

Global Overview of Tuberculosis in Humans and Animals in the Period 2013 - 2022 and Public Health Protection



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Abstract:

Introduction/Objective: Tuberculosis is a zoonosis that ranks among the leading causes of death and disability. Given the increasing prevalence of the disease worldwide, this study analyzes available data on Tuberculosis case prevalence in humans and animals, examines the regulatory frameworks for its control, and synthesizes evidence to formulate recommendations for improving prevention and control strategies.

Methods: This paper synthesizes surveillance data on tuberculosis in humans and domestic animals from Bulgaria, the European Union, and global sources for the period 2013-2022, alongside an analysis of relevant European and international regulatory frameworks. Official reports from EFSA, ECDC, WHO, and WAHIS were examined using descriptive statistical methods to identify trends, regional differences, and challenges in disease control.

Results: The study describes a 27% increase in reported human cases worldwide, reaching record levels, excluding Europe and the USA, and increased total outbreaks in all regions - Asia (74%), Europe (61%), the Americas (30%), and Africa (10%).

Discussion: With thousands of human deaths and huge economic losses in many countries, regardless of their stage of development, tuberculosis remains a major transboundary threat to public health. Implementation of surveillance and various preventive measures against the disease is of paramount importance for protecting public health.

Conclusion: The global crisis, associated with the ongoing threat of increasing infections in animals and humans worldwide, requires improving the effectiveness of international intersectoral cooperation, veterinary and health systems for disease surveillance and control, as well as capacity building to conduct training and educational campaigns.

Keywords: Disease management, Legislation, Public health, Tuberculosis, Zoonoses, Contagious diseases.

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1. INTRODUCTION

Zoonoses are a group of contagious diseases that can be transmitted between humans and animals belonging to the classes of fish, amphibians, reptiles, birds, and mammals. The source of zoonoses is a large number of domestic and wild animals, and their causative agents may

be of bacterial, viral, parasitic, prion, or fungal nature [1]. Zoonotic diseases are contagious in nature and can be transmitted in various ways, mainly referred to as direct, where the source of pathogens is either an animal (through bites and scratches) or its secretions (through contact with body fluids of infected animals, such as

saliva, blood, mucous and feces) or as food contaminated with zoonotic pathogens (e.g. eggs, milk, meat/wild meat) or the environment (e.g., soil and plants) and indirect (through contact with animal habitats or vectors, such as insects) [2, 3]. Another characteristic of zoonoses is that they can be transmitted from animals to humans and vice versa [4].

As zoonoses appear to be a major threat to public health, the implementation of surveillance and preventive measures against them has become an important focus in the international policies [5, 6]. The preventive strategies are crucial to be properly implemented, as the consequences and losses after spreading of infectious zoonotic diseases through foodborne outbreaks were estimated at \$ 1.3 billion per year in Canada alone, due to reduced quality of life, restrictions on international trade, and the movement of people and animals [7]. Parallely, in the USA, governmental bodies estimated that the surveillance programme cost livestock producers \$3 billion in 2003, which contributed to a significant reduction in human Tuberculosis (TB) due to *Mycobacterium bovis*, and estimated that the eradication programme, combined with milk pasteurization, prevented over 25,000 deaths annually [8]. The figures increased over the years as Castro *et al.* [9] reported that the societal benefits of averted TB cases ranged from US\$3.1 to US\$6.7 billion, excluding deaths. The prognosis of Swartwood *et al.* [10] goes further as the authors state that the economic losses due to TB cases in US-born citizens will cost of \$914 million over the 2023 to 2035 period, while in some countries of Europe the cost is estimated to be €70.779 million as a result of death and disability-adjusted life [11], with probably US\$1349 million losses in the health system in India [12].

2. MATERIALS AND METHODS

Within the present study, a review-based and analytical approach was adopted in order to examine the regulation, surveillance, and diagnosis of bovine Tuberculosis (TB), a major zoonotic disease and one of the leading causes of infectious disease-related mortality worldwide, ranked alongside Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS). The analysis focused on the European Union (EU) and the global level, particularly investigating the rates of disease occurrence in humans and domestic animals, relevant regulatory frameworks, and challenges in the implementation of international control policies.

Based on the EU legal acts, policy instruments, and international strategic documents, we conducted a systematic analysis to evaluate the regulatory framework on tuberculosis control and management. At the same time, a structured literature search was performed using the PubMed, Scopus, and Web of Science databases. Defined keywords and combinations, such as *tuberculosis*, *bovine tuberculosis*, *Mycobacterium bovis*, *zoonoses*, *public health*, *surveillance*, *legislation*, *One Health*, and *disease control*, were used to identify and sort relevant references. No formal exclusion criteria were applied;

however, only sources relevant to the study objectives were collected and reviewed.

The period 2013-2022, which was set as a frame line for the investigation, was selected in alignment with the World Health Organization (WHO) and European Respiratory Society targets to reduce tuberculosis-related mortality by 95% and incidence by 90% by 2035, relative to 2015 levels. This timeframe of a decade allowed assessment of trends before and after the adoption of these strategic goals and supported evaluation of their degree of implementation.

Data on tuberculosis outbreaks in domestic animals were obtained from official reports published by the European Food Safety Authority (EFSA), particularly regarding disease-free status within EU Member States. Human tuberculosis case data were collected from reports issued by the European Centre for Disease Prevention and Control (ECDC), while global data on animal outbreaks and human cases were retrieved from the World Animal Health Information System (WAHIS) and WHO databases. Additional data were sourced from publicly available reports of international organizations and institutions involved in zoonotic disease surveillance, monitoring, and control.

Human tuberculosis surveillance data for EU/EEA countries were derived from the European Surveillance System (TESSy) for the period 2013-2022 and included reported case numbers and notification rates per 100,000 population. All officially reported cases in patients and animal outbreaks were included without regional exclusions.

The information on the registered TB outbreaks in animals and reported cases in humans was subjected to analysis by statistical software (IBM SPSS Inc., 2019, SPSS Reference Guide 26 SPSS, Chicago, USA) through descriptive statistics for frequency distribution, and paired t-test, where $p < 0.05$ was considered significant. The results afterwards were presented in tables processed in Excel (Windows 10).

3. RESULTS AND DISCUSSIONS

3.1. Drivers of Zoonotic Emergence

Given the global importance of cattle herd populations and the consumption of meat, milk, and their derived products worldwide, pathogens causing zoonoses in cattle are being studied and classified as potential bioterrorism agents on a daily basis [13]. Of the 24 agents with zoonotic potential in cattle, which represent 53% of the recognized zoonotic pathogens in the bovine species, two pathogens (8%) are Category A (high priority pathogens that pose the greatest risk to national security), 16 pathogens (67%) are Category B pathogens that pose a moderate national security risk, and six (25%) are Category C pathogens, meaning that they have emerged and could be used as biological weapons [14].

Locally, there are zoonoses that are specific to particular regions and animal species, but at the same time, their occurrence and re-occurrence is highly

influenced by residents' occupation, habits, and knowledge on the topic.

3.2. Surveillance and Monitoring of Tuberculosis Caused by *M. bovis* in the EU in Animals

At the EU level, bovine tuberculosis is reported through the Animal Disease Information System (ADIS) and in accordance with the procedure laid down in Directive 2003/99/EC. The reports contain data from surveillance in cattle, part of mandatory national eradication and monitoring programmes implemented in accordance with EU legislation, which allow the assessment of the epidemiological situation and the analysis of trends in the Member States and their zones.

Data on the epizootic situation in the Republic of Bulgaria, in the EU, and at the international level regarding *M. bovis* are presented in Tables 1 and 2, which track the outbreaks reported by the respective countries when bovine tuberculosis was detected in the period 2013-2022 [15-24].

Results in Table 1 present the number of reported outbreaks of bovine tuberculosis in the Republic of Bulgaria. The number of outbreaks detected in the country is sporadic, and it should be noted that during the entire study period, tuberculosis was reported only in cattle.

Data presented in Table 1 for the period 2013-2022, after subjected to statistical analysis show that there are no significant differences according to the selected

criteria (number of reporting MSs with zones under an eradication programme; number of infected herds in zones under an eradication programme), which are monitored annually in the EU by EFSA and ECDC, with the exception of the number of infected herds in areas covered by an eradication programme and the MSs with implemented programmes for animal disease management ($t[10] = -10.668$, $p < 0.05$). It is necessary to emphasize that, during the studied period, the number of infected herds decreased significantly (46%), as compared with their number in 2013, when it was 18059; in 2022, it was found that the number had declined by half to 9696.

Regarding the status of countries free of bovine tuberculosis, it can be stated that it is generally improving, since the number of countries with a "disease-free" status has increased in recent years. In 2013, there were 15 countries with "disease-free" status; in 2014, there were 16 countries, followed by three consecutive years (2017-2015) when the number of countries was 18, and from 2018 until the end of the study period, a lasting trend was observed, represented by 17 countries in the EU free of the disease (Table 1).

Data presented in Table 2 show that the largest number of outbreaks of the disease in domestic animals for the studied period was reported on the territory of Asia, followed by an almost equal relative number in the regions of America and Europe, and Africa is the region in which the smallest total number of outbreaks was reported in all years [25].

Table 1. Summarized data on disease outbreaks caused by *Mycobacterium bovis* and *Mycobacterium caprae* among the EU member states and Bulgaria in particular, 2013-2022*.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Percentage Change 2013/2022
Number of outbreaks per year in Bulgaria (<i>M. bovis</i>)	0	11	6	1	2	7	1	1	5	5	N/A
Number of infected herds in disease-free status zones	197	139	155	147	134	172	143	139	139	149	↓ 24%
Number of reporting disease-free status MSs	15	16	18	18	18	17	17	17	17	17	↑ 13%
Number of infected herds in zones under an eradication programme	18 059	17 122	17 441	17 421	18 857	18 801	16 277	7233	9255	9696	↓ 46%
Number of reporting MSs with zones under an eradication programme	13	12	10	10	10	11	11	9	11	11	↓ 15%

Abbreviations: EU - European Union; MSs - Member States.

Source: The European Union One Health Zoonoses Reports (EFSA and ECDC) [15-24].

Table 2. Total number of bovine tuberculosis outbreaks by year and region in the world (domestic animals), 2013-2022.

World Region	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Percentage Change 2013/2022
Africa	115	99	102	122	113	125	93	91	114	127	↑ 10%
Americas (North and South)	172	177	212	257	267	282	304	259	231	223	↑ 30%
Asia	238	187	194	201	213	220	219	358	390	414	↑ 74%
Europe	157	148	155	135	158	142	167	249	265	252	↑ 61%

Source: World Animal Health Information System (WAHIS) [25].

It is obvious when considering the outbreaks that their total number in all regions for the studied years gradually increased, with the largest increase being observed in Asia (74%), followed by Europe (61%), America (30%), and Africa (10%). The statistical analysis found a significant difference in the prevalence of TB cases between animals registered in Asia and Europe ($t[10] = 6.337$, $p < 0.05$) and between the American region and Europe ($t[10] = 2.617$, $p < 0.02$).

The total number of TB outbreaks for Europe differs among the research sources used; however, it is important to note that these are not technical errors. The differences stem from the fact that the annual reports of EFSA and ECDC on registered outbreaks and cases of zoonoses include twenty-seven Member States and the United Kingdom (Northern Ireland), while within the global WAHIS database there are included more cases from other countries in the European continent such as Bosnia and Herzegovina, North Macedonia, Russia, Serbia and Ukraine, and others, for which outbreaks in domestic cattle have been reported.

Comparing data on reported outbreaks at the global level through WAHIS, it can be concluded that the overall prevalence of tuberculosis in the European Union is decreasing, considering the cases of bovine tuberculosis caused by *M. bovis*, *M. caprae*, or *M. tuberculosis*. At the same time, registered outbreaks caused by *M. bovis* worldwide are increasing in all regions, including European countries that are not Member States but have

reported positive results for the disease in domestic animals.

Mycobacterium tuberculosis is recognized as the main cause of human tuberculosis worldwide, yet for more than 25 years, various studies have suggested that it may be underestimated as a cause of zoonotic tuberculosis in humans [26]. The World Organization for Animal Health recognizes bovine tuberculosis as an important zoonosis [27], while the Food and Agriculture Organization has identified it as an important infectious disease and prioritizes control [28], which should be implemented in humans, animals, and their interactions through national and international measures.

3.3. Surveillance and Monitoring of Tuberculosis Caused by *M. bovis* in the EU in Humans

Results from the analysis of the epidemiological situation in the Republic of Bulgaria, in the EU, and at the international level regarding the reported cases of TB detected in humans during the period 2013 - 2022 are presented in Tables 3 and 4. Data have been collected from ECDC annual reports extracted from TESSy from EU/EEA countries for the period 2013-2022, with the corresponding numbers and rates of TB cases per 100,000 population. For 2022, all reporting countries had comprehensive surveillance systems. Confirmed cases required either a positive culture or both detection of acid-fast bacilli by microscopy and detection of *M. tuberculosis* complex by nucleic acid amplification testing, communicated by the competent authorities (Table 3).

Table 3. Summarized data by number and rates for human cases of TB per 100 000 population, reported by the EU/EEA, 2013-2022*.

Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC
	N / R	N / R	N / R	N / R	N / R	N / R	N / R	N / R	N / R	N / R
Austria	649/7.7	582/6.8	583/6.8	634/7.3	569/6.5	482/5.5	474/5.4	388/4.4	396/4.4	372/4.1
Belgium	963/8.6	959/8.6	977/8.7	1042/9.2	967/8.6	977/8.6	968/8.5	825/7.2	868/7.6	852/7.7
Bulgaria	1932/26.5	1872/25.8	1660/23	1603/2.4	1463/20.6	1358/19.3	1344/19.2	930/13.4	687/9.9	792/11.1
Croatia	522/12.2	497/11.7	488/1.5	464/11.1	378/9.1	372/9.1	303/7.4	194/4.8	173/3.9	212/5
Cyprus	41/4.7	41/4.8	63/7.4	60/7.1	53/6.2	52/6	69/7.9	36/4.1	48/5.4	96/10.6
Czechia	497/4.7	514/4.9	517/4.9	516/4.9	501/4.7	443/4.2	464/4.4	363/3.4	357/3.3	384/3.6
Denmark	356/6.4	320/5.7	357/6.3	330/5.8	275/4.8	291/5	281/4.8	221/3.8	218/3.6	225/4
Estonia	287/21.7	246/18.7	217/16.5	192/14.6	175/13.3	147/11.1	150/11.3	124/9.3	112/8.3	129/9.2
Finland	273/5	259/4.8	272/5	234/4.3	245/4.5	225/4.1	225/4.1	174/3.1	170/3.1	190/3.2
France	4939/7.5	4845/7.4	4744/7.1	5735/8.6	5015/7.5	5092/7.6	5116/7.6	4515/6.7	4207/6.3	4040/6.3
Germany	4319/5.3	4488/5.6	5837/7.2	5925/7.2	5498/6.7	5492/6.6	4791/5.8	4159/5	3939/4.7	1076/5.1
Greece	540/4.9	519/4.7	482/4.4	440/4.1	467/4.3	432/4	459/4.3	396/3.7	206/1.9	320/3
Hungary	1045/10.5	851/8.6	906/9.2	786/8	685/7	640/6.5	552/5.6	406/4.2	335/3.4	440/4.3
Iceland	11/3.4	8/2.5	7/2.1	6/1.8	14/4.1	8/2.3	13/3.6	12/3.3	7/3.4	17/4.7
Ireland	376/8.2	316/6.9	283/6.1	315/6.7	300/6.3	310/6.4	266/5.4	236/4.8	217/4.3	216/4.5
Italy	3153/5.3	./.	3769/6.2	4032/6.6	3944/6.5	3912/6.5	3346/5.5	2287/3.8	2480/4.2	2439/4.3
Latvia	904/44.7	761/38	721/36.3	660/33.5	552/28.3	./.	./.	./.	261/13.8	319/16.7

(Table 3) contd....

Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	RC	RC	RC	RC	RC	RC	RC	RC	RC	RC
	N / R	N / R	N / R	N / R	N / R	N / R	N / R	N / R	N / R	N / R
Liechtenstein	./.	./.	2./.	2/5.3	1/2.6	1/2.6	./.	2/5.2	1/2.6	1/2.9
Lithuania	1705/57.4	1607/54.6	1507/51.6	1442/49.9	1387/48.7	1142/40.7	1058/37.9	726/26	646/23.1	738/24.8
Luxembourg	38/7.1	24/4.4	30/5.3	29/5	32/5.4	42/7	50/8.1	34/5.4	35/5.5	48/7.3
Malta	50/11.9	46/10.8	32/7.3	50/11.1	42/9.1	55/11.6	98/19.9	140/27.2	54/10.5	61/11.4
Netherlands	844/5	823/4.9	862/5.1	887/5.2	783/4.6	797/4.6	759/4.4	622/3.6	681/3.9	635/3.7
Norway	401/7.9	325/6.4	313/6.1	295/5.7	261/5	208/3.9	165/3.1	159/2.9	155/2.9	174/3.3
Poland	7250/19	6698/17.6	6430/16.9	6444/17	5787/15.2	5487/14.4	5321/14	3388/8.9	3704/9.8	4314/11
Portugal	2403/22.9	2226/21.3	2195/21.2	1936/18.7	1914/18.6	1905/18.5	1771/17.2	1519/14.8	1533/14.6	1514/14.2
Romania	16692/83.4	15906/79.7	15183/76.4	13601/68.8	12997/66.2	12199/62.5	11633/59.9	7693/39.8	7976/41.6	9270/48.1
Slovakia	401/7.4	336/6.2	317/5.8	296/5.5	249/4.6	281/5.2	214/3.9	158/2.9	137/2.5	155/2.9
Slovenia	140/6.8	144/7	130/6.3	118/5.7	112/5.4	99/4.8	101/4.9	77/3.7	80/3.8	74/3.3
Spain	5588/12	5048/10.9	5020/10.8	5070/10.9	5660/12.2	4766/10.2	4150/8.8	3697/7.7	3640/7.4	3698/7.7
Sweden	639/6.7	670/6.9	815/8.4	714/7.2	519/5.2	489/4.8	479/4.7	324/3.1	353/3.4	378/3.7
United Kingdom	7863/12.3	7077/11	6228/9.6	6116/9.4	5531/8.4	5036/7.6	5132/7.7	./.	./.	./.
EU/EEA	64821/12.7	58008/12.8	60947/11.9	59974/11.6	56376/10.9	52740/10.2	49752/9.6	33805/7.5	33676/7.4	36179/8

Abbreviations: RC: Reported cases; N: Number; R: Rate;

* Data presented include all officially registered human cases reported and noted in the annual epidemiological reports by ECDC.

Source: ECDC - Annual epidemiological reports. Tuberculosis [29].

In 2013, 64,821 cases of tuberculosis were reported from EU/EEA countries; in 2014, their number decreased significantly by 11%, then in two consecutive years (2015 and 2016) they increased until 2017, when a permanent trend of decreasing the number of people infected with TB was established (Table 3). Comparing the relative number of people infected from EU/EEA countries during the studied period, it can be concluded that a permanent trend of decreasing the overall prevalence of tuberculosis is established, since the percentage of decrease is 44%. The total number of people infected with tuberculosis in the Republic of Bulgaria in the studied period is in line with the established trend of decreasing newly diagnosed cases from EU/EEA countries, as a 59% decrease was observed, comparing the 1932 cases reported in 2013 to the 792 human cases in 2022 [29].

The notification rate per 100,000 population in EU/EEA countries was 8.0 in 2022, reflecting a continued decline since the initiation of enhanced Tuberculosis (TB) surveillance in Europe in 1996. The notification rate for the EU/EEA in 2013 was 12.7 per 100,000, marking a temporary interruption in the otherwise consistent decrease observed since 2002. From 2013 to 2022, notification rates across countries showed significant variability, ranging from 3.4 in Iceland to 83.4 per 100,000 in Romania in 2013, and from 2.9 in Liechtenstein to 48.1 per 100,000 in Romania in 2022.

Regarding Bulgaria, the notification rate fluctuated from 26.6 per 100,000 in 2013 to 11.1 per 100,000 in 2022, demonstrating a clear downward trend. Despite this, the rate remained average compared to other EU/EEA countries. Romania consistently reported the highest notification rates across all years and countries studied, with values ranging from 83.4 in 2013 to 48.1 per 100,000

in 2022. In 2013, the notification rates were higher than the EU/EEA average in Bulgaria, Estonia, Latvia, Lithuania, Portugal, and Romania, while in 2022, only Lithuania and Romania exceeded the EU/EEA average (Table 3).

Tuberculosis was the leading cause of death before the COVID-19 pandemic emerged globally, as the incidence of the zoonosis increased by 3.6% between 2020 and 2021, which was observed in all WHO regions except Africa, reversing around 2% annual declines over most of the previous two decades, as reported by the WHO [30].

In 2022 and 2023, the highest number of newly diagnosed tuberculosis cases were registered since the WHO began collecting data from all countries and regions in the mid-1990s, with 7.5 million and 8.2 million cases, respectively. It could be argued that this surge appeared related to disruptions in health services caused by the COVID-19 pandemic in the preceding two years, noting that global access to tuberculosis diagnosis and treatment has now been restored [31].

Data presented in Table 4 show that despite the established steady trend of decreasing cases of people with tuberculosis in Europe and the United States [32], at the global level, the registered cases are increasing by 27%, reaching record levels [33]. The disease remains persistent and widespread throughout the world despite the joint efforts and collaboration by individual governments. Statistically, there is a significant difference between the registered TB cases in the human population between Bulgaria and the EU/EEA countries ($t[10] = -13.739$, $p < 0.05$) and the EU/EEA TB cases and those notified at the global level ($t[10] = -36.594$, $p < 0.05$), likely due to the common health policies introduced.

Table 4. Prevalence of TB cases in patients per 100 000 population by country and year, EU/EEA/.

Notified TB Cases	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Percentage Change
TB in Bulgaria	1932	1872	1660	1603	1463	1358	1344	930	687	792	↓ 59%
TB in the EU/EEA	64821	58008	60195	59163	55337	52740	49752	33805	33527	36179	↓ 44%
TB in the USA	9556	9379	9539	9238	9066	8996	8895	7170	7866	8332	↓ 13%
TB in the world	6102914	6329198	6388034	6676807	6585171	7218820	7512247	6154489	6707819	7776122	↑ 27%

Source: ECDC - Annual epidemiological reports. Tuberculosis [29]; CDC - Tuberculosis Data [32]; WHO - Global Tuberculosis Report [33].

3.4. Policy Frameworks

In order to ensure high standards of animal and public health in the EU and to limit the emergence and spread of transmissible animal diseases, including zoonoses, which have a negative impact on animals, food safety, livestock farmers, and the economy, Regulation (EU) 2016/429 [34] was published and entered into force in 2021. This Regulation replaced 30 other acts of European law implementing rules on disease prevention and control applicable to various categories of diseases.

The categorization of infectious animal diseases in Commission Implementing Regulation (EU) 2018/1882 [35] is based on the disease profile, the extent of its impact on animal and public health, animal welfare, and the economy, as well as the availability and effectiveness of diagnostic tools and measures for prevention and control of reported outbreaks. In view of these criteria, various rules for disease prevention and control have been laid down in accordance with Article 9 of Regulation (EU) 2016/429 - reporting of the occurrence or suspicion of a disease, surveillance and eradication of a certain disease, and measures related to the movement of animals and products of animal origin within the Union and their introduction into the Union [36, 37].

Mycobacterium bovis is one of the eight zoonotic agents that are reported by Member States each year under Directive 2003/99/EC [38]. The Directive and Regulation (EC) No 2160/2003 [39] lay down the requirements for the control of systems for monitoring zoonoses at different stages of the production of food of animal origin [40].

Although tuberculosis is a zoonotic disease, it has long been neglected, and this requires ongoing efforts to address the effects of *Mycobacterium bovis* on the health and well-being of humans and animals with joint measures. In response to the need, a World Health Organisation (WHO) Technical Advisory Group on Tuberculosis in Geneva in June 2016 endorsed ten priorities forming a roadmap for proportionate actions and the engagement of governments, various stakeholder groups, and academia. They quantified reducing the risk of transmission of tuberculosis from animals to humans, improving access to early diagnosis, monitoring, strengthening laboratory capacity, and promoting intersectoral collaboration [41].

Given that healthy animals provide people with safe food, efforts to reduce the reservoir of *M. bovis* infection

in animals, including livestock and wildlife, should be a priority for every national government everywhere.

3.5. Implementation Challenges

Public health protection involves strategies to prevent and control diseases, among which zoonoses pose a great health threat to both humans and animals. Bringing zoonoses under control requires joint efforts and approaches, including hygiene practices, animal health management, and environmental control.

Globally, ranking next to HIV and AIDS, tuberculosis is one of the leading diseases that cause death worldwide, and as such, it is one of the main problems among the poorest in the world, which deepens the existing inequalities between different social groups in societies [42].

According to the Global Strategy for Tuberculosis, approved by the World Health Assembly on 19 May 2014, tuberculosis is a major global public health problem affecting millions of people, mainly in low- and middle-income countries [43], but is also a constant threat to high-income countries, where poor and vulnerable groups also live. Another aspect of the global nature of the disease is the increasing development and spread of drug resistance in times of increasing mobility, financial and social crises, leading to a scarce range of new technologies for the diagnosis, treatment, and prevention of tuberculosis [44, 45]. Under joint investigation, the WHO and the World Bank state in the Global Monitoring Report on Universal Health Coverage that globally, around 4.5 billion people—representing more than half of the world's population—lack full access to essential health services. In addition, increased health costs force the poorest and most vulnerable groups in society to forgo essential care, which can lead to death [46].

The strategy, developed by the World Health Organization, the European Respiratory Society, and governmental and non-governmental experts from over 30 countries, aims to offer strategic guidance to governments and their partners in implementing measures to reduce tuberculosis-related deaths by 95% and the incidence of tuberculosis by 90% by 2035, compared to 2015 levels. This target is defined by a global incidence of fewer than 100 cases per million population [42].

The WHO TB strategy showed improved results in global TB incidence rate, as it was observed to decrease by 2020, while in three consecutive years of global TB incidence increase (in 2021, 2022, and 2023), the

incidence rate returned to 2019 levels [47]. Given the new trend of increasing incidence, the targets set in the WHO strategy remain recommendable, rather than achievable.

Given the results of this study of a 27% increase in registered human cases globally, reaching record levels, with the exception of Europe and the USA, and the increased total number of outbreaks in all regions Asian region (74%), Europe (61%), Americas (30%) and Africa (10%), it is necessary to initiate a comprehensive discussion on the set goals, the used guidelines and measures to implement the strategy related to reduce tuberculosis-related deaths by 95% and the incidence of tuberculosis by 90% by 2035, compared to 2015 levels. A timely change in the applied measures and a general consensus from all national governments is needed to improve veterinary and health services to ensure and promote equal access to them for all people and animals in the context of the conclusion of the Global Monitoring Report from 2023 that globally, half of the world's population lacks full access to essential health services.

CONCLUSION

Tuberculosis caused by *Mycobacterium bovis* remains a critical threat to both human and animal health. In the Republic of Bulgaria, bovine TB outbreaks remain sporadic and limited to cattle, with a significant reduction of about 46% in infected herds from 2013 to 2022. EU-wide data show a similar positive trend. However, globally, TB outbreaks in domestic animals have risen, especially in Asia, which poses the need for sustained joint efforts and international cooperation for the control of the disease and protection of public and animal health. TB in humans affects not only people from low- and middle-income regions, but also other vulnerable groups in developed countries, due to factors such as inadequate access to essential health services or disruptions during the COVID-19 pandemic. In conclusion, the management of preventive, control, and surveillance measures must significantly increase their effectiveness in order to achieve the goals set by the World Health Organization Strategy for the elimination of TB by 2035. The global crisis associated with the continuous threat of increasing outbreaks in animals and cases in humans worldwide also requires increasing the effectiveness of international intersectoral cooperation, veterinary and health systems for disease surveillance and control, as well as building capacity to conduct training and education campaigns for early diagnosis, the severe consequences after illness in humans, including disability and mortality, as well as the huge economic losses as a result of regulatory restrictions on international trade in animals and their products.

AUTHORS' CONTRIBUTIONS

The authors confirm contribution to the paper as follows: R.R. and G.B.: Study conception and design; R.R. and G.B.: Data collection; R.R. and G.B.: Analysis and interpretation of results; R.R. and G.B.: Draft manuscript. All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

TB	=	Tuberculosis
WHO	=	World Health Organization
EFSA	=	European Food Safety Authority
ECDC	=	European Centre for Disease Prevention and Control
WAHIS	=	World Animal Health Information System
AIDS	=	Animal Disease Information System

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

All the data and supporting material are available within the article.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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