WORLD FOOD SAFETY DAY 2025

Ensuring Food Safety using Science in Veterinary Public Health

Date: 29th May 2025

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VPH in South Africa: Mandate, Legislation, and DALRRD's Role

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- **Veterinary Public Health (VPH):** A science-driven critical function ensuring animal-origin food safety in South Africa. Its activities protect human health, facilitate trade, and build consumer confidence.
- **Legislative Backbone:**
  - **Animal Diseases Act, 1984 (Act 35 of 1984):** Manages animal-related risks.
  - **Meat Safety Act, 2000 (Act 40 of 2000):** Ensures safety of animal-derived foods. These acts mandate VPH to align with national and international standards.
- **DALRRD's Pivotal Role:** The Department of Agriculture, Land Reform and Rural Development (DALRRD) is the custodian of the Meat Safety Act, 2000. It establishes standards for meat inspection personnel and scientific manuals. The Directorate Food Safety and Quality Assurance (DALRRD) also regulates specific agricultural products.

Scientific Application of Acts & Core VPH Objective

- **Scientific Application of Key Acts:**
  - **Meat Safety Act, 2000:** Necessitates scientifically validated hygienic practices, abattoir standards based on scientific criteria, and rigorous meat inspection.
  - **Animal Diseases Act, 1984:** Provides the framework for surveillance, control, and eradication of zoonotic diseases – a core VPH scientific function.
- **Evolutionary Shift:** The move to the comprehensive Meat Safety Act, 2000, reflected a shift to a holistic system centered on food safety outcomes, driven by international concerns and demand for sanitary guarantees.
- **Core VPH Scientific Objective: Farm-to-Fork Safety:**
  - To ensure the safety of meat and meat products. This involves state veterinarians and meat inspectors overseeing hygiene, humane animal handling, and facility standards.
  - Requires applying veterinary science from on-farm animal health (disease prevention, diagnosis, treatment, vaccination) to abattoir control and final product safety, adhering to international standards like Codex Alimentarius.

1. Veterinary Epidemiology & Advanced Surveillance Science

- A cornerstone of VPH, managing "animal risks" through epidemiological understanding.
- Includes "active and passive disease surveillance, disease control and prevention interventions" and "diagnosis, surveillance, monitoring, control, prevention and eradication of notifiable diseases".
- Curricula cover "Epidemiology of Zoonotic Diseases" and "Applied Veterinary Data Analysis".
- FAO emphasizes "surveillance, early warning and early reaction to zoonoses outbreaks".
- Provides the framework for understanding disease distribution and dynamics, informing strategies to prevent diseased animals from entering the food chain.
- Surveillance science (data collection, analysis, interpretation) forms the backbone of early warning systems for emerging threats.

2. Food Microbiology & Pathogen Characterization

- Indispensable for VPH; "Basic microbiology" is mandated knowledge for meat inspectors.
- VPH education covers foodborne diseases and antimicrobial resistance.
- Example: ARC-OVR study on *Listeria monocytogenes* used microbiological isolation and molecular characterization.
- Essential for identifying biological hazards (bacteria, viruses, parasites) and understanding their growth, survival, and inactivation in meat.
- Pathogen characterization (e.g., Whole Genome Sequencing) is vital for source tracking, understanding virulence, and monitoring pathogen dissemination.

3. Veterinary Pathology & Disease Diagnostics

- Central to traditional VPH meat safety; meat inspection relies on identifying pathological lesions indicating disease or unfitness.
- Meat Inspectors Manuals list "Pathology" and "Diseases" as essential knowledge.
- Diagnostic labs use pathology, microbiology, and toxicology to diagnose animal diseases.
- Provides the scientific basis for recognizing disease signs in live animals (ante-mortem) and carcasses (post-mortem).
- Diagnostic capabilities are crucial for confirming diseases and informing control actions, including condemnation.

Table 1: Critical Pathological Conditions & Contaminants in Meat Inspection

Condition/Contaminant	Scientific Basis for Concern (Examples)	VPH Action (Examples)
Abscess	Localized bacterial infection, potential for systemic spread (pyaemia)	Condemnation of affected part; total if pyaemia
Tuberculosis (notifiable)	Zoonotic bacterial disease (*Mycobacterium bovis*), systemic implications	Total condemnation if generalized or with emaciation/fever; partial if localized
Salmonella contamination	Foodborne pathogen, risk of gastroenteritis in humans	Condemnation if systemic (paratyphoid); hygiene focus
Faecal contamination	Gross contamination with enteric pathogens (e.g., *E. coli*, *Salmonella*)	Trimming of affected area; potential condemnation if extensive
Bruising (severe/extensive)	Tissue damage, potential for bacterial growth, aesthetic defect	Trimming; condemnation if associated with systemic illness
Icterus (Jaundice)	Systemic metabolic or infectious disorder, indicates unwholesome meat	Total condemnation if due to bile salts
Cysticercosis (*Taenia* spp.)	Parasitic zoonosis (tapeworm larvae in muscle), public health risk	Condemnation if heavily infested; conditional approval with freezing treatment if light
Anthrax (notifiable)	Highly fatal bacterial zoonosis, severe public health risk, spore persistence	Total condemnation; carcass & contaminated materials must be burnt
Fever (systemic signs)	Indicates acute inflammation/infection, unwholesome meat, poor keeping quality	Total condemnation
Emaciation/Cachexia	Profound ill health, malnutrition, poor quality meat, potential underlying disease	Total condemnation

4. Toxicology, Residue Chemistry & MRL Enforcement

- Addresses chemical hazards (veterinary drugs, pesticides, environmental contaminants) in foods of animal origin.
- DALRRD Strategic Plan highlights "residue testing and monitoring".
- Onderstepoort Veterinary Research Campus is accredited for veterinary drug residue testing.
- Department of Health regulates Maximum Residue Levels (MRLs) for the local market; DALRRD liaises on MRLs for export.
- Uses analytical chemistry to detect/quantify residues; toxicology assesses their health risks.
- MRL enforcement protects consumers and ensures products meet international trade requirements.

5. Quantitative and Qualitative Risk Assessment Methodologies

- A systematic, science-based process integral to modern food safety management.
- VPH services incorporate "risk assessment" for facilitating exports.
- Educational programs cover risk assessment for biosecurity, emergency response, and outbreak investigation.
- International guidelines emphasize "appropriate risk assessment methodology" (e.g., for AMR bacteria, BSE).
- Provides the scientific foundation for evidence-based policies and targeted controls, involving hazard ID, characterization, exposure assessment, and risk characterization.
- Allows VPH to prioritize risks and allocate resources effectively.

Applied Science: Meat Safety - Ante-mortem & Post-mortem Inspection

- These inspections are critical control points rooted in veterinary science.
- VPH teams monitor abattoir procedures, including humane handling and facility standards.
- **Ante-mortem inspection:** Scientific observation of animal behavior, appearance, and history to screen for diseases (e.g., Rabies, FMD) and conditions posing food safety risks.

Post-mortem inspection: Systematic pathological and anatomical examination of the carcass and viscera using observation, palpation, olfaction, and incision to detect abnormalities, contamination, and pathological conditions

Applied Science: Microbiological Control in Abattoirs

- Essential to prevent meat contamination with pathogenic and spoilage microorganisms.
- Meat Inspectors Manuals emphasize "Abattoir hygiene" principles: basic microbiology, abattoir design, sanitation, pest control, personnel hygiene, waste management.
- **Applied measures include:**
    - Mandatory knife sterilization between animals to prevent cross-contamination.
    - Avoiding contact of exposed meat with contaminated surfaces.
    - Proper evisceration techniques to prevent faecal contamination (e.g., from *Salmonella*, *E. coli*).
    - Quality control of water used in abattoirs (e.g., chlorine testing).
- HACCP principles often underpin these systems.

Applied Science: Physicochemical Control (Temperature & pH)

- Physicochemical properties are crucial for meat safety and quality.
- VPH uses quantifiable scientific parameters like temperature and pH.
- **Temperature:** A critical control point influencing microbial growth.
    - Chilling near 0°C; freezing below -12°C to cease bacterial growth.
    - Humidity and air circulation control are also important.
- **pH:** A biochemical indicator of post-mortem muscle metabolism.

Applied Science: Advanced Laboratory Diagnostics - Molecular Techniques (WGS)

- VPH uses a spectrum of lab techniques, from conventional to cutting-edge molecular tools.
- Veterinary diagnostic labs routinely use pathology, microbiology, toxicology.
- Increasing adoption of advanced molecular techniques like **Whole Genome Sequencing (WGS)**.
    - Example: ARC-OVR *Listeria monocytogenes* profiling project (associated with DALRRD) extensively used WGS.
    - WGS involves DNA extraction, *de novo* genome assembly, *in silico* MLST, *in silico* serotyping, and pan-genome analysis.
    - Provides high-resolution pathogen subtyping for source tracking, understanding genetic relatedness, and pathogen evolution.

Table 2: Key Laboratory Techniques in VPH Food Safety Investigations

Technique	Scientific Principle (Brief)	Application in VPH Food Safety (Examples)
Bacterial Culture	Growth of microorganisms on selective/non-selective media for isolation/ID.	Isolation of foodborne pathogens (*Listeria*, *Salmonella*) from food, environmental, or clinical samples.
Microscopy (Light/Electron)	Visualisation of microorganisms, cells, or tissue structures.	Examination of blood smears for parasites/bacteria; histopathology of tissues for disease diagnosis.
Polymerase Chain Reaction (PCR)	Enzymatic amplification of specific DNA sequences for detection.	Rapid detection of pathogen-specific genes in samples; confirmation of pathogen identity.
Whole Genome Sequencing (WGS)	Determination of the complete DNA sequence of an organism's genome.	High-resolution subtyping, source tracking, outbreak investigation, AMR & virulence gene ID.
Multi-Locus Sequence Typing (MLST)	Characterisation of strains based on DNA sequences of multiple housekeeping genes.	Strain typing for epidemiological surveillance and outbreak investigation.
Serotyping (Conventional/In Silico)	Identification of specific surface antigens (serogroups/serotypes).	Classification of pathogens like *Salmonella*, *Listeria* for epidemiological purposes.
Analytical Chemistry (e.g., LC-MS/MS)	Separation, detection, and quantification of chemical compounds based on physical/chemical properties.	Detection and quantification of veterinary drug residues, pesticides, mycotoxins, other chemical contaminants.

AMR Profiling & Analytical Chemistry for Residues

- **Virulence Factor ID & AMR Profiling:**
  - WGS enables identification of virulence genes (e.g., *Listeria* Pathogenicity Islands) and mutations affecting pathogenicity.
  - Addresses Antimicrobial Resistance (AMR) by identifying AMR genes; VPH curricula include AMR as a key topic.
- **Analytical Chemistry for Residues:**
  - Ensures food is free from harmful chemical residues.
  - Onderstepoort Veterinary Research Campus has accredited techniques for veterinary drug testing in various matrices.
  - Relies on sophisticated methods like LC-MS/MS and GC-MS/MS to detect antibiotics, pesticides, etc..

Scientific Basis of Surveillance and Outbreak Response

- Effective surveillance and rapid outbreak response are fundamental, relying on epidemiology and lab support.
- **Pathogen Surveillance Programs:** Systematic collection, analysis, and interpretation of data (e.g., ARC-OVR *Listeria* project). Challenges include data sharing and lab capacity.
- **Epidemiological Tools for Outbreak Investigation:** Case definition, descriptive epidemiology, hypothesis testing, environmental investigation, and molecular subtyping (especially WGS). Example: 2017-2018 listeriosis outbreak investigation.
- **Monitoring Zoonotic Diseases:** Ongoing surveillance in animal populations using diagnostics, epidemiological studies, and a "One Health" approach.

Collaborative Scientific Ecosystem

- VPH endeavors involve a collaborative ecosystem:
  - **DALRRD Inter-directorate Synergies:** Collaboration between VPH, Animal Health, Food Safety and Quality Assurance is crucial for comprehensive risk management.
  - **Agricultural Research Council (ARC) - Onderstepoort:** Vital partner for DALRRD, providing advanced diagnostics (WGS), research (e.g., *Listeria* profiling), residue testing, and vaccine R&D (e.g., FMD vaccine).
  - **Provincial Veterinary Services:** Implement VPH science on the ground via inspections, local surveillance, and enforcement.
  - **Academic Institutions (e.g., University of Pretoria):** Train VPH specialists and conduct research contributing to food safety.
- Effective data sharing and coordinated action are key.

Conclusion: Summary and Path Forward

- VPH in South Africa uses diverse, evolving scientific disciplines (epidemiology, microbiology, pathology, toxicology, risk assessment), mandated by law (Animal Diseases Act, Meat Safety Act), to safeguard food of animal origin.
- Applied via meat inspection, hygiene management, physicochemical controls, and advanced lab diagnostics (WGS, residue analysis by ARC).
- Surveillance, outbreak response, and a collaborative ecosystem (DALRRD, ARC, Provincial services, Academia) are crucial, though challenges in data sharing and resource consistency exist.
- Future focus: addressing food fraud and AMR with innovative technologies and "One Health" strategies; enhancing early warning and risk-based decisions with rapid diagnostics, predictive modelling, and data analytics.

Strengthening VPH science depends on sustained investment, collaboration, data integration, and translating science into risk-based policies for a safe food supply

THANK YOU