Public Policies for the Control of Zoonotic Tuberculosis

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ABSTRACT

Tuberculosis or TB is an infectious disease that has been rising rapidly in the world. Along with a rapid increase in regular TB cases zoonotic TB is also up surging. Several etiologic agents responsible for causing TB in animals have also been identified in human TB patients presenting strong evidence for laying the foundation of TB transmission through zoonosis. The more concerning portion is the lack and improper implementation of TB control policies made by local and international disease control bodies. Such situations have led to the emergence of increased TB prevalence while giving rise to antibiotic resistance among TB germs simultaneously.

Concerning zoonotic TB human-animal interaction in the case of pets and domestic animals is the only chance of direct contact for TB transmission and hence needs the application of proper hygiene measures for its control. Another possibility to come in contact with TB germs is by using unpasteurized milk products and being undercooked which may contain viable germs, leading to TB infection if consumed. Although the risk and load of TB through zoonosis have reduced a lot in economically developed regions after initiatives like the extermination of bovine termination programs middle and lower-income countries are still struggling to fend it off due to lack of awareness and resources. Still, there is a need for international health security institutes to collaborate with local governments to introduce changes in laws that can help in limiting TB transmission. This chapter focuses on different strategies that have been implemented on a larger scale as public policies to mitigate zoonotic tuberculosis and fruitful outcomes have been gained from them. The developing countries or the countries that are still fighting to eliminate tuberculosis must implement these policies on a national level to get rid of tuberculosis and set forth freedom from this malady.

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1. INTRODUCTION

We have seen an upsurge in the pace and frequency of the emergence and reemergence of infectious illnesses in recent decades (Morse et al. 2012). Zoonoses contribute to nearly 60% of all new infectious illnesses, demonstrating the importance of this aspect regarding the spread of diseases (Karesh et al. 2012). Human tuberculosis (TB) produced by Mycobacterium bovis, or zoonotic TB (zTB), is a specifically serious group of zoonosis. (Morse et al. 2012; Morand et al. 2014). In the past, zTB has widely been linked to extrapulmonary strains of TB infections and was believed to be typically contracted by consuming unpasteurized milk (Wedlock et al. 2002).

Humans infected with M. bovis showed signs of tuberculous cervical lymphadenitis in approximately 91% of patients and tuberculous meningitis in 28% of patients during the years 1901 to 1932 in Wales and England among children with less than 5 years of age (Grange and Yates 1994). Nevertheless, the extensive employment of pasteurization in milk over the twentieth century resulted in a significant decrease in its frequency in most regions of the world (de la Rua-Domenech 2006). This tells us how a small step of pasteurizing the milk can prevent such a notorious disease.

2. HISTORY

In the course of the past ten years, the World Health Organisation (WHO), World Organisation for Animal Health (OIE), and Food and Agriculture Organisation (FAO), have refocused their attention on zTB, listing it among the reappearing overlooked infectious diseases (WHO 2005; Maudlin et al. 2009; WHO 2014; El-Sayed et al. 2016). The expected number of fresh cases of zTB globally in 2016 was 147,000, with the majority occurring across Southeast Asia and Africa. (WHO 2017). These statistics, however, may have been underreported since the laboratory procedures for diagnosing zTB are not always available, particularly in countries with middle or low incomes (de la Rua-Domenech 2006; Olea-Popelka et al. 2017). This scenario guided the addition of zTB in WHO's End TB Strategy, which advocates for the early identification and treatment of all individuals with TB and represents one of the 17 Sustainable Development Goals established by the United Nations (United Nations General Assembly 2015; WHO 2017). Furthermore, zTB was featured for the very first time in the Stop TB Partnership's Global Plan to End TB 2016-2020—The Paradigm Shift (United Nations Office for Project Services 2015).

3. ETIOLOGICAL AGENT

Mycobacterium contains both obligatory infectious and saprophytic species in its genus. Approximately there are around 140 species, which have been divided into three major classifications: *Mycobacterium leprae* group, nontuberculous mycobacteria and *Mycobacterium tuberculosis* complex. The weakened strain of *M. bovis* utilised for the vaccine (bacille Calmette-Guérin, or BCG) and *M. bovis* itself, the causal agent of zTBvv and bovine TB (bTB) belong to the typical members of the *M. tuberculosis* complex. Other members include *Mycobacterium microti, Mycobacterium canettii, Mycobacterium caprae, Mycobacterium pinnipedii* and *Mycobacterium africanum* subtypes I and II (Smith et al. 2006; Wirth et al. 2008; Jagielski et al. 2014; El-Sayed et al. 2016). Throughout the past ten years, the following fresh variants of the complex have been outlined: *Mycobacterium orygis* (van Ingen et al. 2012), *Mycobacterium mungi* (Alexander et al. 2010), and chimpanzee bacillus (Coscolla et al. 2013).

4. TRANSMISSION

There are variable routes by which the transmission of *M. bovis* to humans can occur. When unpasteurized milk is consumed and the microbe enters the body through the digestive system, it can cause the extrapulmonary type of zTB. This is the primary method for passing on the infection to human beings, particularly in nations without enough coverage or hygienic milk regulations (de la Rua-Domenech 2006). Since *M. bovis* is less sensitive to the pH of cheese compared to other pathological agents (de la Rua-Domenech 2006), the production process of cheese derived from raw milk does not ensure that the bacterium would be rendered inactive. As a result, conditions are created that suggest this food may be a means of transmission, even to people living in cities (Silva et al. 2013). Both high-income nations like the United States (Kinde et al. 2007; Gould et al. 2014) and middle-income nations like Brazil and Mexico (Harris et al. 2007; Cezar et al. 2016) have shown evidence of *M. bovis* contamination in cheese It is noteworthy to mention that in many different countries, raw milk cheeses are significant and customary products of family agriculture (Kinde et al. 2007). Except when properly cooked, livestock meat from animals with zTB is not considered a means of transmitting *M. bovis* since the bacillus rarely exists in muscle (de la Rua-Domenech 2006). People contract pulmonary bTB from cattle when they inhale droplets carrying mycobacteria. This is known as airborne transmission (Wedlock et al. 2002; LoBue et al. 2010). The development of molecular tools has yielded a body of data suggesting human-to-human transmission through the air, which was not much addressed until recently (Fritsche et al. 2004; de la Rua-Domenech 2006; Olea-Popelka et al. 2017). Some research indicates that *M. bovis* may spread directly from person to person and from person to cattle (reverse zoonosis), proposing individuals may behave as infectious agents (Fritsche et al. 2004; de la Rua-Domenech 2006). The discovery that *M. bovis* can be isolated from human sputum suggests that it may be a source of disease, particularly in enclosed spaces. Presumably as a result of the greater number of research published in high-income nations, the majority of reports of *M. bovis* transmission between humans originate from these nations. Dissemination has also been documented between humans and non-bovine household animals (Shrikrishna et al. 2009; Ramdas et al. 2015). *M. bovis* can be transmitted naturally between wild and domesticated animals (de la Rua-Domenech 2006). Percutaneous infection through wounds and scratches in the skin during the processing of carcasses from mammals with bTB (Shrikrishna et al. 2009), especially among personnel who do not employ sufficient equipment and clothes to reduce the risk of infection (Sa'idu et al. 2015), is another probable route of transmission. The incidence of zTB epidemics ought to be brought to light. Multidrug-resistant *M. bovis* forms have been transmitted nosocomially by Spanish hospitals (Blázquez et al. 1997; Guerrero et al. 1997; Rivero et al. 2001) which then later extended to Canada, the Netherlands (Samper et al. 1997), and other areas according to many investigators. There have also been reports of further outbreaks in Scotland (Hughes et al. 2003), the United States (Nitta et al. 2002), and, lately, Mexico (Vazquez-Chacon et al. 2015).

5. CONTROL STRATEGIES FOCUSED ON ANIMALS

Tuberculosis in cattle is a worldwide disease. In countries with higher incomes, the prevalence of TB has significantly declined since the start of bTB extermination initiatives in cattle (Amanfu 2006). Following 27 years of continuous eradication programmes Australia finally proclaimed itself to be a TB-free region (More et al. 2015). But despite a well-established campaign to eradicate the disease, cattle herds affected by various routes of transmission with bTB are still being found in other well-off countries like the United States (McCluskey et al. 2014). High bTB loads in herds are reported by low- and middle-income nations in Asia, South America and Africa (Amanfu 2006). Research reveals that the frequency is 13% in Uganda, 17% in Chad, and 39.6% in Mozambique (Ayele et al. 2004; Moiane et al. 2014). Some of the elements that lead to the loss of management of animal TB include the unregulated movement of cattle, the absence of mechanisms for tracking animals, and the shortage or lack of access to veterinary care (Amanfu 2006).

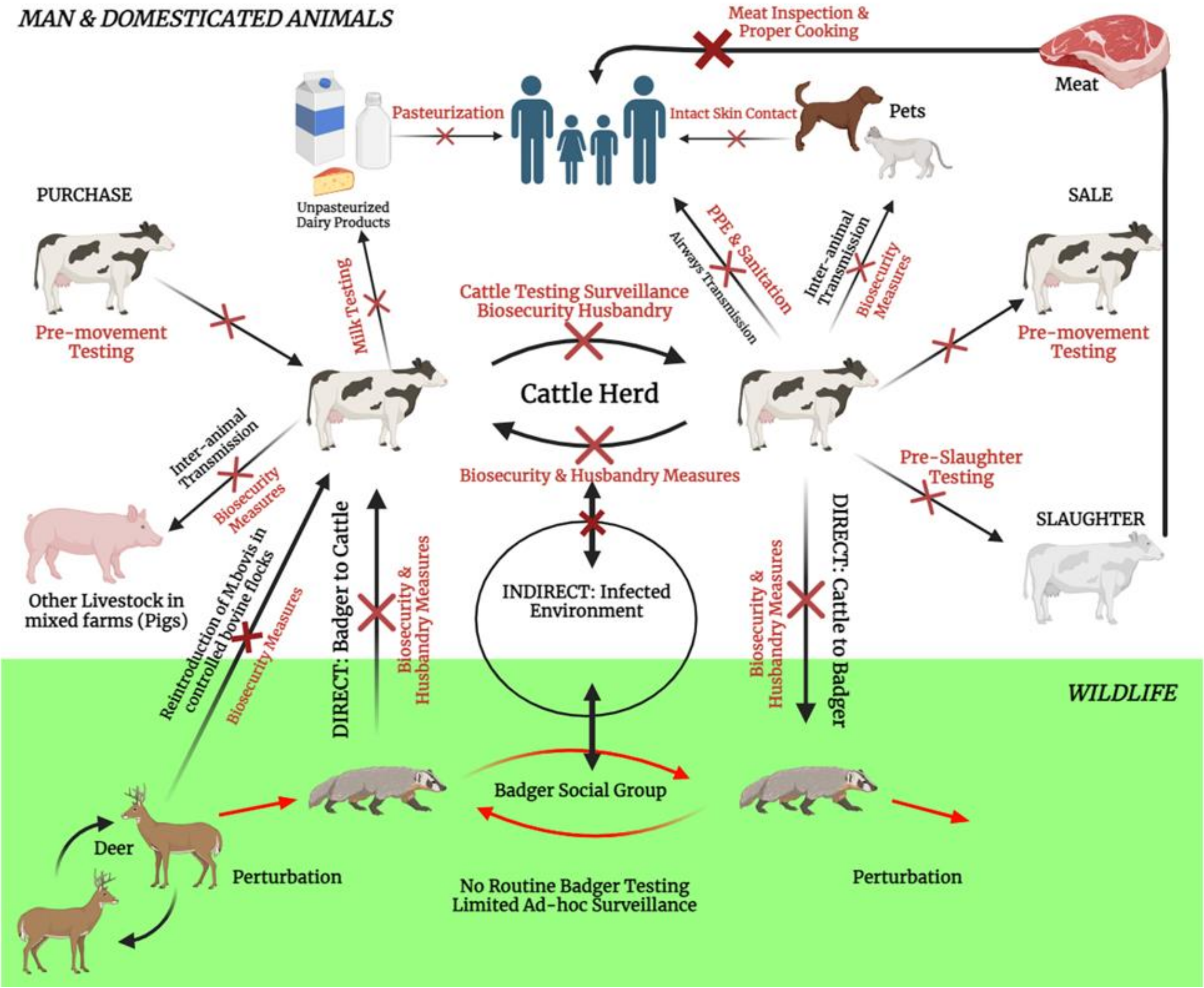

Fig. 1: Control Measures for Zoonotic Tuberculosis.

The risks imposed by this disease are affected a great deal by the management strategies implied to control it. Compared to beef cattle fed on pasture, dairy cows kept in confinement have a greater frequency of bTB. This research can be demonstrated by the longer lifespan of cattle intended for milk production and the fact that they are placed together for milking a minimum of one time a day, both of which are the elements that stimulate the growth of chronic illnesses like bTBPrograms to prevent bovine tuberculosis are often limited to domestic animals, which may limit their efficacy due to the potential for reintroduction of the disease through interaction with wild animals having *M. bovis* infections (Hlokwe et al. 2014).

Because wild animals can serve as significant reservoirs for *M. bovis* infections, prevention and control strategies should also be implemented for these infections (Fig. 1) (Musoke et al. 2015). It's crucial to remember that keeping wild or exotic animals in captivity, especially in wildlife parks and zoos encourages the spread of *M. bovis* and the potential for human transmission (Krajewska et al. 2015). Research carried out in South African parks has revealed that at least sixteen distinct wild animal species have been found to possess bTB (Hlokwe et al. 2014). Furthermore, there is a chance that animals that are shot or hunted for sport might carry the infection to people. According to some investigations on bTB in Spain, these animals had a five-fold greater incidence than cattle from the same area (Parra et al. 2006). Some writers support the production of vaccinations for wildlife as a preventative step against this particular group (Buddle et al. 2013).

6. CONTROL STRATEGIES FOR THE ENVIRONMENT

M. bovis, like other mycobacteria, is immune to changes in the environment and can survive in soil for a period of 88 days and in water for approximately up to 58 days. However, throughout the warmer months of the year, this bacterium's resistance is significantly decreased (Fine et al. 2011; Barbier et al. 2016). Because of the potential to spread to healthy animals, the infection's existence in surroundings can jeopardize bTB control initiatives while clarifying why the illness persists in herds (Fine et al. 2011). The research has linked bTB to several environmental factors, including agricultural practices, weather-related aspects, and landscape characteristics. By optimizing these characteristics on farms, bTB can be lessened and, as a result, transmission among humans can be reduced. For example, extensive usage of hedgerows (especially along borders), along with having scattered water sources, could serve as a control measure to reduce the probability of bTB transmission (Winkler and Mathews 2015; Broughan et al. 2016).

7. HUMAN-FOCUSED CONTROL STRATEGIES

When it comes to preventive measures that lessen the likelihood that the general public will become infected with *M. bovis*, scientists and the World Health Organization agree that pasteurizing milk is the most successful approach even when weighed against inspecting slaughterhouses and testing animals for tuberculin (Roug et al. 2014; Vranjeˇs et al. 2015). Observing the carcasses of livestock in slaughterhouses to make sure that their flesh is fit for consumption by humans is known as inspection. Thus, slaughtered animals that may be *M. bovis* infected must be disposed of appropriately, and more research should be done for verification of *M. bovis* infection (Fig. 2). Take tainted items out of the food chain and implement proactive measures to manage their animal source. Conversely, the purpose of the intradermal tuberculin test is to discover as many infected animals as possible, hence emphasizing the necessity of eliminating all positive patients (Pritchard DG 1998). In well-developed countries, the pasteurization of milk is a common practice (Müller et al. 2013).

The federal regulation in the United States for this goal was established at the start of the previous century. Nonetheless, 25 of the 50 states allow the sale of raw milk, mostly in the states along the West Coast and the central region. States that allow raw milk have seen a higher frequency of outbreaks associated with it; nevertheless, there is little data linking these outbreaks to zTB (Lejeune et al. 2009; Langer et al. 2012). As long as certain hygienic requirements are fulfilled, some European Union nations, including Wales, Germany, Northern Ireland, England, and France allow the sale of milk and dairy products unpasteurized (Vranjeˇs et al. 2015). Low- and middle-income nations face somewhat distinct circumstances. Small farmers in Brazil continue to sell unpasteurized milk despite the country's prohibition on the purchase of unpasteurized milk for consumption by humans and an initiative to enhance the nutritional value of milk production (Nero et al. 2004).

Pastoral communities and low-grade dairy farms mostly sell about 80-90% of the total milk produced in several African states where pasteurisation of milk is not a common practice (Müller et al. 2013; Jans et al. 2017). In areas like Tanzania, approximately only 39% of the population has been reported to use boiling milk whereas approximately 90% of livestock farmers drink milk daily (Roug et al. 2014). In addition to that, in several well-developed countries like Belgium and America using less-processed dairy goods has become a trend and there is a frequent use of raw milk followed by the misconception that boiling the

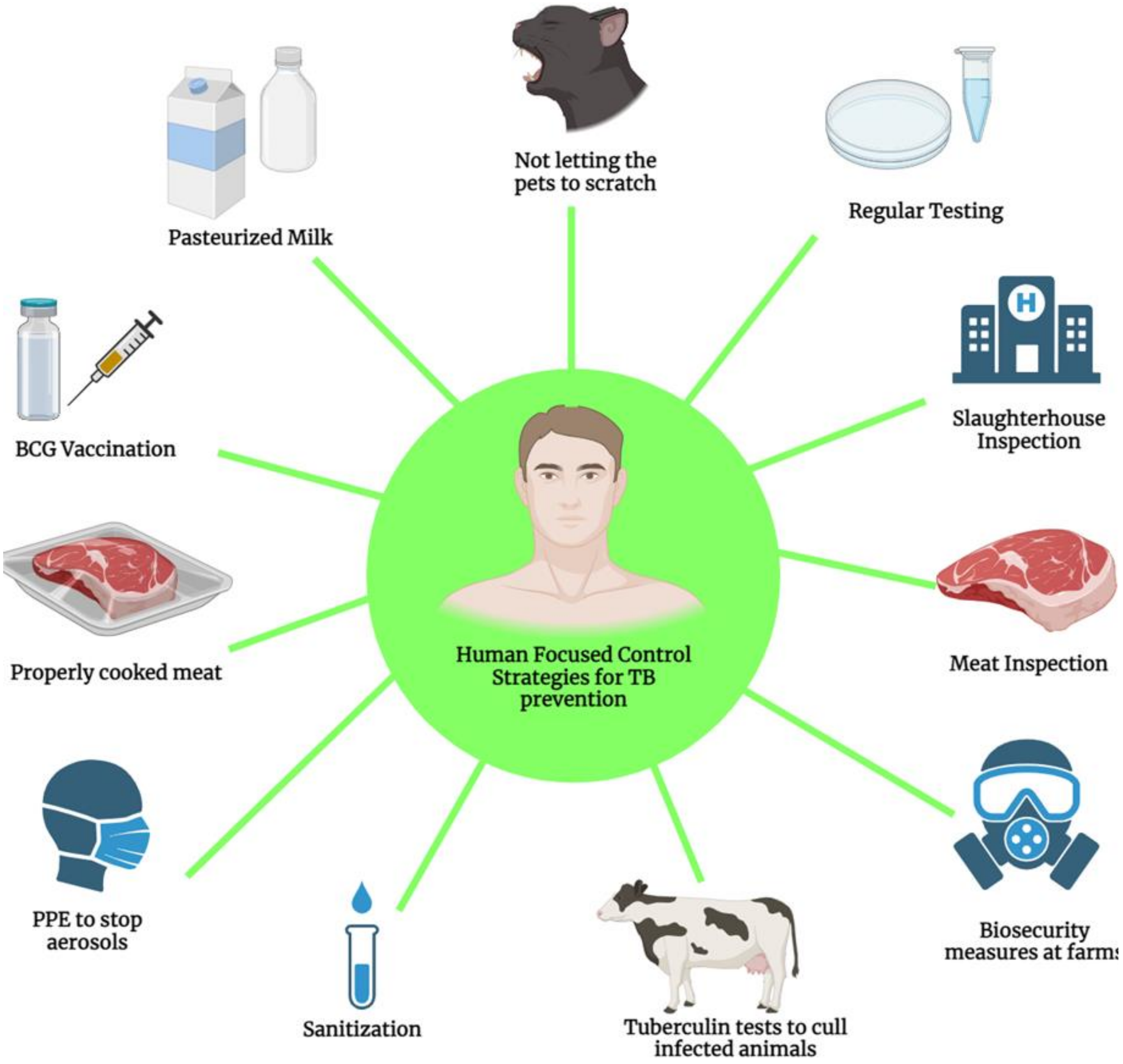

Fig. 2: Human Focused Control Strategies for TB Prevention.

milk ends its nutritional value (Oliver et al. 2009; Claeys et al. 2013). The contraction of *M. bovis* infection by humans can also be prevented by the use of the bacilli Calmette-Guérin (BCG) vaccine. Although the use of this vaccine has increased drastically, its quality and effectiveness are still debatable (Ottenhoff and Kaufmann 2012). This vaccine has proved to be more beneficial in children as it focuses on preventing the dissemination of the bacteria from the primary infection site thus preventing tuberculous meningitis and miliary disease which are more severe forms of TB (Grange and Yates 1994).

8. INTERNATIONAL EFFORTS

The World Organization for Animal Health (Office International des Epizooties; OIE) adopted a resolution in 1983 in response to the seriousness of the dangers posed by zoonotic tuberculosis to public health. The decision called for the complete eradication of *M. bovis* for both economic and public health motives, the implementation of strict meat inspection regulations, the boiling or pasteurization of milk for consumption by humans, and ongoing investigations into BTB, with a focus on improving diagnostic tests (Kleeberg 1984). Other variations of BTB include cases that recur in older people who contracted the disease before BTB control measures were put in place; cases that are imported into developed nations from other parts of the world where BTB control measures are either nonexistent or useless; and cases linked to the ingestion of tainted animal-origin food items or contact with dead animals that were infected with bovine tuberculosis (Awah-Ndukum et al. 2011). Implementing a One Health strategy to manage zoonotic tuberculosis Control of zoonotic illnesses, such as tuberculosis (TB), is complicated due to the interaction of people, livestock, animals, and ecology in the epidemiology of these diseases (Palmer et al. 2012a). This makes the diseases a prime candidate for the use of the One Health strategy. Among the "deadly dozen," or possibly fatal zoonoses that might expand globally as a result of behavioural adjustments made to offset the consequences of global warming, is TB, according to the Wildlife Conservation Society (Singer 2009). The general decline in human and animal health (and immune systems) brought on by food and water scarcity can aid in the dissemination of zoonotic illness (Lamy et al. 2012). A test-and-cull approach is used in industrialized nations to control bovine tuberculosis (BTB) in cattle. For cattle owners in underdeveloped nations, the socioeconomic costs of this strategy may be unaffordable, which might lead to their unwillingness to take part in BTB control initiatives. (Katale et al. 2012). To control BTB in wildlife reservoirs, more shooting, capturing, or poisoning of the population has been done (Nugent et al. 2012), along with vaccination (Palmer et al. 2012b).

9. CONCLUSION

Tuberculosis is a very problematic disease for mankind. Although curable, its treatment is long, exhaustive and expensive. Additionally, zoonotic TB cases have also started rising making it a global threat to the human population. These circumstances along with the emergence of antibiotic resistance in etiologic agents of TB have necessitated the formulation of proper guideline-based policy-making efforts to prevent TB transmission. Local governments and international health-related bodies are now becoming more and more concerned about policy-making efforts regarding the control of TB and limiting its transmission.

International organizations and local governments are now concerned about stopping TB transmission both among animals and humans. Policies are now being introduced to control TB and reduce its spread to a minimum. These policies focus on both humans and animals to cover both human-to-human and animal-to-human transmission aspects of the spread of TB. Such policies include control of border movement and elimination of zoonosis through initiatives like bovine tuberculosis eradication. Some innovative efforts in this respect are being my international bodies. These efforts include the formulation of a TB vaccine and the development of cheap rapid test kits to prevent and identify TB right from the start. Additionally, there is a need to start awareness campaigns, especially in lower and middle-income countries to help people know more about the steps they need to take for participating in TB control efforts. Base-level efforts by local health security entities will primarily result in the reduction of TB transmission and ultimately its eradication.

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