

The Situation and Future Prospects of Zoonotic Tuberculosis Prevention and Control

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Agricultural Research System regarding the National Dairy Industry Technology System

WOAH Regional Capacity Training on Priority Animal
Disease Control and Prevention in Asia and the Pacific
14-18 September 2026
Qingdao, China



Outline

Core objective: Control zoonotic tuberculosis from the animal source and promote the "One Health" concept

01 What We Have Completed

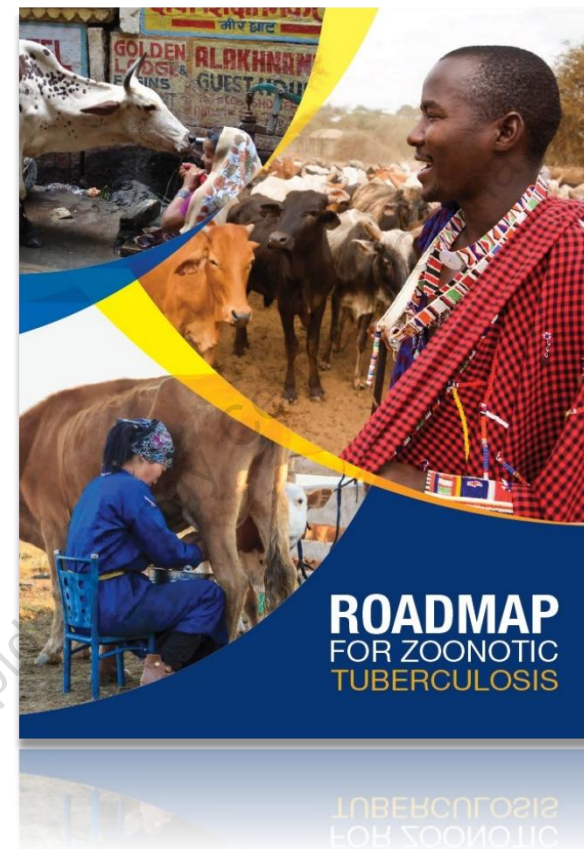
Laws & top-level design · Historical experience & disease burden · Identification & investigation

02 What We Are Currently Doing

Reference materials · Rapid detection (RAA & immunochromatography) · IGRA optimization · Whole-genome sequencing · Vaccines & zoned management · New disinfection technologies

03 What We Will Do in the Future

International cooperation · Differentiated control for four scenarios · Stakeholder communication & risk management under "One Health"





What We Have Completed

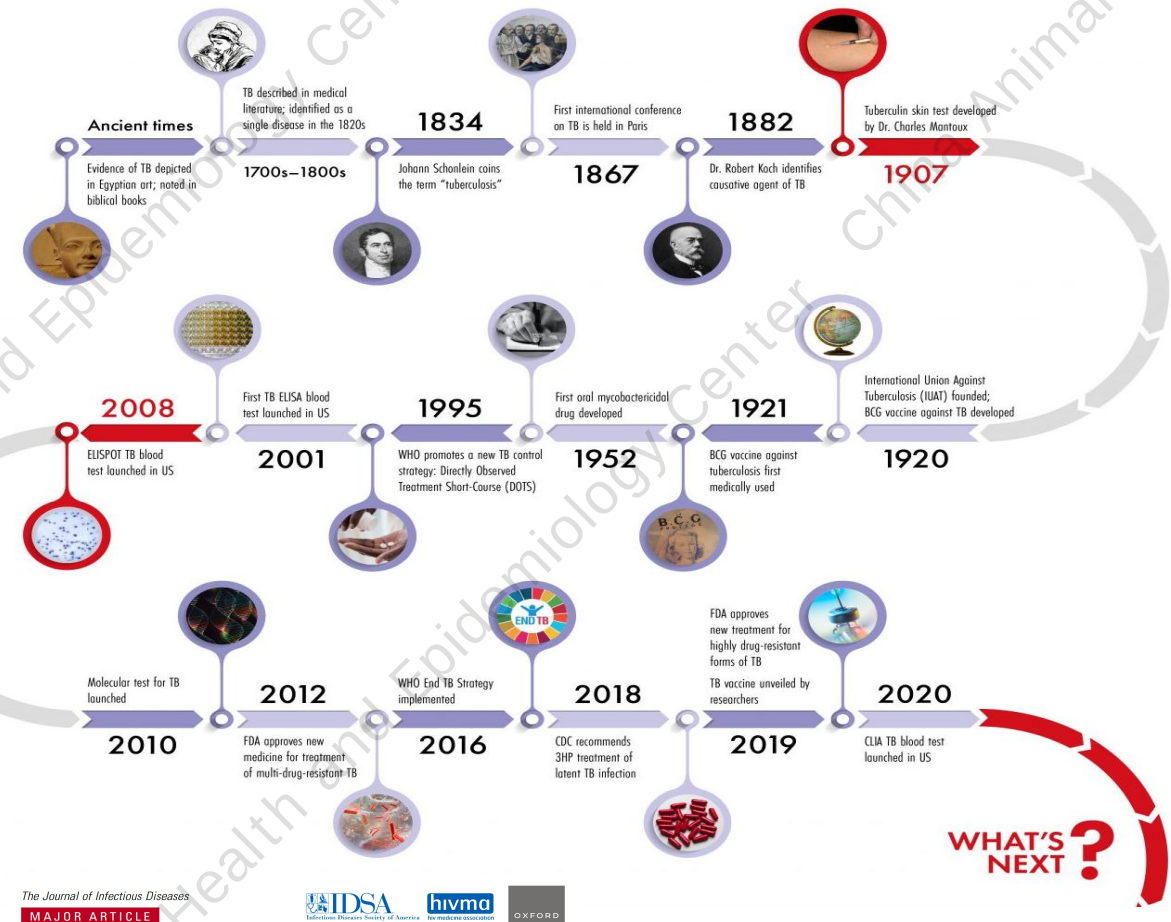
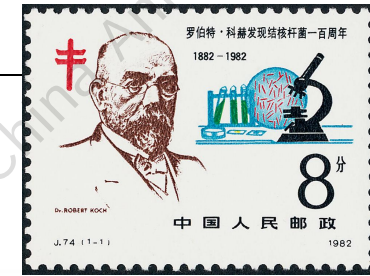
EMPHASIS · UNDERSTANDING



1. What We Have Completed

- In **1900**, approximately **10% of human TB** cases in the United States resulted from human exposure to cattle or related products infected with *M. bovis*
- In **1947**, approximately **30% of TB cases in children** under 5 years old in the UK were caused by *Mycobacterium bovis*
- In the **past**, zTB was commonly associated with **extrapulmonary TB** because of unpasteurized milk

✓ With the use of **BCG**, tuberculosis drugs and milk **pasteurization**, human zTB infection in most parts of the world has been effectively controlled



The Journal of Infectious Diseases
MAJOR ARTICLE



Characterization of *Mycobacterium oryzois*, *Mycobacterium bovis*, and *Mycobacterium caprae* Infections in Humans in Western Canada

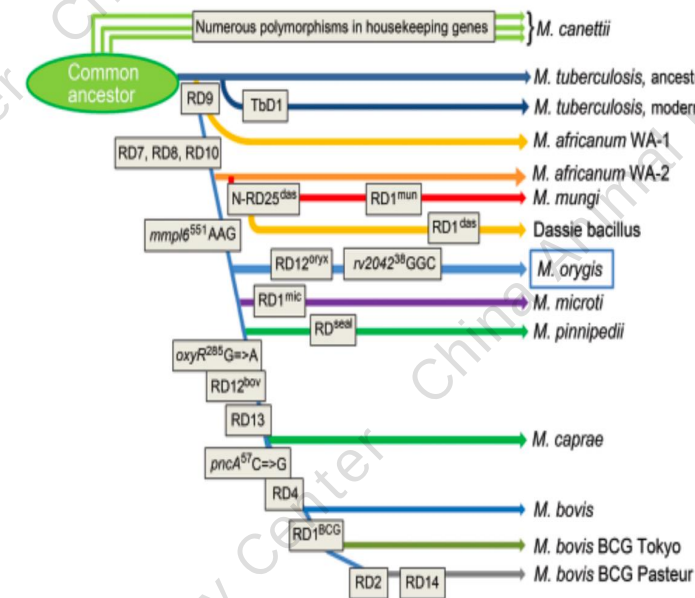
Nicholas D. Riegel,^{1,2,3,4} Richard Lang,^{1,2,3,4} Courtney Heffernan,^{1,2,3,4} Gregory J. Tyrrell,^{1,2,3,4} Cary Shandro,^{1,2,3,4} Vincent Li,^{1,2,3,4} Md Rashidul Islam,^{1,2,3,4} Michael Roberts,^{1,2,3,4} Meenu K. Sharma,^{1,2,3,4} Haid Soualhi,^{1,2,3,4} and Ryan Cooper^{1,2,3,4}

14-18 September 2026, Qingdao, China



1. What We Have Completed

CURRENT GLOBAL BURDEN



143,000

New zTB cases globally each year

12,500

Associated deaths annually

zTB = 1%–28% of all human TB. Lack of surveillance in developing countries means the actual burden may be up to 10× higher

High-risk groups:

- **Occupational:** breeding, slaughtering, processing, quarantine, transport, catering, research, biologic production
- **Gender:** Men — more frequent animal contact
- **Immunodeficiency:** HIV-positive individuals

Ongoing investigation:

- Assess zTB awareness in occupational populations
- Compare TB incidence rates across groups
- Differential diagnosis for latent infection & MTBC members
- Optimize prevention & control measures



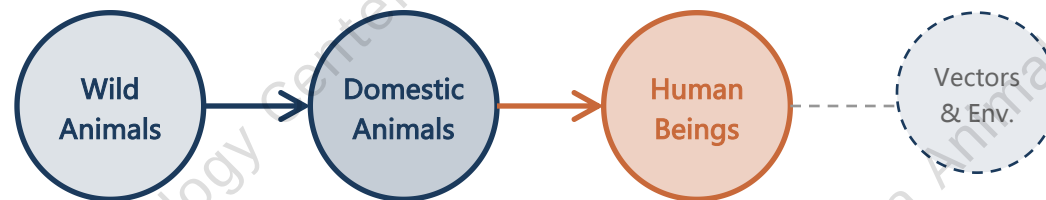
1. What We Have Completed

INSTITUTIONAL FRAMEWORK

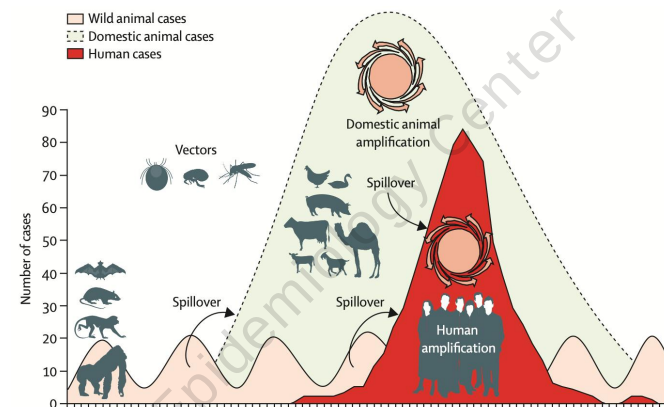
- Animal Epidemic Prevention Law of the PRC
- Biosafety Law of the People's Republic of China
- Catalogue of Class I, II & III Animal Epidemic Diseases
- National Prevention & Control Plan for Zoonoses Among Livestock (2022–2030)
- Annual surveillance & epidemiological investigation system for bovine TB

- Bovine TB is one of the eight key zoonotic diseases for priority prevention and control
- Control zoonotic TB from the animal source

TRANSMISSION CHAIN & BIOSAFETY



Spillover across species with both animal and human amplification links



One Health Approach: A multi-sector integrated management framework covering human health, animal health and environmental health is essential to control zoonotic tuberculosis at the animal source



1.What We Have Completed

Annual Special Epidemiological Investigation of Bovine Tuberculosis

- **On-site Questionnaire**
 - Breeding Mode, Species and Scale
 - Biosafety and Disinfection Measures
 - Bovine Tuberculosis Quarantine Status and Other Related Items
- **Sampling (>10,000)**
 - Whole Blood, Milk Sample, Environmental Swab, Tissue
- **Laboratory Testing**
 - Interferon-Gamma Release Assay (IGRA)
 - Real-time Fluorescent Quantitative PCR (qPCR)
 - Isolation and Characterization





1.What We Have Completed

Risk Analysis	Key Points	Risk Factors
Epidemiological Links	Source	Active TB animals shed via droplets, dairy, feces
	Route	Respiratory, digestive, contact transmission
	Host	Multi-host, wildlife reservoir, human exposure
Breeding Mode	Pastoral	Wildlife exposure, dispersed, weak monitoring
	Intensive	Aerosol risk, unregulated introduction, movement
	Free-range	Low awareness, cohabitation, complex feed
Industry Chain	Breeding	Contaminated feed, water, shared equipment
	Slaughtering	Inadequate quarantine, waste, occupational risk
	Consumption	Raw food, unquarantined meat, waste handling
Cross-Border	Trade	Latent carriers, contaminated hay, bone meal
	Migration	Seasonal border migration, shared pastures
	Climate	Expanding habitats, rising wildlife-livestock contact



II

What We Are Currently Doing

STANDARDIZATION · DETECTION



2.What We Are Currently Doing

Development of **national reference materials** and standardized detection, providing a unified measurement scale for bovine TB and zoonotic TB detection

National Certifications

- Multiple national reference material qualification certificates obtained
- Covering nucleic acid and antibody detection
- Metrological traceability established

Quality Assurance Framework

- Proficiency testing programs
- Method evaluation & validation
- Reagent selection & quality control
- Standardized operating procedures

Evaluation of the Detection Performance

GB IS6110 · GB IS1081 · GB Mtb · GB Btb
HB TB · DB Mtb · DB Btb
WOAH IS1081 · WOAH IS6110
MTBC · MAP
11 reference Primer-Probe Combinations



- The purified protein derivative (PPD) of M. bovis Reference Material is expected to obtain official authorization within this year



2. What We Are Currently Doing

RAA — Recombinase-Aided Amplification

INCLUDED IN NATIONAL STANDARD

10 copies

Sensitivity per reaction for *M. bovis*

100%

Specificity

Key breakthrough: Overcame milk fat/protein interference; efficient pathogen cell wall lysis; no cold chain needed; suitable for farms, slaughterhouses & field sites. Detection time: < 1.5h in total

- ✓ 2024 National Agricultural "Spark Technology" Cultivation Achievement
- ✓ 2026 National Major Promoted Agricultural Technology

Cost reduction: Detection cost from 50–80 RMB down to 5–8 RMB per sample; consistency >98% with national standard qPCR

Economic benefit: Covers 30% of farms nationwide; estimated annual output value of 6 billion RMB; farm annual net profit +5%–8%

Fresh milk sample processing



- High-speed centrifugation, remove the supernatant
- Resuspend the sample in PBS
- Remove 70%–80% of the fat and protein from the milk sample

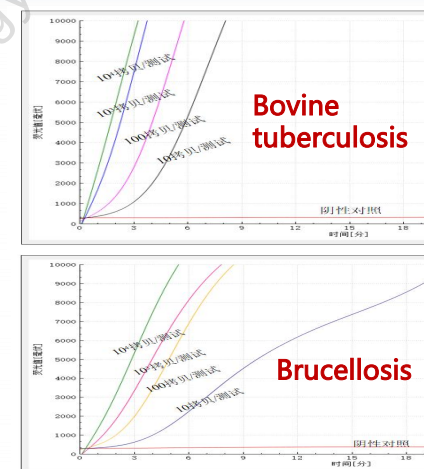
Automatic nucleic acid extraction



Specific amplification



Result output





HIGH-SENSITIVITY TB ANTIBODY DETECTION

Detection time

Sample throughput

Specificity

Performance: Five TB proteins expressed (ESAT6, CFP10, etc.). Repeatability CV: 3.51%–9.23%. Clinical performance >90% vs commercial bovine TB antibody kits

Wild animal application: Applicable to samples from elephants, deer, monkeys, badgers and other wildlife species



2.What We Are Currently Doing

Focus on promoting and simplifying the DIVA-IGRA method, with comprehensive diagnostic performance evaluation to enable grassroots and large-scale application

Diagnostic Performance Evaluation

0.953

AUC (Area Under Curve)
of the optimal model

0.962

Sensitivity at threshold
0.287

0.871

Specificity at threshold
0.287

Simplified workflow: N (negative control), P (positive control), T (test sample) — streamlined from a complex multi-step procedure to a user-friendly format suitable for field laboratories

Identify BCG vaccinated vs infected

Cost Reduction for Large-Scale Application

Commercial Kit

¥200

per test

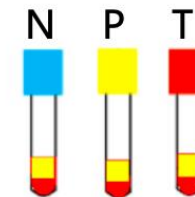
VS

Self-Developed

¥50

per test

75% cost reduction significantly lowers the barrier for grassroots and large-scale application, enabling comprehensive surveillance coverage across farms and regions





2. What We Are Currently Doing

INTEGRATED PRECISION DETECTION WORKFLOW

Sample collection → Nucleic acid extraction → ddPCR screening → WGS confirmation → Bioinformatics analysis → Phylogenetic & phylodynamic reporting.
This integrated workflow combines rapid screening with definitive strain-level characterization, enabling real-time molecular surveillance and evidence-based outbreak response

Droplet Digital PCR: Low-Abundance Detection

5.43

copies/ μ L
M. tuberculosis

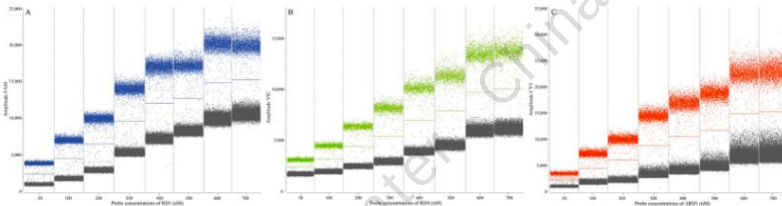
5.79

copies/ μ L
M. bovis

2.64

copies/ μ L
BCG

Application scope: Detects low-abundance targets in milk samples, environmental samples and mixed samples — critical for early warning and environmental surveillance in high-risk farms and slaughterhouses



Sequencing Turnaround Time Revolution

1–3 months

Previous: commercial company outsourcing

1–3 days

Now: local laboratory in-house



Enhanced capabilities:

- Accurate diagnosis at strain level
- Phylogenetic analysis for transmission tracing
- Phylodynamic analysis for epidemic trend prediction
- Real-time surveillance support for outbreak response



2. What We Are Currently Doing

Disinfectant Efficacy Against *M. bovis*

Compound Phenol

>0.2% kills within 12 hours

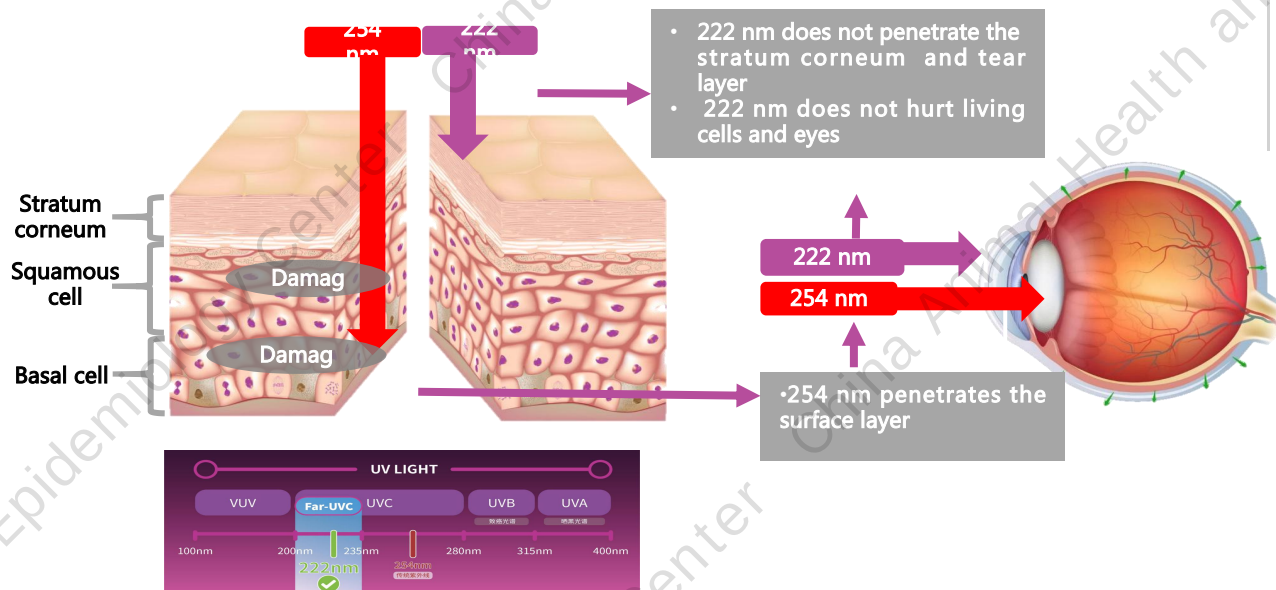
Povidone-Iodine

>1% kills within 6 hours

NaOH (0.1–20%)

NO killing effect — important finding

Key misconceptions: Higher concentration ≠ better (cost, residue, pollution); Higher temperature ≠ optimal (evaporation, decomposition like chlorhexidine); More types combined ≠ better (incorrect sequence causes failure); Procedures and effect evaluation must not be ignored



Human-Animal-Machine Coexistence Technologies

222 nm Far-UVC

Cannot penetrate stratum corneum or tear film — safe for living cells and eyes.

At 1000 mJ/cm²: log reduction > 3, killing rate >99.9% within 1 hour against *Geobacillus stearothermophilus*

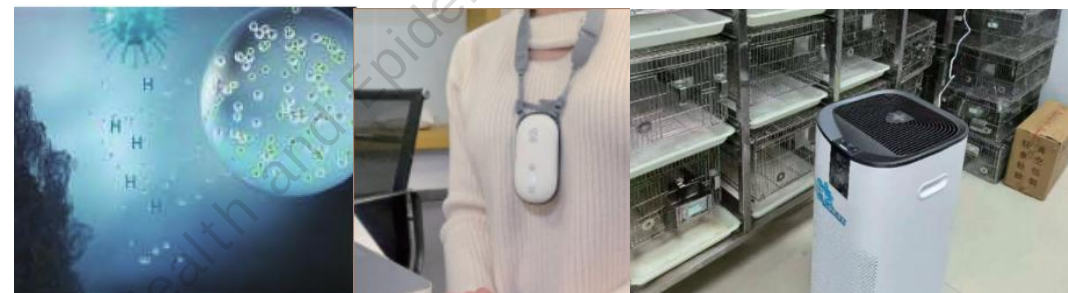
Active Fog Ion

Nano-scale water mist (6–20 nm), weak acidic, no ozone or nitrogen radicals

Active lifetime 20–30 min, converts to water

Against *M. abscessus*: 94.32% killing after 24h, log value 1.25

Patented technologies with wearable devices and space disinfection equipment developed. Features: safe coexistence of humans, animals and machines; broad-spectrum, high-efficiency disinfection — expected to transform traditional farm biosafety management

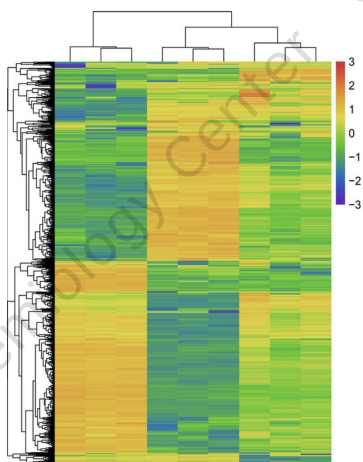




2.What We Are Currently Doing

Omics Analysis & Biomarkers

- Transcriptomics, proteomics and metabolomics analysis
- Identify potential diagnostic biomarkers for early detection
- Understand host-pathogen interaction mechanisms
- Discover novel therapeutic targets and intervention strategies
- Support precision medicine and individualized control



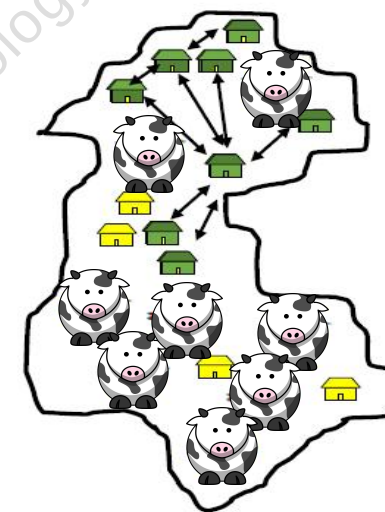
BCG Vaccine Exploration

- Explore BCG immunization effect in cattle
- Evaluate protection in wild animal reservoir hosts (badgers, deer, possums)
- Optimize vaccination routes and dosage regimens
- Assess DIVA (Differentiating Infected from Vaccinated Animals) compatibility
- Reduce infection rate and clinical severity



Zoned Management & Eradication

- Regional and sub-regional management strategies
- Build tuberculosis-free zones
- Advance TB eradication on individual farms
- Implement animal movement control and traceability
- Certification and market access incentives





III

What We Will Do in the Future

COOPERATION · IMPROVEMENT



3.What We Will Do in the Future

WOAH & CAHEC Co-hosted Asia-Pacific Regional Seminar on zTB & Brucellosis

2024 Joint 50 attendees: WOA representatives, observers, and invited experts
Share Asia-Pacific epidemic updates on the two diseases
Present latest laboratory technology advances
Discuss regional prevention and control priorities

WOAH Reference Laboratory for Animal TB Twinning Project

2023 , tripartite twinning agreement with WOA and UK APHA
2023–2025, CAHEC and APHA experts for on-site exchange 4 times
• bTB diagnosis, lab management and quality control

Asia-Pacific Training on Laboratory Diagnostics & Proficiency Testing for TB

2025 Co-hosted by CAHEC & WOA Regional Representativetation for Asia-Pacific

- 9 countries
- Trainees mastered core bTB diagnostic operations
- Enhanced regional lab diagnostic capacity
- Strengthened Asia-Pacific technical exchange & collaboration
- Foundation laid for sustained TB control cooperation

in the future

WOAH Regional Capacity Training on Priority Animal Disease Control and Prevention in Asia and the Pacific

2024年世界动物卫生组织亚太区人兽共患结核病和布鲁氏菌病研讨会



14-18 September 2026, Qingdao, China

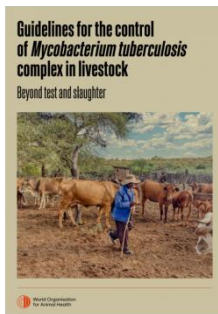


3.What We Will Do in the Future

WOAH Guidelines: Beyond Testing and Culling — Strategic Shift

Traditional: Test-and-Cull

Test positive animals → immediate culling.
Limitations: restricted by resources, infrastructure, wild animal reservoirs, and economic compensation.
High cost, difficult to sustain in low-resource settings



Innovative: Test-and-Segregate

Replace culling with segregation — isolate infected domestic animals promptly. Effectively curbs within-herd spread, reduces epidemic risk.
Low control cost, strong feasibility — suitable for low- and middle-income countries

Scenario 1: Disease-Free / Very Low

Context: No bovine TB or extremely low prevalence; intensive agriculture; implemented national control programs.
Goal: Maintain disease-free or low-prevalence status.

Priorities:

- Continue test-and-cull with compensation
- Maintain biosafety, zoning, certification and traceability
- BCG vaccination for domestic animals NOT recommended

Scenario 2: >5% Herd Prevalence

Context: Partially implemented national control; good veterinary services; emerging economies transitioning to intensive farming.

Goal: Reduce prevalence, improve productivity and market access, and reduce zoonotic transmission.

Priorities:

- Strengthen surveillance, update control strategies
- Promote zoning and regionalized management
- Implement animal movement control and risk communication
- Carefully evaluate BCG in high-prevalence areas

Scenario 3: >5% Prevalence

Context: No effectively operating national control; limited resources; extensive farming; weak veterinary and public health infrastructure.

Goal: Manage TB with limited resources; focus on reducing the epidemic in intensive dairy herds and cutting zoonotic transmission.

Priorities:

- Targeted surveillance at markets and slaughterhouses
- Raise public awareness, feasible biosafety measures
- Promote zoning and eradication in high-risk farms
- Test-segregate when conditions permit
- Consider BCG in high-prevalence areas

Scenario 4: Wild Animal Reservoirs

Context: Important wild animal reservoir hosts—badgers, possums, African buffaloes, white-tailed deer, wild boars.

Goal: Reduce transmission from wild to domestic animals; lower infection rate in wild populations.

Priorities:

- Risk communication, habitat management
- Physical barriers, buffer zones, zoned management
- BCG immunization for wild animals (Ireland: badger BCG since 2018)

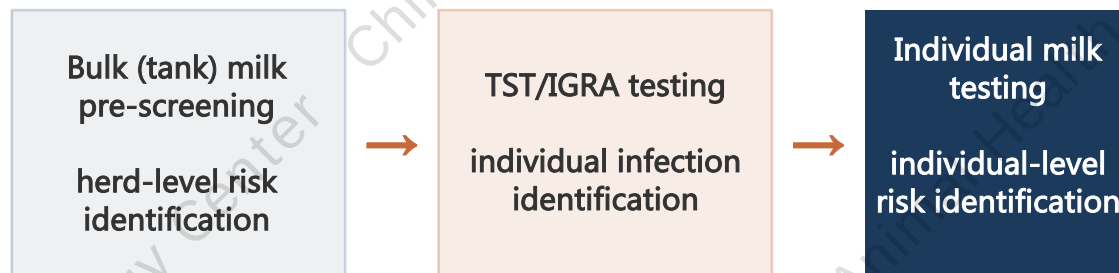


3.What We Will Do in the Future

Knowledge → Attitude → Practice: Virtuous Cycle



Rapid Risk Identification & Source-Based Prevention of TB in Dairy Animals



TEST COST	TURNAROUND TIME	ACCURACY	ECONOMIC IMPACT
¥50–80 → ¥5–8	2–3 d → 1.5 h	>98%	+5–18% profit
per test 90% reduction	from sampling to result	consistency with national standard qPCR	–10–15% milk yield loss ¥6B annual added output value in 30% farms nationwide

Risk Management: "Wooden Barrel Principle"

Risks often come from the shortest board. Key focus areas:

Surveillance & Investigation
Epidemiological monitoring,
outbreak investigation, early
warning systems

Test-and-Cull / Segregate
Rapid identification, timely removal
or isolation of infected animals

Biosafety & Biosecurity
Farm biosecurity, disinfection
protocols, personnel protection

Zoned Management
Disease-free zones, buffer zones,
movement control, traceability

SHIFT: PASSIVE EMERGENCY RESPONSE → PROACTIVE RISK CONTROL

One Farm, One Strategy

- Cuts whole-herd testing cost; reduces animal stress & milk yield loss
- Fresh milk samples without cold-chain logistics
- Minimizes reliance on specialized personnel & laboratory equipment
- Proactive source-level risk detection under limited resources
- Extendable to bovine mastitis and other important diseases

Thank you!

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