

Tuberculosis: Current Situation, Challenges and Overview of its Control Programs in India

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ABSTRACT

Tuberculosis (TB) is one of the most ancient diseases of mankind, with molecular evidence going back to over 17,000 years. In spite of newer modalities for diagnosis and treatment of TB, unfortunately, people are still suffering, and worldwide it is among the top 10 killer infectious diseases, second only to HIV. According to World Health Organization (WHO), TB is a worldwide pandemic. It is a leading cause of death among HIV-infected people. In India, historically speaking, fight against TB can be broadly classified into three periods: early period, before the discoveries of x-ray and chemotherapy; post-independence period, during which nationwide TB control programs were initiated and implemented; and the current period, during which the ongoing WHO-assisted TB control program is in place. Today, India's DOTS (directly observed treatment-short course) program is the fastest-expanding and the largest program in the world in terms of patients initiated on treatment; and the second largest, in terms of population coverage. Major challenges to control TB in India include poor primary health-care infrastructure in rural areas of many states; unregulated private health care leading to widespread irrational use of first-line and second-line anti-TB drugs; spreading HIV infection; lack of political will; and, above all, corrupt administration. Multidrug-resistant TB (MDR-TB) is another emerging threat to TB eradication and is a result of deficient or deteriorating TB control program. WHO with its "STOP TB" strategy has given a vision to eliminate TB as a public health problem from the face of this earth by 2050. For this review article, data available at the official websites of WHO; and from the Ministry of Health, Government of India, were consulted, and search engines PubMed® and Google Scholar® were used.

Key words: Bovine TB, DOTS (directly observed treatment-short course), HIV/TB, Multidrug-resistant TB, RNTCP (revised national TB control program), Short course chemotherapy (SCC), TB control program in India, The "Stop TB" strategy, Treatment of TB, Tuberculosis, Zoonosis

INTRODUCTION

Tuberculosis (TB) is one of the most ancient diseases of mankind and has co-evolved with humans for many thousands of years or perhaps for several million years.^[1] The oldest known molecular evidence of TB was detected in a fossil of an extinct bison (Pleistocene bison), which was radiocarbon dated at $17,870 \pm 230$ years^[2]; and in 9000, year old human remains which were recovered from a neolithic settlement in the Eastern Mediterranean.^[3] Although as early as 1689, it was established by Dr. Richard Morton that the pulmonary form was associated with "tubercles," due to the variety of its symptoms, TB was not identified as a single disease until the 1820s and was eventually named

"tuberculosis" in 1839 by J. L. Schönlein.^[4] In 1882, the bacillus causing tuberculosis, *Mycobacterium tuberculosis*, was discovered by Robert Koch; and for this discovery, he was awarded Nobel prize in physiology or medicine in 1905.^[5] Tuberculosis is caused by a group of closely related bacterial species termed *Mycobacterium tuberculosis* complex. Today the principal cause of human tuberculosis is *Mycobacterium tuberculosis*. Other members of the *M. tuberculosis* complex that can cause tuberculosis include *M. bovis*, *M. microti* and *M. africanum*. *M. microti* is not known to cause TB in humans; infection with *M. africanum* is very rare, while *M. bovis* has a wider host range and is the main cause of tuberculosis in other animal species. Humans become infected by *M. bovis*, usually via milk, milk products or meat from an infected animal.^[6,7] It is estimated that in the pre-antibiotic era, *M. bovis* was responsible for about 6% of tuberculosis deaths in humans.^[8,9]

In spite of newer modalities for diagnosis and treatment

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of TB, unfortunately, millions of people are still suffering and dying from this disease. TB is one of the top three infectious killing diseases in the world: HIV/AIDS kills 3 million people each year, TB kills 2 million and malaria kills 1 million.^[10] Even though tubercle bacilli was identified nearly 130 years ago, a definitive understanding of pathogenesis of this disease is still deficient.^[11,12] Although it can affect people of any age, individuals with weakened immune systems, e.g., with HIV infection, are at increased risk. Since the immune system in healthy people walls off the causative bacteria, TB infection in healthy people is often asymptomatic. This bacterium lives and multiplies in the macrophages, thus avoiding the natural defense system in the patient's serum. Infection with TB can result in two stages: asymptomatic latent tuberculosis infection (LTBI) or tuberculosis disease. If left untreated, the mortality rate with this disease is over 50%. For this review article, data available at the official websites of world health organization (WHO); from the Ministry of Health, Government of India; through PubMed central and Google scholar® search engines were extensively consulted.

GLOBAL SCENARIO

According to WHO, TB is a worldwide pandemic. Among the 15 countries with the highest estimated TB incidence rates, 13 are in Africa, while half of all new cases are in six Asian countries, viz., Bangladesh, China, India, Indonesia, Pakistan and Philippines. A WHO fact sheet dated March 2010^[10] on tuberculosis stated that overall one third of the world's population (over 2 billion) is currently infected with the TB bacillus. According to it, every second, someone in the world is newly infected with TB bacilli and 1 in every 10 of these newly infected people will become sick or infectious later in life. Since concurrent infection with HIV weakens the immune system, people with co-infection of HIV and TB are much more likely to develop TB; it is a leading cause of death among HIV-positive people. In Africa, HIV is the single most important factor contributing to the increase in the incidence of TB since 1990. The same fact sheet^[10] stated that in 2008, globally speaking, there were 9.37 million new cases of TB, with the African region and the Southeast Asian region (SEAR) having a share of 30% and 34%, respectively. However, the estimated incidence rate in Sub-Saharan Africa is nearly twice that in the SEAR with over 350 cases per 100,000 individuals of the human population. In the same year 2008, an estimated 1.3 million people died from TB. The highest number of deaths was in SEAR, while the highest mortality per capita was in the African region. The global community woke up to this disease when, in 1993, WHO declared TB as a global

emergency. It was estimated that by 2004, the world as a whole would have achieved the Millennium Development Goal (MDG) of halting and reversing the incidence to half of its 1990's prevalence and mortality rate. Now the revised time limit to achieve that MDG is by 2015.^[13]

Directly observed treatment-short course (DOTS) is an internationally recognized strategy for delivering the basics of TB case-finding and cure. It is not simply a clinical approach to patients, but rather a management strategy for public health systems, including political commitment, case-detection through quality-assured bacteriology, short-course chemotherapy, ensuring patient adherence to treatment, adequate drug supply and sound reporting and recording systems.^[13] Worldwide, between 1995 and 2008, a cumulative total of 36 million TB patients were successfully treated in DOTS programs, and up to 6 million deaths were averted. The treatment success rate (~86%) achieved in DOTS cohorts worldwide exceeded the global target of 85% for the first time in 2007.^[13]

The southeast asian region (SEAR) of the WHO is critically important from the global perspective. It is home to 25% of the world human population; and with 30% of the world's poor living in this region, it suffers from high burdens of communicable and noncommunicable diseases, against a background of relatively poor health infrastructure. Progress in global health will not be possible without visible progress in this region. Six of the 14 million deaths in this region are caused by communicable diseases, which in turn result in 42% of all the disability-adjusted life years lost.^[14,15]

About 3.6 million persons are estimated to be living with HIV/ AIDS in SEAR. This region is distinguished by a complex, heterogeneous HIV epidemic at different stages, both within countries and across the region. For example, approximately two thirds of the estimated HIV burden in India is in the six states in the south and northeast, which make up only one third of the country's population. In the four states in southern India, the HIV prevalence appears to be slowly decreasing. In Indonesia, where the overall prevalence of HIV is low, three provinces have been reported to have much higher rates of HIV. In other countries, such as Bangladesh and Nepal, increasing HIV prevalence among high-risk groups, such as intravenous drug users (IDUs), has raised concerns about the potential risk of a generalized HIV epidemic in these countries.^[15]

INDIAN SCENARIO

In India, TB has been mentioned in the *Vedas* and the old *Ayurvedic* scriptures. Historically speaking, fight against TB

in India can be broadly classified into three periods: early period, before the discoveries of x-ray and chemotherapy; post-independence period, during which nationwide TB control programs were initiated and implemented; and the current period, during which the ongoing WHO-assisted TB control program is in place.

Early period of TB control

It was marked with non-availability of any chemotherapeutic agents, absence of diagnostic x-ray facilities and lack of any TB control program. This period lasted around middle of the 20th century. During this period, as no drug or treatments with combinations of drugs were available/effective against TB, a sanatorium movement originated in Europe and quickly spread worldwide. Popular rationale for sanatoria was that a regimen of rest, good nutrition, open fresh air and high altitude offered the best chance that the sufferer's immune system would "wall off" pockets of pulmonary tuberculosis (TB) infection. In 1863, for the treatment of tuberculosis, Hermann Brehmer opened the world's first sanatorium named *Brehmerschen Heilanstalt für Lungenkranke* in the city of Görbersdorf (Sokolowsko), Silesia (now Poland).^[15]

In India, the first open air sanatorium for treatment and isolation of TB patients was founded in 1906 in Tiluana, near Ajmer city of Rajasthan, followed by the first TB dispensary in Bombay in 1917.^[16] By 1925, chest radiology started playing diagnostic role in detecting deep-seated areas of TB consolidation. By 1945, the capability of this apparatus was enhanced to embody the MMR (mass miniature radiography) version. The first genuine success against TB was in immunizing against tuberculosis. Developed from attenuated bovine strain of tuberculosis by Albert Calmette and Camille Guerin in 1906 was BCG (bacillus of Calmette and Guerin); it was first used on humans in France on July 18, 1921. In 1948, with support from WHO and UNICEF, a BCG vaccine production center in Guindy, Madras (now Chennai), was set up. In 1951, India started a mass BCG campaign to control TB. This was the first nationwide campaign against TB^[17]; and for the first time in the history of India, message of health and prevention of disease was taken to the remotest parts of the country.

Post-independence initial nationwide TB control programs

This period can be conveniently subdivided into the following two phases:

District TB program

In 1961, District Tuberculosis Program was prepared by the Indian government, and Anantapur district in Andhra Pradesh state was the first model district TB center (DTC). This program was aimed at integration of TB control schemes with the existing government health services to reduce the TB problem in the community as economically as possible.^[18] Shortly after establishing the Anantapur DTC, it became evident that although case-finding could be done at any place without difficulty, the major problem in the fight against TB was that of keeping the patients on continuous treatment until cure was achieved.^[19] Using this district TB center model, in 1962, the Indian government launched the National TB Control Program (NTCP).

Era of short-course chemotherapy

In the middle of the 20th century, around the time India gained independence in 1947, effective drugs against TB started becoming available (Streptomycin: 1944, PAS: 1946, Thiacetazone: 1950, Isoniazid: 1952 and Rifampicin: 1966).^[20] In 1956, under the auspices of the Indian Council of Medical Research (ICMR), the government of Chennai state, the WHO and the British Medical Research Council (BMRC), the Indian government established the Tuberculosis Research Center (TRC) in Chennai. This center provided information on the mass domiciliary application of chemotherapy in the treatment of pulmonary TB. In 1959, National Tuberculosis Institute (NTI) was established at Bangalore to evolve, through research, a practicable TB program that could be applied in all parts of the country by training medical and paramedical workers to efficiently apply proven methods in rural and urban areas.^[21]

Chemotherapy for TB underwent revolutionary changes in the seventies owing to the availability of two well-tolerated and highly effective drugs, Rifampicin and Pyrazinamide. These drugs allowed short-course chemotherapy (SCC) and made it possible to simplify treatment and reduce its duration. Discovery of Rifampicin in 1967 is considered to be one of the greatest achievements in the history of development of anti-TB drugs. Since its discovery, no new drug has been discovered yet that is as efficacious as Rifampicin against TB.

Current WHO-assisted ongoing TB control program

In 1992, Government of India, together with the WHO and the Swedish International Development Agency (SIDA), reviewed the national program and concluded that it suffered from managerial weaknesses, inadequate funding, over-reliance on x-ray, nonstandard treatment regimens,

low rates of treatment compliance and completion and lack of systematic information on treatment outcomes.^[22] Around the same time, in 1993, WHO declared TB to be a global emergency and devised the DOTS strategy and recommended that all countries adopt this strategy. This strategy was built on five pillars, viz., political commitment and continued funding for TB control programs, diagnosis by sputum smear examinations, uninterrupted supply of high-quality anti-TB drugs, drug intake under direct observation and accurate reporting and recording of all registered cases.

World Bank acknowledged that the DOTS strategy was the most economical health intervention and agreed to provide credit assistance for the NTCP, initially for the coverage of a population of 271 million persons, which was later revised to cover a population of 730 million persons. Presently, other bilateral and multilateral agencies, Danish International Development Agency (DANIDA), Department for International Development (DFID), US Agency for International Development (USAID), Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria (GFATM), Global Drug Facility (GDF) and WHO are providing invaluable support to the program. The Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria is the single biggest source of external funding for TB control.^[23]

To give new thrust and to revitalize the NTCP, with assistance from the above-mentioned international agencies, in 1997, the Revised National TB Control Program (RNTCP) was launched.^[24] It formulated and adopted the internationally recommended DOTS strategy, as the most systematic and cost-effective approach to revitalize the TB control program in India. Political and administrative commitment to ensure the provision of organized and comprehensive TB control services; reliable and early diagnosis through smear microscopy; an uninterrupted supply of good-quality anti-TB drugs; effective and patient-friendly treatment with short-course chemotherapy (SCC) given under direct observation; and accountability through proper reporting and recording and through effective supervision was heavily emphasized.^[25] Today, India's DOTS program is the fastest-expanding and the largest program in the world in terms of patients initiated on treatment; and the second largest, in terms of population coverage.

HIV AND TB

People who are HIV-positive and infected with TB are 20 to 40 times more likely to develop active TB than people not infected with HIV living in the same country.^[26] TB

is a leading cause of death in people with HIV infection, accounting for more than a quarter of the 2 million AIDS deaths in 2008; it is the commonest HIV-associated opportunistic disease in the world^[27]; it accelerates HIV disease progression, increasing infectivity and reducing HIV treatment efficacy.^[28,29]

In India, there were 2.5 million people living with HIV and AIDS (PLHIV) at the end of 2007, while the incidence of TB was approximately 1.8 million cases per year.^[30] The interaction between HIV and TB in persons co-infected with HIV and TB is bidirectional and synergistic. The level of immunosuppression determines clinical presentation of the resulting disease.^[31,32] Pulmonary involvement occurs in about 75% of all HIV/TB-infected patients.^[33,34] It was observed that the most frequent extra-pulmonary form of TB in HIV-positive people is that with involvement of the lymph nodes, with cervical region being the commonest.^[35] Co-infection of HIV and TB also results in more rapid development of MDR-TB.^[36,37]

A national policy to coordinate common activities for HIV/AIDS and TB has been formulated by the National AIDS Control Organization and the Central TB Division. TB and TB/HIV interventions are reciprocally included in the national policies of both programs.^[30] Among the 1.5 million TB cases reported under the national program in 2008, an estimated 73,720 cases were HIV-infected. Implementation of the revised "*national framework of joint TB/HIV collaborative activities*" began in early 2008, and interventions now cover the entire country. An "*intensified TB/HIV package*" initiated in 2008 is now being implemented in 11 states and in districts of other states with high HIV prevalence, covering a total population of over 400 million. Indian government plans to cover the entire country with the intensified package by 2012.^[21]

Current guidelines (National AIDS Control Organization, 2007) recommend that irrespective of HIV status of the patient, TB requires a minimum of 6 months of treatment — with 4 drugs (including Rifampin) in the intensive phase and 2 drugs in the continuation phase.^[30] Treatment consists of Isoniazid (INH), Rifampicin (RIF), Ethambutol (EMB) and Pyrazinamide (PYZ) for 2 months followed by INH and RIF for 4 months, given either daily or intermittently. It further classifies the currently available antiretroviral (ART) agents as follows: nucleoside reverse transcriptase inhibitors (NRTIs), non-nucleoside reverse transcriptase inhibitors (NNRTIs), protease inhibitors (PIs), integrase inhibitors, chemokine receptor antagonists and entry (fusion) inhibitors. A reduction by 80% in incident TB in HAART (highly active antiretroviral therapy)-treated

patients (treated with a combination of at least 3 ART drugs) was demonstrated as compared to ART-naïve HIV-infected persons in Brazil.^[38] Regimens recommended for use in India for HIV/TB patients are a combination of 2 NRTIs with Efavirenz or, less commonly, Nevirapine. The NRTI combinations used commonly are Zidovudine with Lamivudine; Stavudine with Lamivudine; Tenofovir with Lamivudine; and rarely “Abacavir with Lamivudine” or “Didanosine with Lamivudine.”^[30]

A commonly observed side effect of HAART is immune reconstitution inflammatory syndrome (IRIS), which is defined as transient worsening of existing symptoms, signs or radiographic manifestations or transient appearance of new symptoms, signs or radiographic manifestations after initiation of HAART. Tuberculosis is the most frequent pathogen associated with IRIS, of which, lymph node enlargement is the commonest manifestation. In one study, the incidence of IRIS in TB alone was 2%; with HIV co-infection, it was 7%; and in those started on HAART, it was 36%.^[39]

Surveillance for HIV infection among TB patients has been previously conducted in special surveys, and now relies upon routine reporting of HIV status of TB patients. Based on pilot-testing of decentralized delivery of co-trimoxazole preventive therapy (CPT) for HIV-infected TB patients in three high-HIV-prevalence districts of Andhra Pradesh, CPT for HIV-infected TB patients has been included in the national policies. PLHIV are eligible for free HIV care at a network of antiretroviral treatment (ART) centers. These centers are located in medical colleges, mainly staffed and operated by the State AIDS Control Societies, and a few are situated within the facilities of private or NGO partners. As of September 2009, 217 ART centers were operating in the country, in addition to ten Regional Centers of Excellence providing state-of-the-art services for PLHIV.^[30]

CURRENT CHALLENGES

Even today in India, two deaths occur every three minutes from TB. Major challenges to control TB in India include poor primary health-care infrastructure in rural areas of many states; unregulated private health care leading to widespread irrational use of first-line and second-line anti-TB drugs; spreading HIV infection; poverty; lack of political will; and, above all, corrupt administration. A collaborative effort is in progress between NTCP and National Rural Health Mission (NRHM), which is a reform initiative of which the goal is to improve primary health care in rural areas. In addition to this, NTCP has established several initiatives in coordination with the

private sector and the Indian Medical Association (IMA) to improve TB care.

Surprisingly, in India, people are still under the impression that TB is a disease of poor people, mostly of those living in slums. The rich and affluent persons need to know that their cooks/servants/drivers can be asymptomatic carriers of this deadly disease, right in their mansions, and hence they can potentially get infected with TB even without stepping into these slums. The consumption of unpasteurized milk or dairy products made from raw milk is another potential source of TB for humans, as there is ample evidence that bovine TB (*Mycobacterium bovis*) gets transmitted to humans.^[6,7]

MULTIDRUG-RESISTANT TUBERCULOSIS

M. tuberculosis strains that are resistant to the two most potent anti-TB drugs, viz., Isoniazid and Rifampicin, are termed as multidrug-resistant TB (MDR-TB) strains. Extensively drug-resistant TB (XDR-TB) is a form of TB caused by bacteria that are resistant to Isoniazid and Rifampicin (i.e., MDR-TB), as well as to any fluoroquinolone and any of the second-line anti-TB injectable drugs (amikacin, kanamycin or capreomycin). These forms of TB do not respond to the standard six-month treatment with first-line anti-TB drugs and can take up to two years or more to treat with drugs that are less potent, more toxic and much more expensive.^[40] Both MDR-TB and XDR-TB are the emerging threats to the success of anti-TB programs.

In the words of Sir John Crofton, whose pioneering work in the use of combination drug therapy for the treatment of tuberculosis has resulted in countless lives saved, “The greatest disaster that can happen to a patient with tuberculosis is that his organisms become resistant to two or more of the standard drugs. The development of drug resistance may be a tragedy not only for the patient himself but also for others, for he can infect other people with his drug-resistant organisms.”^[41]

Drug resistance may be broadly classified as primary and acquired. Drug resistance in a patient who has never received anti-TB treatment previously is termed as primary resistance. Acquired resistance is that which occurs as a result of specific previous treatment. WHO and the IUATLD have now replaced the term *primary resistance* with the term *drug resistance among new cases*; and *acquired resistance*, with the term *drug resistance among previously treated cases*.^[42,43] The emergence of drug resistance in TB patients is mostly a result of deficient or deteriorating TB control programs. Factors related to the development of drug resistance include the following: inadequate or inefficient

administration of effective treatment; poor case holding; use of substandard drugs; inadequate or irregular drug supply; ignorance of health care workers in the treatment and control of TB; interruption of chemotherapy due to side effects; non-adherence of patients to the prescribed regimens; availability of anti-TB drugs without prescription; illiteracy; low socioeconomic status of patients; massive bacillary load; laboratory delays in identification and susceptibility-testing of *M. tuberculosis* isolates; and the lack of the use of uniform laboratory methodology and quality control measures.^[44]

As per WHO guidelines,^[40,45] the current protocol for treatment of MDR-TB recommends standardized treatment regimen for empirical treatment in patients who have previously received only first-line TB drugs. The standardized regimen includes mixture of *essential* drugs — Streptomycin, Pyrazinamide, Ethambutol and Thioacetazone; and *second-line* drugs — Aminoglycosides (Kanamycin, Amikacin, capreomycin), Thioamides (Ethionamide, Prothionamide), Fluoroquinolones (Ofloxacin, Ciprofloxacin), Cycloserine/Terizidone and Para-aminosalicylic acid. Surgery should be considered for a patient with bacilli resistant, or probably resistant, to all except two or three relatively weak drugs. Unfortunately many such patients will have too extensive disease and/or too poor lung function for surgery to be possible. If the patient has a large localized cavity with little other disease, reasonable lung function and only two or three (weak) drugs available, surgery should be seriously considered.

Since current drug resistance data have a bearing on the design of the treatment regimens and policies, reliable information on these at the national level is both urgently and regularly needed. In the year 2005, 0.04% of the TB cases in India were diagnosed and reported as MDR-TB, which rose to 0.15% (~4 times) in the year 2007. Services to control MDR-TB are now available at designated sites in six states, with culture and DST facilities offered in five state-level laboratories. Weak laboratory capacity is a major barrier to scaling-up MDR-TB services. Collaborative TB/HIV activities have considerable scope for expansion. Government should ensure and promote rational use of anti-TB drugs outside the revised national TB control program.^[46]

Since available data from India cover only a small portion of this vast country, there is need for continuous surveying of drug resistance by a network of investigators in different regions of the country, by employing a common protocol, with an emphasis on quality control, which will serve as a useful parameter in the evaluation of current and past chemotherapy programs.

CONCLUSIONS

As is evident from the above discussion, we have come a long way in our fight against this deadly disease, but as the famous English poet Robert Frost said, “... *miles to go before I sleep*”, we still have miles to go before we will make this planet TB free. WHO with its “STOP TB” strategy has given a vision to eliminate TB as a public health problem from the face of this earth by 2050.^[46] In order to intensify our fight against this deadly disease, we need to further strengthen our surveillance programs to accurately estimate the burden of all kinds of TB (childhood, HIV/TB, MDR-TB). There is dire need to regulate the rational use of first- and second-line anti-TB drugs. They should absolutely not be sold as *over the counter* drugs. In India and in other developing countries, local governments should put in and encourage wholehearted efforts for local manufacturing of anti-TB drugs, thus resulting in more efficient monitoring of their manufacturing and quality control standards. Monitoring the quality of products available in the marketplace should involve identifying products that are defective because of poor manufacturing practices; deteriorated because of inadequate distribution and storage; and adulterated, tampered or counterfeit because of vested interests. Many studies have documented the circulation of counterfeit and substandard medicines, especially antimalarials, in developing countries.^[47-49] If counterfeit drugs belonging to this category are circulating in the markets, then there is every reason to assume that the counterfeit anti-TB drugs are also available in these markets.

Working association between physicians; private sector; religious bodies; and other local nonprofit organizations, e.g., Lions Club, Rotary International, should be strengthened for better dissemination of awareness about diagnosis, management and control of this disease. Existing diagnostic laboratories need to be strengthened with routine training/refresher courses for the involved personnel for better utilization of these already scarce resources. Better diagnostic tests for quick screening of this disease at field level should be developed and made available at the grass-root level. The links between primary health centers and DOTS centers should be strengthened, and special attention should be given to prioritizing the groups which need to be followed first; utilizing human resources of related public health programs, e.g., programs for HIV/malaria; promoting development of new drugs and vaccines against TB; and discouraging the use of homeopathy medicines for treating TB and HIV.^[50]

To eliminate the potential zoonotic sources of TB, pasteurization of milk before marketing and organized

goat/sheep abattoirs should be made mandatory under law; where milk samples and carcasses can be routinely tested/examined for TB; and the cause of TB possibly traced to the infected herds. Vaccination of our livestock against TB and routine screening of livestock (e.g., on a yearly basis at the farms and also at the animal fairs) should be made mandatory. Our fight against TB will be incomplete without considering this zoonotic aspect of this deadly disease.

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Sandhu: TB: Current situation and control programs in India

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