Protecting health care workers from tuberculosis in China: a review of policy and practice in China and the United States

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Tuberculosis causes >1.7 million deaths worldwide each year and is frequently transmitted in hospitals. Outbreaks of multidrug-resistant tuberculosis have led to illness and death among health care workers (HCWs) in many countries. Some countries, such as the United States, implemented occupational health policies that substantially reduced tuberculosis rates among HCWs. Inadequate tuberculosis infection control in China may contribute to its high burden of tuberculosis and multidrug-resistant tuberculosis, which are both the second highest worldwide. Occupational health policies in China for tuberculosis control can be strengthened.

We reviewed the development and content of tuberculosis infection control policies in the United States and China. Sources included published academic literature, Chinese Ministry of Health policies, US government agency reports, legal databases, personal observations of hospitals, review of internet discussion sites, and discussions with HCWs and health care and law experts.

In the United States, slow acceptance of the tuberculosis problem in HCWs resulted in decades of inaction. Tuberculosis infection control policies, based mostly on expert opinion, were implemented only after tuberculosis resurged in the 1980s. Effective evidence-based policies were developed only after multiple cycles of policy implementation, evaluation and revision. These policies have now substantially reduced occupational tuberculosis. In China, tuberculosis has not been formally recognized as an occupational disease, and data regarding the burden in HCWs are sparse. Vagueness of current labour laws and suboptimal alignment of infection control authority and expertise result in varied and sometimes absent protection of HCWs against tuberculosis. Formal evaluations of occupational tuberculosis policies have not been reported.

By collecting data on its current HCW tuberculosis burden and infection control practices, refining policies, continually evaluating its policies based on accumulated evidence and rapidly identifying unsuspected tuberculosis cases, China can develop a more comprehensive strategy to ensure the health of HCWs and reduce transmission of tuberculosis and multidrug-resistant tuberculosis.

Keywords Occupational tuberculosis, health policy, China, United States
KEY MESSAGES

- Tuberculosis (TB) in health care workers was recognized slowly in the United States, but strictly enforced regulations, and a cycle of evidence-based policy evaluation and policy revision, resulted in dramatically decreased TB burden.
- Although evidence is sparse on the magnitude of TB burden, effectiveness of infection control options and enforcement of current policies among health care workers in China, health authorities are beginning to formulate new TB control policies.
- By collecting data on its current health care worker TB burden and infection control measures, refining policies, improving regulatory implementation and continually evaluating its policies based on evidence, China can develop a more evidence-based, effective approach to reduce transmission of TB and multidrug-resistant TB.
- China can utilize lessons learned from the US experience to develop a comprehensive strategy to ensure the future health of its health care workforce.

Introduction

In 2009, an estimated 9.4 million new cases of tuberculosis (TB) disease occurred worldwide, resulting in 1.3 million deaths (WHO 2010a). TB is an infectious disease transmitted by small particles produced in the lungs of ill persons. Once airborne, these particles stay suspended for long periods and can infect people when they are inhaled. About 10% of infected people eventually develop active TB disease (American Thoracic Society 2000). Transmission of TB is a particular problem in hospitals, because patients with TB frequently present to hospitals with non-specific symptoms of respiratory infection and may spend substantial time in a hospital before they are diagnosed, begin effective anti-TB treatment and become non-infectious (Edlin et al. 1992; Kenyon et al. 1997). Health care workers (HCWs) are at high risk of acquiring TB, regardless of economic setting, when they are exposed to inpatients with untreated TB (Menzies et al. 2007). The rate of TB in HCWs is a reliable measure of the effectiveness of TB infection control in hospitals (WHO 2009). Other patients are also placed at risk of TB when infection control measures are not implemented properly (Li et al. 2007). Recently, the World Health Organization (WHO) has begun advocating for greater investments in hospital infection control because of the global, unabated dissemination of multidrug-resistant TB strains (MDR-TB) and the recognition that hospitals are an intense locus of MDR-TB transmission (WHO 2007).

One effective strategy for reducing TB transmission in health care facilities is through occupational health policies. In the United States and some other high-income countries, TB has been considered an occupational disease for many years. In October 2009, the International Labour Organization (ILO) added TB to its list of occupational diseases, in recognition of the fact that HCWs are at increased risk for TB compared with the general population, and that methods to prevent, diagnose, treat and follow-up cases are well-established (International Labour Organization 2009).

Inadequate TB infection control in China may contribute substantially to the high burden of TB. According to the WHO in 2009, China has the second highest burden of TB in the world, with an estimated 1.3 million new TB cases (97 new cases per 100 000 persons) per year (WHO 2010a). In 2000, a nationwide survey concluded that an estimated 550 million persons (45% of the population) have latent TB infection and that 4.5 million have active pulmonary TB disease (National Technical Steering Group of the Epidemiological Sampling Survey for Tuberculosis 2002). China also has the second highest number of MDR-TB cases annually (100 000 in 2008), with 5% of new TB cases and 26% of previously treated TB cases estimated to be MDR (WHO 2007; WHO 2010a). Because of China’s large population, high TB and MDR-TB rates, and increased global travel and migration, improvements in TB infection control in China can decrease both the domestic and global burden of TB and MDR-TB.

With 30 years of experience developing, implementing and evaluating TB infection control policies, the United States experience can serve as one possible model for China to develop TB infection control policies. Although the policy context and disease burden are markedly different—the United States has less than 13 000 new cases of TB (4 new cases per 100 000 persons) per year (WHO 2010a) and less than 1% are multidrug-resistant (WHO 2010b)—the process needed to develop evidence-based policies should be similar. Moreover, the lessons learned from the US experience in reducing the incidence of new TB cases from 52.6 per 100 000 persons in 1953 to 4.2 per 100 000 in 2008 (US Centers for Disease Control and Prevention 2009a), can be used to inform TB control efforts in China.

We examined key policy development processes and content regarding TB infection control in China and the United States to decrease occupational TB in HCWs. Our aim is to provide policymakers in China answers to three questions:

1. What are the existing gaps in TB infection control policy?
2. How can lessons learned from the TB control experience in the United States be used to effectively fill those gaps?
3. What policy options can help improve effective TB control in China?

Methods

Anderson provides a suitable model to conduct reviews of the policy-making process and policy content, which involves a ‘sequential pattern of action’: (1) problem identification and agenda setting, (2) policy formation, (3) adoption, (4) policy implementation, and (5) policy evaluation (Palmer and Short 2000). We reviewed policy processes in China and the United States regarding TB infection control in HCWs, using published
studies and documents to examine steps in Anderson’s model. We then compared the current state of HCW TB infection control policies and programmes between countries. Based on these comparisons, we identified steps for improving policy process and content in China.

To understand policy process and content in China, we obtained data from multiple Chinese language sources. For the problem identification, implementation, and evaluation steps of the policy process, we searched for published literature using CNKI (www.cnki.net), Wanfang (www.wanfangdata.com.cn), and VIP (www.cnjip.com), three searchable Chinese online databases of academic literature, using the terms “tuberculosis” (肺结核，结核病), “healthcare worker” (医护人员医院职工，防治人员，医务人员), and “regulation” / “law” / “statute” (规则 規定 法律，法规，政策). To examine policy formation and adoption steps, we searched the regulations, laws and statutes published on the Ministry of Health’s (MOH) website (www.moh.gov.cn/publicfiles/business/htmlfiles/zwgkzt/pzcfg/index.htm) for all policies pertaining to health care facilities, HCWs and TB infection control. We also obtained documents from MOH’s Department of Nursing and Infection Control, which is responsible for national policies on health care facility infection control. Relevant Chinese articles were translated into English by a professional translation service. We also consulted an expert in Chinese labour law, a governmental legal database run by China’s Supreme People’s Court and the People’s Court Daily (chinacourt.org), and searched a commercial portal for Chinese legal cases and news (110.com). Because limited information is publicly available about actual implementation of infection control to prevent occupational TB, we relied on personal observation of health care facilities, discussion with HCWs and reviews of internet discussion forums for anecdotes about policy implementation.

For the United States, we used government agency reports and published peer-reviewed literature to evaluate the policy process. For government-supported work, we relied primarily on reports from the National Institute for Occupational Safety and Health and the Institute of Medicine of the US National Academy of Sciences.

Results

United States

Policy process step: problem identification

In the United States, scientific consensus that HCWs are at significant increased risk of TB was reached only after decades of research and debate (Institute of Medicine 2001). In the 1920s, after decades of public health improvements, a new generation of uninfected health care workers became exposed to older, highly infectious TB patients in hospitals, which began to raise awareness of occupationally-acquired TB. Studies in the 1930s and 1940s documented increased risk among nursing (Sapkowitz 1994) and medical students, and by the 1950s, the idea began to emerge that the risk of TB infection correlated with different levels of exposure to active TB patients.

Several possible reasons help explain the delay in establishing a scientific consensus. Private hospitals feared a loss of clients by admitting the existence of a problem (Clark 1924), while other health care facilities feared liability for an occupational hazard (Childress 1951). Some experts felt that HCWs had better access to health care, resulting in higher reported rates in HCWs (Brandy 1940; Bren and Kane 1946; Riggins 1953). Eventually, evidence about the elevated risk of TB in HCWs became overwhelming, and TB’s role as an occupational hazard became widely accepted.

Policy process step: policy formation and adoption

In the United States, the first national agency to address occupational safety was the Bureau of Mines, which was created in 1910. However, until 1969, individual states were responsible for developing laws to protect worker safety, and few states had laws to impose penalties for non-compliance. Most state laws focused on training and consultation with employers (Institute of Medicine 2001). In 1969, the national government finally adopted laws to address worker safety, with the passage of the Federal Coal Mine Safety and Health Act. In 1970, the Occupational Health and Safety Act was passed, whose goal was ‘to assure so far as possible every working man and woman in the Nation safe and healthful working conditions’ (US Congress 1970a). Specifically, it included a ‘general-duty’ clause which required that employers ‘(1) furnish their employees work and a workplace that is free from recognized hazards that are likely to cause serious physical harm or death, and (2) comply with safety and health standards set forth under the act’ (Institute of Medicine 2001).

In addition to other mandates, the Occupational Health and Safety Act created two new government agencies: (1) the Occupational Health and Safety Administration (OSHA), which was charged with setting standards, issuing regulations and enforcing compliance through penalties, and (2) the National Institute of Occupational Safety and Health (NIOSH), which was charged with conducting scientific research into worker safety. The creation of dual agencies, one for regulation and one for research, provided a mechanism for scientific evidence to be gathered and fed directly to a policy-setting and enforcement body.

Specifically for TB, OSHA’s power to enforce protection of HCWs rested upon the ‘general-duty’ clause of the Occupational Health and Safety Act and also its general standards on respiratory protection (US Occupational Safety and Health Administration 1996b) and biological hazards (US Occupational Safety and Health Administration 1996c). Through the Act, OSHA could issue mandatory health standards, which, notably, are required to be based on ‘latest available scientific data in the field’ (US Congress 1970b). The highest court in the United States, the US Supreme Court, has noted the importance of epidemiologic evidence for this purpose (Institute of Medicine 2001).

In the mid-1970s, NIOSH became a part of the US Centers for Disease Control and Prevention (US CDC), the agency tasked with protecting the public health of the nation through scientific research, public health programmes and technical assistance. To address the issue of TB transmission in health care facilities, US CDC issued TB control guidelines in 1982 (US Centers for Disease Control 1982). Although evidence was well established regarding the risk of occupationally-acquired TB, little direct scientific evidence existed to support specific
interventions to prevent transmission; US CDC’s recommenda-
tions, therefore, were based mainly on expert consensus (US
Centers for Disease Control 1982; Garner and Simmons 1983).
Recommended control measures included use of medications,
masks, patient isolation and proper room ventilation. In
addition, US CDC recommended risk-based surveillance for TB
among HCWs routinely exposed to TB, adequate record keeping
of testing and treatment of latent TB infections (US Centers for
Disease Control 1982).

Policy process step: policy implementation
As a scientific agency, US CDC issues non-binding guidelines
about preventing TB transmission in health care facilities and
how to protect HCWs. Guidelines rely on data from TB outbreak
investigations, observational studies documenting declining TB
infections in HCWs and mathematical modelling. OSHA’s
regulations and standards, which cover all private employers
and national government employees, are largely based on the
guidelines issued by US CDC. OSHA enforces these regulations
and standards by inspecting employers for violations and
levying financial penalties for non-compliance.

For health care facilities at high TB risk, where incidence
of TB infection is higher than the general population, as defined
by US CDC guidelines (US Occupational Safety and Health
Administration 1996a), and where HCWs have direct exposure
to suspected or confirmed TB disease patients, OSHA requires
specific infection control and HCW protection measures. These
measures are classified as administrative controls, engineering
controls and personal protection. Under administrative controls,
facilities are required to implement US CDC’s protocol for early
TB patient identification, including symptom screening. HCWs
are required to have free initial and annual screening for TB
infection. HCWs who test positive for TB infection must be
given free evaluations for TB disease and free follow-up and
treatment evaluations. In all workers with active disease,
worker compensation must be provided for lost wages.

Training and education must be provided to HCWs on
TB infection control and prevention. Reporting of TB disease cases
to OSHA is mandated, and a system by which employees can
report violations to OSHA must also be present. Under
engineering controls, facilities must provide negative pressure
isolation rooms that are consistently used, maintained and
tested. Under personal protection, employers are required to
provide appropriate particulate respirators to employees and to
ensure that they fit correctly.

US CDC provides additional guidance to hospitals regarding
TB administrative controls beyond those enforced specifically
by OSHA. US CDC recommends preparing and implementing a TB
infection control plan, which includes an assessment of the risk
of encountering TB patients and evaluation of the plan’s
implementation. The guidelines also recommend that hospitals
work with local public health officials to report active TB cases
among HCWs and jointly investigate TB transmission from
HCWs diagnosed with active TB (Jensen et al. 2005).

The structure of the legal system and health care regulation in
the United States supported development of protections against
occupational TB. Because US CDC is the recognized scientific
authority on public health issues, health care facilities which
did not abide by US CDC guidelines were often more vulnerable
in court to injury claims (Institute of Medicine 2001). In
addition, other agencies began requiring stronger TB infection
control, including state licensure agencies and private organi-
izations that accredit hospitals, such as the Joint Commission.
Accreditation by the Joint Commission has been a particularly
powerful lever for change, because many health care payers
(including the state and federal government) will only pay for
services from institutions that are accredited. US policy towards
occupational health protection for HCWs was also implemented
concurrently with the development of a worker disability
system, in which employers are partially responsible for bearing
the costs of injured workers (MacLaury 1981).

Policy process step: policy evaluation
National reporting for TB disease began in 1953, even before
OSHA existed, and TB incidence trended downwards from that
time until the mid-1980s. While OSHA’s requirements might
have contributed to the decline, the advent of effective
chemotherapy, coupled with improved working conditions,
housing, nutrition and sanitation, likely played a substantial
role (Rieder et al. 1989).

Beginning in 1985, however, TB incidence increased dramat-
ically; by 1992, TB cases had increased 20% nationwide
(Reichman 1996). Multiple high-profile outbreaks occurred in
hospitals, affecting HCWs and patients, and some of the most
lethal involved MDR-TB strains and HIV-infected patients
(Edlin et al. 1992; US Centers for Disease Control and
Prevention 1993; Frieden et al. 1996). This resurgence has
been attributed to multiple factors, including a dissolution of
TB control infrastructure due to a change in Congressional
funding from specific TB control funds to block grants for
general public health, incomplete treatment of cases leading to
drug resistance, the emergence of HIV, an influx of immigrants
from high TB burden countries, and a rise in substance abuse,
homelessness and incarceration (Reichman 1996).

The resurgence of TB led to multiple evaluations of OSHA
regulations, US CDC TB guidelines and their implementation.
Evaluations in the late 1980s and early 1990s documented
widespread non-compliance with all classes—administrative,
engineering and personal protection—of TB infection control.
A survey from 1989 to 1992 of infection control practices in
hospitals demonstrated that, even after the release of updated
US CDC guidelines in 1990, only 56% of HCWs were tested for
TB infection, less than half used appropriate respirators and
only about 60% of hospitals had an isolation room that met US
CDC standards (Fridkin et al. 1995). A separate survey from
1989 to 1992 of over 3000 acute care hospitals across the United
States found similarly inadequate implementation of infection
control (Sinkowitz et al. 1996).

These evaluations provided the evidence needed for further
policy change, which became a cycle of policy evaluation and
revision that has been critical to implementation of
evidence-based TB infection control in the United States.
Although sparse direct evidence supported the specific infection
control interventions recommended in US CDC’s 1982 guide-
lines (US Centers for Disease Control 1982; Garner and
Simmons 1983), US CDC updated its guidelines in 1990 and
then again in 1994 as scientific evidence was gathered.
Concurrent with the development of scientific evidence, OSHA
issued a memorandum in 1993 that stated that it would issue citations and fines to health care facilities that did not follow appropriate respiratory protection standards (Jarvis et al. 1995). Studies from Atlanta, Miami and New York City (Institute of Medicine 2001) showed that implementation of US CDC-recommended infection control measures effectively controlled outbreaks and prevented TB transmission. Initial surveys of health care facilities in the early 1990s provided a baseline against which follow-up surveys in 1996 could demonstrate a significant increase in compliance with recommended TB infection control methods. Improved compliance correlated directly with reduced rates of TB infections in HCWs. For example, rates of new skin test conversions in one site dropped from 3.3% to 0.4% (Blumberg et al. 1995; Sotir et al. 1999). This and other evaluations of the 1994 guidelines provided evidence to support their effectiveness.

Further evidence supporting the effectiveness of these measures came from national surveillance data. In the late 1990s, the national surveillance system documented decreases in the number of TB cases occurring in HCWs. Ongoing declines in HCW TB cases documented through surveillance have led to further policy change. In a 2005 update to its guidelines, US CDC recommended decreasing the screening frequency for TB infection, because TB rates, obtained from an effective surveillance system for occupational TB in HCWs, have continually decreased in HCWs since the 1990s (Jensen et al. 2005).

Less attention has been given to decreasing the time to TB diagnosis. Since the mid-1990s, rapid molecular tests have been available. These tests can reduce the time to a confirmed TB diagnosis from 1–2 weeks to 1–2 days in many patients (US Centers for Disease Control and Prevention 2009b). National guidelines for clinical use of nucleic acid amplification (NAA) tests were disseminated in 1996 and 2000 after they were approved for use (US Centers for Disease Control and Prevention 1996; US Centers for Disease Control and Prevention 2000). These guidelines only supported adoption of NAA tests as one approach for diagnosis; recommendations for routine use on all suspected TB cases only occurred in 2009 (US Centers for Disease Control and Prevention 2009b). Rapid molecular tests that can also identify drug-resistant TB have also been developed and validated in many countries and even endorsed by WHO. These tests are now available for use in both economically advanced and developing countries, but none have been approved for use in the United States despite recognition of their public health importance (US Centers for Disease Control and Prevention 2009b).

China

Policy process step: problem identification

China first began to regulate occupational injuries in the 1950s through regulations to prevent workplace diseases such as silicosis (Lou and Zhou 1989). Over the past two decades, as the Chinese economy deepened its global links, the central government passed new labour laws to protect workers from occupational hazards and diseases (Liu and Fu 2006). These laws include the Labor Law of the People’s Republic of China (LLPRC) (National People’s Congress of China 1994), the Law of the People’s Republic of China on the Prevention and Control of Occupational Disease (LPRCPCOD) (National People’s Congress of China 2001), and the Law of the People’s Republic of China on Work Safety (LPRCWS) (National People’s Congress of China 2002). These laws provide general guidelines for worker safety and require certain employers to provide regular medical screenings for workers (Ronald C Brown, personal communication, 13 September 2010).

HCWs do not appear to be covered under these laws, due to ambiguity over what constitutes an occupational disease and which occupations are included in these laws. While worker protection is promulgated by labour laws, what defines an ‘occupational disease’ is defined by the MOH (Ministry of Health 2001). The MOH’s occupational disease catalogue does not include TB, which means that employers are not required to conduct occupational health screenings or regular medical checkups. In fact, the MOH classifies disease acquired by staff working in the hospital as a nosocomial infection (Ministry of Health 2001), a term usually used to refer to infections that occur in hospitalized patients as a complication of their direct medical care. Under current labour laws, the only potential coverage for HCWs would be work-related injury insurance. If such insurance is available to them, a HCW could receive limited benefits such as payment of medical expenses or partial disability, but only after injury has occurred (i.e. after active TB disease has already been diagnosed) (Ronald C Brown, personal communication, 13 September 2010).

China’s labour law specifically ‘doesn’t cover all occupations’ (National People’s Congress of China 2002). LPRCWS specifically states that occupational safety and health protections extend only to ‘work safety in units that are engaged in production and business activities’. LLRC and LPRCPCOD both mandate regular health examinations for workers exposed to occupational hazards or diseases, but there is no separate requirement for HCWs or mention of examination frequency (e.g. annual TB examinations). In short, gaps in the scope of China’s labour laws mean that HCWs are not legally protected against acquiring infections, such as TB, during their work, and are not obligated to receive routine TB testing and treatment.

China has greatly increased TB detection and treatment rates in the past decade (WHO 2010a). Few studies in China, however, have been conducted to determine the incidence of TB in HCWs. In 2010, WHO began asking countries to report, for the first time, the number of HCWs diagnosed with TB. For 2009, China reported 2833 cases of TB in health care workers, but it is not clear how complete these data are. The government does conduct a country-wide survey every 10 years to assess the prevalence of TB in the general population, but while the survey does record data about occupation, this information has not been published.

Research that has been performed has been conducted in a few specialty hospitals in two provinces. Despite their limited scope, the results from these studies suggest that the TB burden is high among HCWs. A retrospective survey of 4429 employees of TB hospitals in Henan found a TB disease rate in HCWs with patient contact almost three times that in HCWs without patient contact (Wang 2007). Another study in a separate TB hospital in Henan found that HCWs had a TB disease rate four times greater than other residents in the province (Zhu and Zhang 1994). A third study found that TB infection control measures in TB centres in Henan were inadequate and also that...
increased exposure to TB patients increased HCW TB infection and disease rates (He et al. 2010). One small study in Shandong, in contrast, reported that only 19% of 98 clinical staff from one hospital had a positive tuberculin skin test (TST); no comparison group was available, and this is far below the national average (Zhao 2004). Based on our searches, however, there do not appear to be nationally representative data about the incidence of TB infection and disease among Chinese HCWs. Representative data are important, because local conditions, such as prevalence of HIV infection, can substantially affect the TB rate. Three of the four studies are from Henan where an epidemic of HIV, which is the strongest risk factor for TB disease, occurred due to plasma donation in the 1990s (Dou et al. 2010).

Several papers in medical journals have highlighted the problem and called for changes to regulations and guidelines. Zhu recommended annual testing, better surveillance of upper respiratory tract infections and increased use of personal protective equipment among HCWs (Zhu and Zhang 1994). Other studies, such as the one conducted by Zhang, have advocated for increased HCW training to improve hospital infection control practices (Zhang 2008).

Based on a review of internet blog and forum postings, we found that there is substantial concern among HCWs and their families about the occupational risk of TB. A large number of forum postings by nurses and doctors queried whether contracting TB at work qualifies as an occupational injury and therefore qualifies them for compensation. Many HCWs who posted in forums like Zhida (‘to know’) on Baidu.com (China’s largest online search engine) were also unaware that TB medicine is free at local government dispensaries. While there is clearly bias in who accesses the internet and who posts on forum sites, dozens of postings on frequently-trafficked forums like Wenwen (wenwen.soso.com), suggest that many HCWs are concerned about occupational TB and its consequences. A search of legal databases found no lawsuits in which HCWs sued hospitals for compensation for occupational TB. However, many labour-related disputes are settled through mediation or are settled privately (Ministry of Labor and Social Security 2009).

**Policy process step: policy adoption and formation**

The Chinese health system can effectively reduce transmission of infections in hospitals when there is political commitment. In 2003, enhanced infection control procedures likely helped contain the severe acute respiratory syndrome (SARS) epidemic in China (Li et al. 2003). From the perspective of TB control, the MOH recently incorporated HCW protection into its TB control and implementation guidelines. While the 2002 and 2005 national TB control guidelines do not mention measures for HCW protection (Ministry of Health 2004), the 2008 guidelines recommend improved hospital infection control management (including risk assessment, planning, prevention and education), attention to environmental factors (such as natural ventilation, forced ventilation and disinfection) and standard personal protection measures (especially masks) (Ministry of Health 2008). The guidelines recommend specialized respirator masks, including NIOSH-approved N95 masks, but state that due to their high cost, providing these masks for all HCWs may be infeasible for some facilities.

It is unclear what evidence from China supports these recommendations. Although some recommendations are clearly in line with international practice, none of the guidelines provide any reference to scientific studies conducted in China or other countries to support them. Although not stated explicitly, the recommendations stem from the opinions of an expert panel convened to write the guidelines. From our review of the published literature, no data from China exists to describe the effectiveness of various recommended prevention measures. Even if we assume that internationally accepted TB infection control guidelines are applicable in China, some recommendations in the Chinese documents contradict current scientific evidence. For example, the guidelines recommend sterilization of surfaces and fumigation of rooms to reduce the risk of TB transmission, but the accumulated scientific evidence demonstrates that TB cannot be transmitted once on surfaces (Jensen et al. 2005). Although the MOH has direct authority over hospitals, these guidelines are not regulatory requirements and lack important details, such as how hospitals should conduct risk assessment, implementation, monitoring and reporting. The guidelines also do not identify which institutions are responsible for enforcing these policies and what penalties, if any, are imposed for non-compliance.

China’s MOH has also recently adopted some additional standards for infection control in hospitals. The 2009 ‘Standard for Techniques for Isolation in Hospitals’ (Ministry of Health 2009a) specifically recommends ‘isolation and precaution’ for TB cases, which is defined as use of a respirator, cap and gloves by HCWs and placement of TB patients in isolation rooms. The specific standards for TB isolation rooms are not clearly defined, although the document does separately recommend the use of negative pressure isolation rooms in patients with airborne infectious diseases, which presumably includes TB. The 2009 ‘Standards for Nosocomial Infection Surveillance’ (Ministry of Health 2009b) also explicitly mention TB as one of several infectious diseases for which hospitals should conduct surveillance. However, hospitals are only required to report outbreaks of 10 or more TB cases. These standards give significant discretion to hospitals about how to develop and conduct surveillance and to local government agencies to supervise them.

In 2010, a separate entity, China CDC, published a new infection control manual that includes in-depth HCW protection guidelines. This manual was developed in collaboration with experts drawn from the Chinese medical community, in consultation with the WHO and US CDC. The manual includes detailed recommendations for organizational management systems, administrative controls, engineering controls, personal protection and education, including specific information about best practices for HCWs, which previous guidelines lacked. The recommendations appear to be more aligned with current international practices. Similar to the MOH guidelines from 2008, however, none are based on data from China, and no data from other countries are referenced. Certain long-held beliefs, which are contrary to current scientific evidence, still persist, such as use of ultraviolet germicidal irradiation (UVGI) for room surface disinfection, when no patients are in the room, as opposed to using UVGI to kill TB circulating in droplet nuclei in the air while patients are in the room. In addition, because
the recommendations are promulgated by China CDC, which has no direct authority over hospitals and is not clearly recognized in China as the expert technical agency for medical services, this manual likely has less authority than the 2008 MOH guidelines.

**Policy process step: policy implementation**

Based on our searches, only two studies in China have been published to document how health care facilities implement TB infection control practices. A cross-sectional study from Henan demonstrated that implementation of TB infection control and reporting of TB cases are both fragmented, due to the wide discretion enjoyed by Chinese hospitals and local agencies (He et al. 2010). However, the study was limited because no systematic method was used to ensure all current TB infection control guidelines and standards were followed, and only a small subset of TB control practices were examined. A second study examined four health care facilities in Inner Mongolia, which found varied implementation of all infection control measures, including administrative controls, engineering controls and personal protection (Weimin Zhang et al. 2011). Although the restricted scope of the study limits interpretation of its results, its results were consistent with the Henan study.

Our visits to hospitals in multiple provinces and discussions with HCWs confirm that implementation of HCW screening for TB is highly variable. For example, although HCWs report that their jobs are supposed to offer them annual screening for TB, some HCWs report that this rarely happens every year. If screening does occur, results are usually kept by individual workers instead of by the employer, especially in smaller hospitals. Negative results are frequently not recorded. Moreover, these records are usually not systematically reported to the national TB programme or to occupational health authorities.

Our observations and discussions with Chinese health officials confirm that few hospitalized TB patients (including those with MDR-TB) are kept in appropriate isolation, few HCWs routinely wear personal respirators when evaluating patients for TB, and only some facilities have modern engineering controls for ventilation or upper room UVE. Our reliance on non-systematic observations and anecdotes, and the existence of only two limited studies of TB infection control practices, highlights one of the major gaps in policy implementation: the need for routine, nationally-representative surveys of health care facilities to measure compliance with all administrative, environmental and personal protection controls. Without large, representative surveys about current facility practices, it is difficult to determine whether the 2008 MOH guidelines or the recommendations in China CDC's 2010 infection control manual are feasible.

There is evidence that some local health agencies have promoted the MOH’s ‘Standards for Nosocomial Infection Surveillance’. Based upon an internet search of government websites, at least 112 sub-national governments have promoted the national standards on their websites in a wide range of locations, from the relatively wealthy Jiangsu province (gross domestic product (GDP) 3.4 trillion yuan, 2009) to the comparatively poor Shaanxi province (GDP 0.8 trillion yuan, 2009) (People's Daily Online 2010). Additionally, some have adopted new reporting practices based on the standards, including one agency in Qingdao that has made implementation of the nosocomial infection standards 25 out of 100 points in a June 2010 inspection of local hospitals (Qingdao Bureau of Public Health 2010). Nevertheless, no incentives exist for agencies to accurately report the status of implementation or cases of HCW TB.

**Policy process step: policy evaluation**

To our knowledge, the government and other stakeholders have not systematically evaluated existing HCW occupational safety policies or the newly proposed TB infection control policies. Although one-time studies have been published from selected health facilities about TB infection rates, no studies have evaluated TB rates in HCWs over time, which is necessary to provide data to evaluate the effectiveness of TB infection control policies.

**Discussion**

In the United States, policy makers were slow to recognize the problem of TB in HCWs. Consensus among experts was reached only after several decades, and only after overwhelming scientific evidence was collected. Once the risk and consequences of occupational TB were well documented, strong regulations were implemented nationally. These included establishment of a research entity to provide scientific evidence and a regulatory agency to mandate and monitor compliance. Minimal direct evidence for specific TB infection control measures was initially available (Garner and Simmons 1983), requiring the first national guidelines to rely primarily on expert opinion (US Centers for Disease Control 1982). The emergence of drug-resistant TB strains and HIV, combined with poor hospital TB infection control practices, led the government to implement stricter infection control, collect scientific evidence in the late 1990s to demonstrate effectiveness of these measures, and begin cycles of policy evaluation and revision to incorporate the latest evidence. The dramatic decline in HCW TB rates that followed could not have occurred without regulation, which included systematic inspections for compliance, and consistent, substantial, expected and timely penalties for non-compliance. Regulation was implemented through both a government regulatory agency and industry surrogates, such as the Joint Commission.

The evolution of TB control policies and practices in the United States holds important lessons for the current situation in China. Similar to the United States before the 1990s, existing infection control policies in China are based on expert opinion with little supporting evidence from studies done locally, and such policies do not appear to be consistently enforced. China's challenge for infection control in the 2010s is much greater than the one that the United States faced 20 years ago. The estimated incidence of TB and MDR-TB is more than 10 times greater in China today than it was in the United States in 1993 at the peak of the US TB resurgence. China is also much larger, with huge disparities in economic development and in the quality and quantity of health care. Infection control techniques required a long period of development in the United States and have proven to be effective. If these methods are implemented rapidly and effectively in China, the road leading to control of
TB among HCWs has the potential to be much shorter. Based on the US experience, we recommend that Chinese public health officials embark on a multi-pronged strategy that includes baseline data collection, regulatory reforms, a cycle of policy evaluation and revision, and rapid detection of unsuspected TB cases.

The first major need in China is to obtain high quality data about the current state of TB infection control. We recommend that studies be conducted to reliably measure the incidence of TB infection and disease among HCWs, ideally from a sample of facilities that is sufficiently representative to account for variances in epidemiology, economic development, climate and facility resources. Such studies would also collect data about specific facilities, including their policies and practices related to infection control. An entity within the MOH, such as the Department of Nursing and Infection Control, will need to be sufficiently funded and empowered to promulgate policies, conduct frequent inspections at all levels of the health system and impose penalties for non-compliance. Adding TB to the list of occupational diseases has the potential to motivate private stakeholders and associations, as well as other government authorities, to direct resources and attention to TB infection control. The actual policies themselves would also benefit from further refinement, such as inclusion of details about minimum requirements for health facilities at all levels, and specific indicators that should be measured in all facilities to ensure compliance.

The third major need is for ongoing surveillance and policy evaluation and revision. There are large opportunity costs to developing and implementing flawed policies. Surveillance and policy evaluations completed before, during and after policy formation help ensure that policies can be practically implemented—a particular concern given China’s size and economic diversity—and that policies are effective. Documenting that government policies are actually working can create a virtuous cycle in which actual implementation of those policies increases. Ongoing data collection about TB in health care facilities—plans that might necessitate symptom-based screening and testing of all patients entering health care facilities—can provide important insights into which facilities and which health care practices increase the risk of TB transmission within Chinese health care facilities. An added benefit to data collection is that it is likely to stimulate interest among HCWs in their risk of TB, potentially increasing demand for better hospital practices. China has seen a recent surge in factory workers’ demands for better pay and working conditions, presumably associated with their awareness of how much wealth is being generated by their work. It is conceivable that greater awareness of the occupational risks associated with hospital work could mobilize HCWs also to demand greater attention to TB infection control.

The second major need is to revise China’s regulatory framework for infection control. An entity within the MOH, such as the Department of Nursing and Infection Control, will need to be sufficiently funded and empowered to promulgate policies, conduct frequent inspections at all levels of the health system and impose penalties for non-compliance. Adding TB to the list of occupational diseases has the potential to motivate private stakeholders and associations, as well as other government authorities, to direct resources and attention to TB infection control. The actual policies themselves would also benefit from further refinement, such as inclusion of details about minimum requirements for health facilities at all levels, and specific indicators that should be measured in all facilities to ensure compliance.

The fourth major need is to build routine institutional surveillance for TB combined with validated molecular methods for rapid diagnosis and treatment of TB and drug-resistant TB. Given China’s high burden of TB and the urgent need to actively find TB cases, local TB risk assessments should be conducted to develop relevant infection control plans for health care facilities—plans that might necessitate symptom-based screening and testing of all patients entering health care facilities. By capturing cases of unsuspected TB and decreasing time to diagnosis of MDR-TB, China can implement a comprehensive infection control system in health care facilities that not only stops transmission but also decreases the sources of exposure to TB.

Conclusion

As the world’s two largest economies, China and the United States both have substantial public health and economic interests in controlling occupational TB in HCWs. By developing high quality data on the current state of HCW TB burden and TB infection control in health care facilities, China can better quantify the problem and identify the risk factors for occupational TB. By refining policies to include specific measurable indicators for compliance and adding TB to the list of occupational diseases, China can strengthen the content of its infection control policies to prevent occupational TB. By designing a sufficiently funded and empowered entity in the MOH to promulgate policies, conduct inspections and impose penalties, China can then effectively implement the strengthened policies. By conducting ongoing surveillance for TB, routinely analysing surveillance data and using these analyses to evaluate and revise policy, China can then develop effective evidence-based policies. By building institutional screening for TB and taking advantage of rapid diagnostic technologies, China can build an infection control system that also decreases sources of TB exposure. Although its burden of TB is substantially greater, China can develop a strong comprehensive strategy for reducing TB transmission in hospitals and ensuring the health of its health care workforce for the future.

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Conflict of interest

None declared.
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