa to treat all cases of TB. Patients on standard chemotherapy experience a delay in sputum-smear conversion from positive to negative, and at the end of 2 months’ treatment, approximately 50% of patients are still sputum-smear-positive (35). Short-course chemotherapy of 6–8 months’ duration using multiple drugs such as rifampicin,isoniazid,pyrazinamide and streptomycin (or ethambutol) is much more effective, and after 2 months’ therapy 85–95% of patients become smear-negative, irrespective of their HIV serostatus (41,58,59) Short-course chemotherapy should, wherever possible, be used for all smear-positive pulmonary TB cases.

Environmental control

One of the most effective measures to reduce TB transmission is proper ventilation.

TB wards and other high-risk areas in the hospital. TB wards and general medical wards with suspected pulmonary TB patients should have plenty of light, many windows that open to the outside, and doors to other parts of the hospital that are kept closed most of the time. Exhaust fans that move air from wards to the outside are useful, but may be too costly for many health care institutions. The same principles apply to outpatient clinics and to rooms in which sputum-induction procedures are carried out.

Some authorities have recommended that ultraviolet (UV) lights be installed in areas where TB transmission is likely. Although there is experimental evidence that UV light has a germicidal effect on tubercle bacilli (60), its effectiveness in reducing TB transmission has not been confirmed in practice. UV lights are also expensive, require proper maintenance, and are potentially harmful if not installed properly. Sunlight is a cheap source of UV light, is in plentiful supply in most parts of Africa, and reinforces the recommendation that wards should have large windows that allow plenty of sunlight to penetrate.

Laboratories. Laboratories which process sputum specimens for acid-fast bacilli should wherever possible follow published guidelines to minimize TB transmission to laboratory workers (25). As far as resources permit, the measures listed in Table 4 should be implemented.

Protecting the health care worker

Health care workers must know about TB and about the risks and dangers posed by patients with the pulmonary form of the disease, especially those who are sputum-smear-positive. National TB programme managers and trainers must make this information available. The measures outlined below should be considered for personal protection.

• HIV-infected staff should avoid working with TB patients and TB specimens. Health care workers with HIV infection are at increased risk of acquiring tuberculous infection and of progressing to a TB disease state (3,4). While it used to be commonly believed that TB in HIV-infected persons was due to reactivation of latent infection, studies from the USA using molecular epidemiology techniques have shown that in about two-thirds of HIV-infected persons TB is due to recent transmission rather than reactivation of disease (45,46). In sub-Saharan Africa the proportions of TB cases that arise from recent infection, reactivation, and re-infection are not known.

Health care workers posted to general medical wards or TB wards, and laboratory staff who work
with mycobacterial specimens could be offered confidential HIV testing with pre- and post-test counselling. If they are HIV-seropositive, they should be moved to other safer areas within the hospital; laboratory staff should be transferred from mycobacterial work. In countries where HIV infection still carries a social stigma, it is likely that many health care workers, particularly women, will not come forward for voluntary HIV testing. One study in Kenya found that 65% of women tested after giving their informed consent did not actively request their results, less than one-third informed their partners, and violence against women because of a positive HIV-antibody test was common (61). Several women were also chased away from home or replaced by another wife upon informing their partners that they were HIV seropositive. These cultural attitudes are likely to dissuade female health care workers from seeking HIV testing.

Another approach is for hospitals to advise health care workers who exhibit some of the clinical features (62) shown in Table 7 to request transfer from high-risk environments. The presence of these clinical features strongly suggests infection with HIV, but avoids the definitive knowledge which accompanies the results of an HIV-antibody test. Since most people living with HIV infection are asymptomatic, this measure only has the potential to prevent exposure to TB in a small proportion of HIV-infected health care workers.

- **Face masks.** HEPA masks ensure protection against TB by filtering out droplet nuclei of diameter 1–5μm. In the USA their use is recommended by CDC for workers caring for patients with possible TB in isolation rooms (20); however, since each mask costs US$5–7, no low-income country in Africa could afford to use them for widespread nosocomial TB control (21, 63, 64). Standard surgical masks have been developed to prevent the exhalation of particles, and while they are effective in doing so, their efficacy in preventing the inhalation of droplet nuclei containing AFB of diameter 1–5μm is less than 50% (65). Nevertheless, the use of such masks by TB patients with a productive cough who are being transported to other areas of the hospital for investigations such as chest radiographs may help to reduce transmission of the disease. Routine use of such masks by staff or ward visitors is not generally recommended, although they may be of some help for staff supervising coughing procedures.

- **Patient cough hygiene.** Educating patients to place a hand in front of their mouth when coughing and ensuring that coughing patients are examined with their heads turned away from the health worker are hygienic measures of unproven benefit, but which are simple to implement.

- **Screening of health care staff for infection and disease.** Tuberculin skin testing at regular intervals has been recommended as a means of providing surveillance of health care workers in the USA (12, 15). Individuals who develop tuberculin skin test conversions are offered chemoprophylaxis to prevent active disease. However, even in the USA this measure is controversial because many workers do not comply with screening requirements, the prevalence of true positive tests is low, and in consequence the cost per case of TB prevented is high. Moreover, less than 25% of personnel identified by tuberculin screening complete at least 6 months of antituberculosis chemotherapy (12).

Surveillance of health care staff in areas of high TB prevalence by regular tuberculin testing is probably of little value. Since the annual risk of infection in sub-Saharan Africa is 1.5–2.5% (66), and with >50% of over-15-year-olds giving positive tuberculin tests (67), many health care workers will already have a positive skin test. BCG vaccination coverage in infancy is high (68) and this makes the interpretation of the tuberculin skin test difficult. Cutaneous anergy is also common among immunosuppressed TB patients: in one study in Zaire, >50% of HIV-positive pulmonary TB patients with a CD4 lymphocyte count <200 per μl had a negative tuberculin skin test (69). Regular screening using chest radiographs every 6–12 months is also probably not cost-effective. A few early lesions may be identified, but in the absence of symptoms it will be difficult to interpret the significance of these findings.
Protection of health care workers from TB in low-income countries

Symptoms in TB patients develop soon after the onset of disease (35). The most cost-effective way of screening, therefore, is to follow rigorously the guidelines for screening TB suspects recommended by the International Union against Tuberculosis and Lung Disease (IUATLD) (25) and WHO (70), and to treat health care workers as soon as active TB is confirmed. Posting large notices in all the wards, and distributing pamphlets to health care workers informing them that if they have a cough for longer than 3 weeks which has not responded to a course of antibiotics they must report to the designated medical attendant responsible for staff, might assist in reminding such workers about the importance of nosocomial TB.

- **Use of BCG vaccine.** In the USA there has been renewed interest in the use of BCG vaccine to prevent TB among health care workers. However, a recent decision analysis favoured tuberculin skin testing and preventive therapy over use of BCG vaccine (71). This is because of the variable protective efficacy of BCG (0–80%) when tested in controlled trials (72), and because when given to adults the vaccine makes subsequent skin reactions to tuberculin uninterpretable.

In low-income countries, the majority of health care workers will have received BCG vaccine at birth or as part of the expanded programme on immunization (EPI) during the first 5 years of life (68). The questions then arise of whether revaccination with BCG confers additional protective efficacy against TB and whether BCG vaccination of adult HIV-positive individuals is safe. In 1995 WHO discouraged the use of BCG revaccination on the basis of lack of evidence for additional protection over and above that resulting from a first vaccination (73). Observations from a recent community-based study in Malawi have supported these recommendations, and have shown that BCG revaccination, while providing additional protection against leprosy, offers no protection against TB (74).

There have been several case reports of BCG complications involving patients with AIDS, but prospective cohort studies comparing such complications in HIV-positive and HIV-negative children vaccinated with BCG have found no differences between these groups (75, 76). Based on this information, current recommendations by WHO are that BCG vaccine can safely be given to children with asymptomatic HIV infection but that it should be withheld from children with clinical AIDS or with asymptomatic HIV infection (77). In the Malawi study discussed above, BCG revaccination of adults appeared to increase the risk of pulmonary TB among HIV-positive individuals (74). Although this may have been a chance observation, if harm is added as an additional consideration the argument against revaccination becomes even stronger (78). At present, BCG revaccination as a means of preventing TB in health care workers cannot be recommended.

- **Isoniazid preventive therapy.** Two placebo-controlled trials have shown that isoniazid given at a dose of 300mg daily for either 6 months or 12 months to asymptomatic HIV-infected persons significantly reduces the annual rate of TB, particularly among those with positive tuberculin skin tests (79, 80). Isoniazid preventive therapy may rarely be associated with hepatitis; the risk of this complication is low, however, although it is greater for over-50-year-olds and for those who are heavy drinkers (81). In a study of isoniazid preventive therapy in Uganda, no case of isoniazid toxicity requiring cessation of treatment was observed (82).

At present, WHO and the IUATLD hold that there is insufficient information to recommend implementation of isoniazid preventive therapy for coinfected (TB/HIV) persons as one of the components of the TB control strategy in programme settings worldwide (83). However, WHO currently recommends that isoniazid can be used in tuberculin-positive, HIV-infected persons who do not have active TB (83).

Research is necessary to evaluate the feasibility and cost-effectiveness of a policy of offering isoniazid preventive therapy for health care workers while they are being exposed to infectious TB cases. Implementation of such a policy would require thoughtful deliberation of the criteria for selecting which health care workers in which departments should receive isoniazid preventive therapy and of the duration of such therapy. Voluntary HIV testing is unlikely to be widely accepted and tuberculin skin tests will probably be positive in the majority of adult health care workers. All “at-risk” staff should therefore have active TB excluded by a medical examination and a normal chest radiograph, and, provided they have no evidence of liver disease or heavy alcohol consumption, should commence regular isoniazid preventive therapy at a dose of 300mg daily. If staff subsequently develop symptoms compatible with pulmonary or extrapulmonary TB, appropriate investigations should be carried out and if the TB is confirmed, preventive therapy should be stopped and treatment commenced.

**Conclusions**

The factors associated with nosocomial transmission of TB in industrialized countries are now well
known, and the measures required to control or prevent outbreaks of the disease in health care facilities and laboratories have been tested and are of proven value. However, severe resource constraints limit the relevance of these measures in low-income countries. In such countries, particularly in areas of sub-Saharan Africa where the prevalence of HIV/TB is high, there is still much information that needs to be gathered. There is an urgent need to quantify the risk of TB to health care workers in hospital wards, clinics, X-ray departments and laboratories, and to determine the factors responsible for spread of TB.

Operational research is necessary to test and evaluate inexpensive, sustainable, and cost-effective control measures. Ministries of health and national TB programmes need to consider contentious measures, including voluntary testing of health care workers for HIV infection (in order to relocate HIV-infected staff to low-risk areas) and instituting isoniazid preventive therapy for those workers at particular risk of TB, to determine whether these measures really do protect health care workers from TB. More resources are needed to enable full implementation of currently recommended measures to decrease the risk of nosocomial TB transmission and of laboratory-acquired TB. Health care workers are a vital resource and are scarce in many countries; it is therefore vital to retain their services to protect them against the risk of occupationally acquired TB.

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Résumé
Des mesures pratiques et abordables pour protéger contre la tuberculose le personnel soignant des pays à faible revenu

La résurgence mondiale de la tuberculose, qu’alimente la pandémie d’infections par le virus de l’immunodéficience humaine (VIH) et qu’aggrave l’apparition de souches de *Mycobacterium tuberculosis* polypharmacorésistantes, fait de la tuberculose un sérieux risque professionnel pour le personnel soignant de toutes les régions du monde.

Les auteurs font le point des connaissances actuelles sur la transmission nosocomiale de la tuberculose et examinent les méthodes qui permettent d’y faire efficacement obstacle, notamment aux pays d’Amérique du Nord et d’Amérique du Sud, et aux pays d’Europe de l’Est, en cherchant à déterminer dans quelle mesure elles sont transposables aux pays à faible revenu.

En fait, l’étude porte essentiellement sur les pays africains au sud du Sahara car c’est dans cette région que l’incidence de la tuberculose et celle de l’infection à VIH sont les plus fortes, que l’épidémie de tuberculose liée au VIH est la plus grave et que le personnel soignant court vraisemblablement le plus de risque d’être contaminé. Alors même que, dans ces pays, le personnel soignant court un risque non négligeable de contamination tuberculose nosocomiale en raison d’une sensibilité plus élevée due à la prévalence du VIH et de la surpopulation fréquente des établissements de soins, l’information relative à ce type de transmission reste limitée. Ainsi, une étude effectuée au Malawi a révélé que l’incidence annuelle de la tuberculose parmi les infirmières des services de médecine était de 6 600 pour 100 000, soit près de 40 fois plus que dans la population générale (180 pour 100 000). Les mesures de lutte contre la contamination nosocomiale qui sont mises en œuvre dans les pays industrialisés, comme l’amélioration des systèmes de ventilation, l’installation de salles d’isolement, et le port d’un équipement individuel de protection, sont hors de portée de la plupart des hôpitaux d’Afrique subsaharienne. Il n’empêche que la mise en place de mesures destinées à protéger le personnel soignant est devenue d’une urgence nécessaire. Il faudrait également que s’instaure un large débat sur des suggestions ou recommandations qui pourraient être faites au sujet des questions suivantes: dépistage et traitement des cas contagieux de tuberculose, aménagement des locaux pour lutter contre la transmission, protection individuelle et surveillance médicale du personnel soignant. Il serait souhaitable d’élaborer une stratégie en vue d’identifier les organismes de financement, les centres de recherche et les programmes de lutte antituberculose qui seraient prêts à se lancer dans la recherche opérationnelle. Celle-ci devrait porter sur la faisabilité et la rentabilité des mesures de lutte contre la contamination nosocomiale, comme le test VIH volontaire chez les soignants (de manière à réaffecter les personnes porteuses du virus dans des services moins exposés) et la prophylaxie à l’isoniazide pour le personnel en poste dans des secteurs à haut risque. Dans l’ensemble du monde, la lutte antituberculose manque visiblement de moyens. Des ressources supplémentaires sont nécessaires pour que les mesures permettant de réduire le risque de contamination tuberculose en milieu hospitalier ou au laboratoire puissent être intégralement mises en œuvre.
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