Risk-based meat assurance systems; a work in progress

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1. Assurance systems for fresh meat

Meat hygiene assurance systems

- All of those components of food control that collectively assure the safety and suitability of meat
- Require a clear understanding of the respective roles of the food business operator, government and third-party accredited inspection bodies
- Contribute to animal health
- Enable trade
- Strive to be risk-based
- Codex recommendations to governments

Codex principles

- Industry has primary responsibility
- Farm-to-plate control and monitoring systems
- Science
- HACCP
- Risk analysis
- International harmonisation
- Equivalence

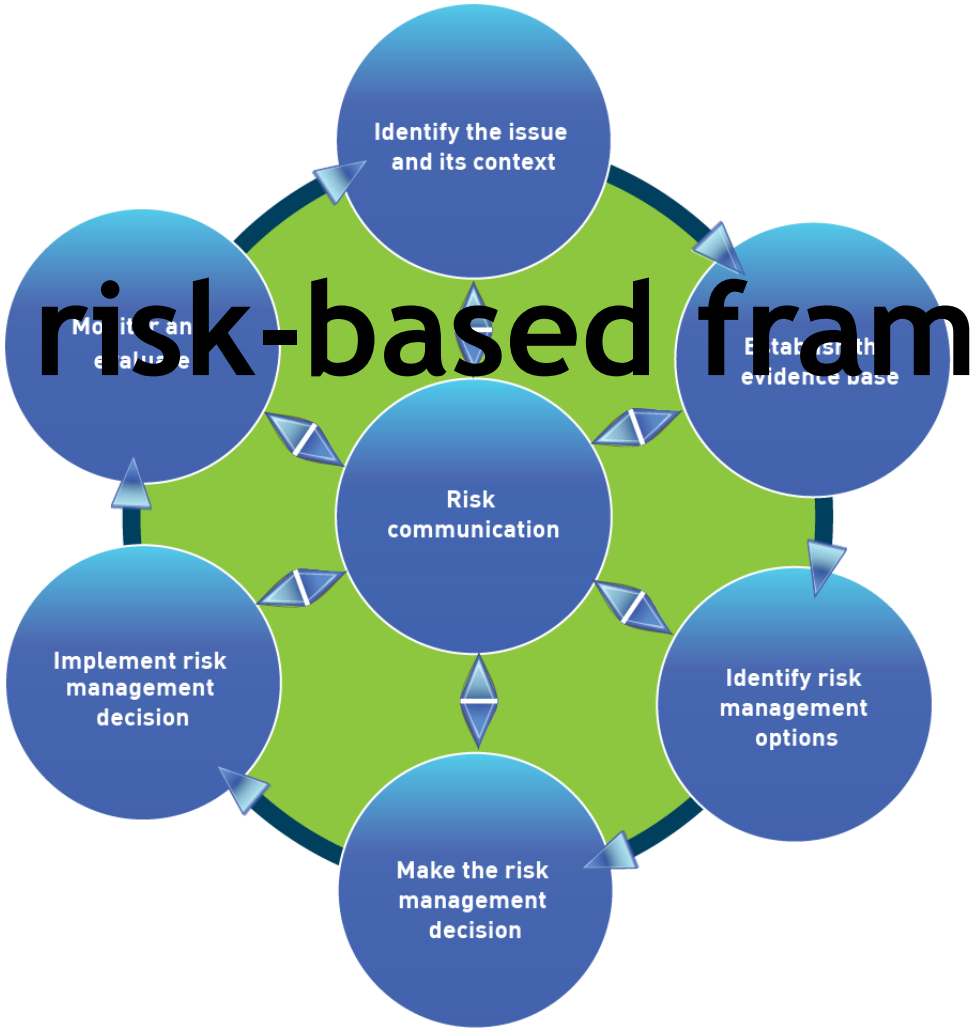
High level international guidance

- WTO SPS Agreement (1995)
- CCMPH: Code of hygienic practice for meat (2005)
- CCGP: Working Principles for Risk Analysis for Food Safety for Application by Governments (2007)
- CCFICS: Guidelines on judgement of equivalence of sanitary measures associated with food inspection and certification systems (2008)
- CCFICS: Guidelines for design, operation, assessment and accreditation of food import and export inspection and certification systems (2010)
- CCFICS: Principles and guidelines for monitoring the performance of national food control systems (2017)
- CX / EXEC project – operationalising statements of principle in regard to “other legitimate factors” for food in trade (2022)

Detailed international guidance

- Codex standards for chemical residues and environmental contaminants
- CCFH: Guidelines for the control of *Campylobacter* and Salmonella in chicken meat (2011)
- WHO: Multicriteria-based ranking for risk management of food-borne parasites (2014)
- CCFH: Guidelines for the control of *Trichinella* spp. in meat of Suidae (2015)
- FAO: Technical guidance – Principles of risk-based meat inspection and their application (2019)
- TFAMR: Guidelines on integrated monitoring and surveillance of foodborne antimicrobial resistance (2021)
- CCFH: Proposed draft guidelines on the control of STEC in raw beef, fresh leafy vegetables, raw milk and raw milk cheeses, and sprouts (2022)
- FAO / WHO web-based tool for *Salmonella* and *Campylobacter* in poultry

1. The risk-based framework



GHP outcomes for fresh meat

- Outcomes measured in terms of hygienic practice compliant with regulations and process hygiene parameters
- Tailored to general rather than specific end use of the product
- Thermal / chemical interventions can result in significant log reductions in indicator organisms and pathogens
- Post mortem inspection outcomes often focused on suitability and interventions not necessarily fit-for-purpose, especially in respect of effectiveness and efficiency
- Links between hygiene practices and public health outcomes mostly unquantified

Hazard-based outcomes for fresh meat

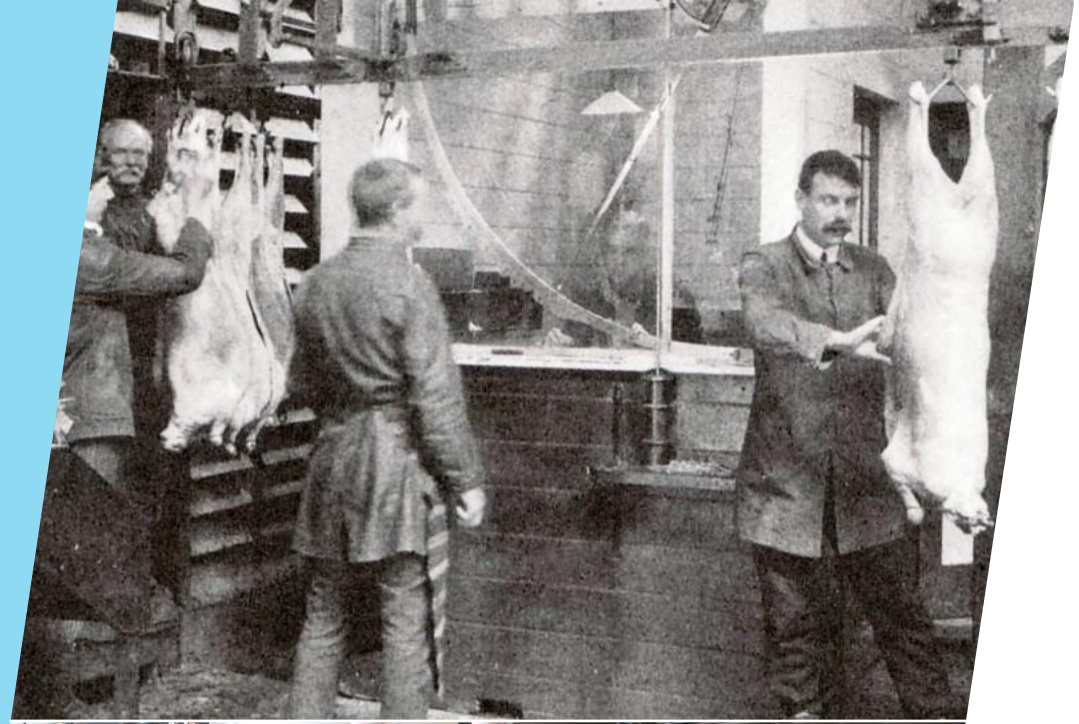
- Outcomes measured in terms of prevalence and/or level of hazards at the end of primary processing
- HACCP – What is the acceptable level of control of significant hazards at the particular step in the food chain that ensures safe food? (CCFH General Principles of Food Hygiene 2020)
- The decision on acceptability is informed by food chain data, legislation, availability of interventions, and information on food-borne illness
- *Expected* and sometimes evidenced reduction in risks to the consumer e.g. compliance with regulated safety criteria such as detection of Salmonella may have qualitative links with level of consumer protection

Risk-based outcomes for fresh meat

- Outcomes measured in terms of actual risks to human health
- Requires:
  - a quantitative model establishing links between hazard control and risks
  - ensuring that required levels of hazard control at appropriate steps in the food chain are met
  - making choices on ALOP under national conditions
  - transparency of decision-making
- In the ideal situation, regulated food safety criteria should be risk-based

“Fit-for-purpose” tools

- Risk profiles
- Comparative exposure (PM)
- Risk ranking
- Systematic review
- “Simplified” risk assessment
- “Full” risk assessment
- Food source attribution



2. Risk-based MSAS; Examples of risk-based approaches

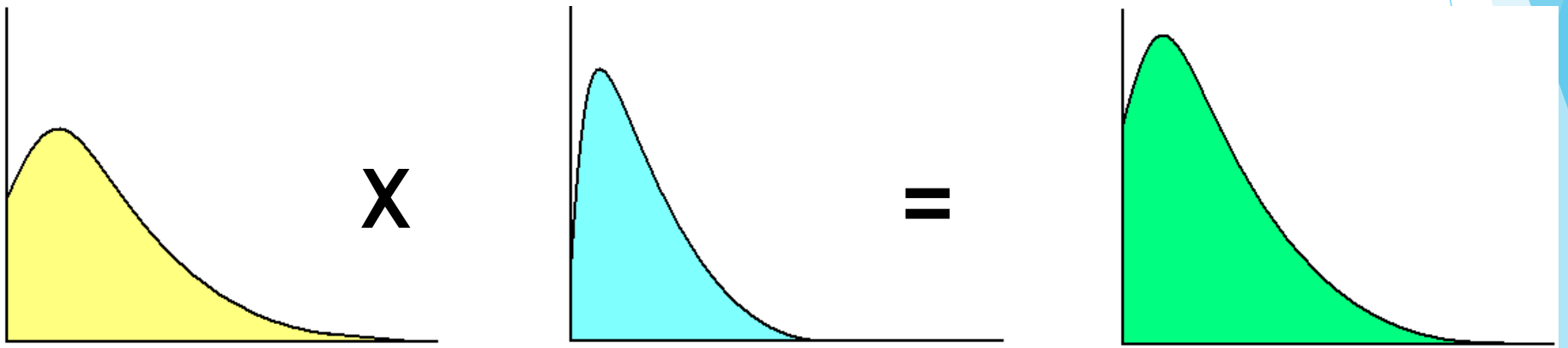
Priority hazards for fresh meat: a short list of unseen agents

- Chemicals
- Salmonella
- *Campylobacter*
- STEC
- *Yersinia*
- *Trichinella*
- *(M. bovis* - biosecurity)
- (AMR - public health)

Chemical hazards

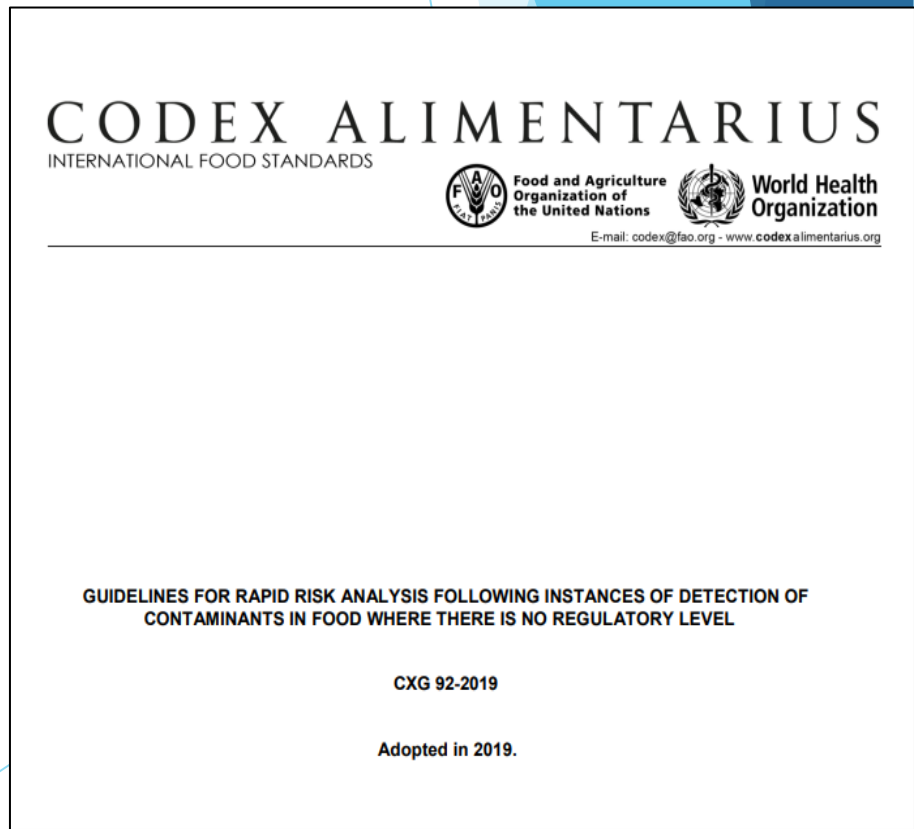
- Well established “risk-based” methodologies with high level of global harmonisation
- FAO/WHO Expert Committees do safety assessments to establish health-based guidance values e.g. ADI
- Regulatory limits have high levels of precaution
- For environmental contaminants, an ALARA standard-setting process is often needed
- Quantitative risk assessment continues to develop in a number of areas where it adds value
- Perceptions of food safety often have more impact with stakeholders than risks e.g. response to non-compliances with allowable levels

Value of probabilistic approach e.g. for determining dietary exposure?



The trade dimension: Sporadic and low levels of chemical contaminants in meat

- With new farming and food technologies and ever more sensitive testing methods (ppb), low levels of chemical contaminants may sometimes be found unexpectedly in food
- There are often no regulatory limits for such contaminants and detection on import can have a significant trade impact
- Codex has developed an evidence-based approach to guide internationally-harmonised risk management action

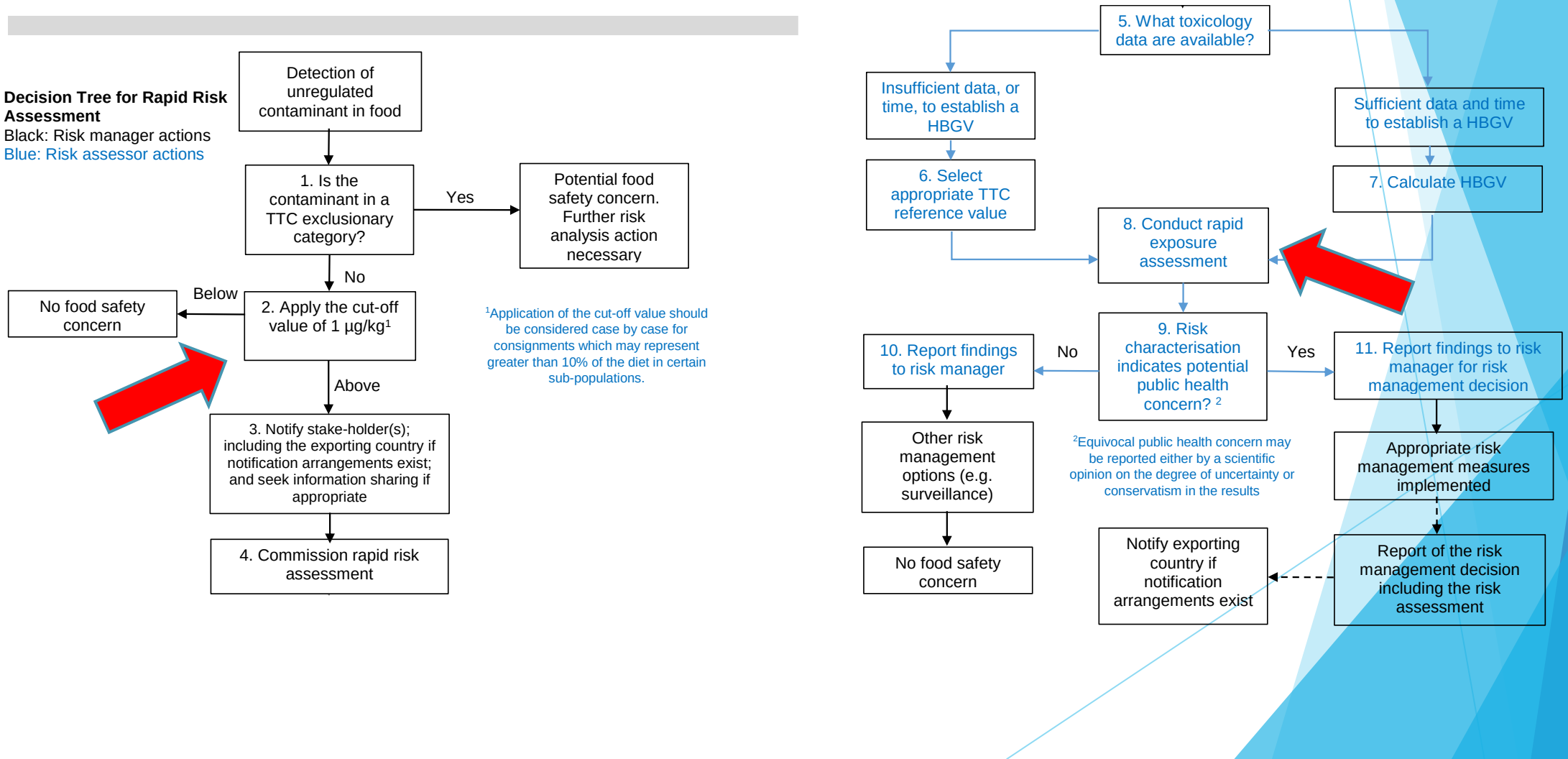

CODEX ALIMENTARIUS
INTERNATIONAL FOOD STANDARDS
Food and Agriculture Organization of the United Nations
World Health Organization
E-mail: codex@fao.org - www.codexalimentarius.org

GUIDELINES FOR RAPID RISK ANALYSIS FOLLOWING INSTANCES OF DETECTION OF CONTAMINANTS IN FOOD WHERE THERE IS NO REGULATORY LEVEL

CXG 92-2019

Adopted in 2019.

Chemical contaminants - incorporating a food safety "threshold of toxicological concern" approach



Biological hazards: parasites

- Quantitative models are relatively simple cf. models for micro-organisms
- Profound changes in inspection over the last decade
- EU / NZ: no testing of *Trichinella* for pigs from negligible risk compartments; US applies HACCP approach (HRLTO)
- *Taenia saginata* – risk modelling has led to highly differentiated PM in several countries

Trichinella: FAO risk contour for 1 or less human cases per million slaughtered pigs

	Population Size				
Proportion sampled	**10,000**	**100,000**	**1,000,000**	**10,000,000**	**100,000,000**
0.1%	118970	11897	1190	119	12
1%	13908	1391	139	14	1
10%	1326	133	13	1	0.1
20%	614	61	6	0.6	0.06
50%	186	19	2	0.2	0.02
90%	59	6	0.6	0.06	0.006
100%	43	4	0.4	0.04	0.004

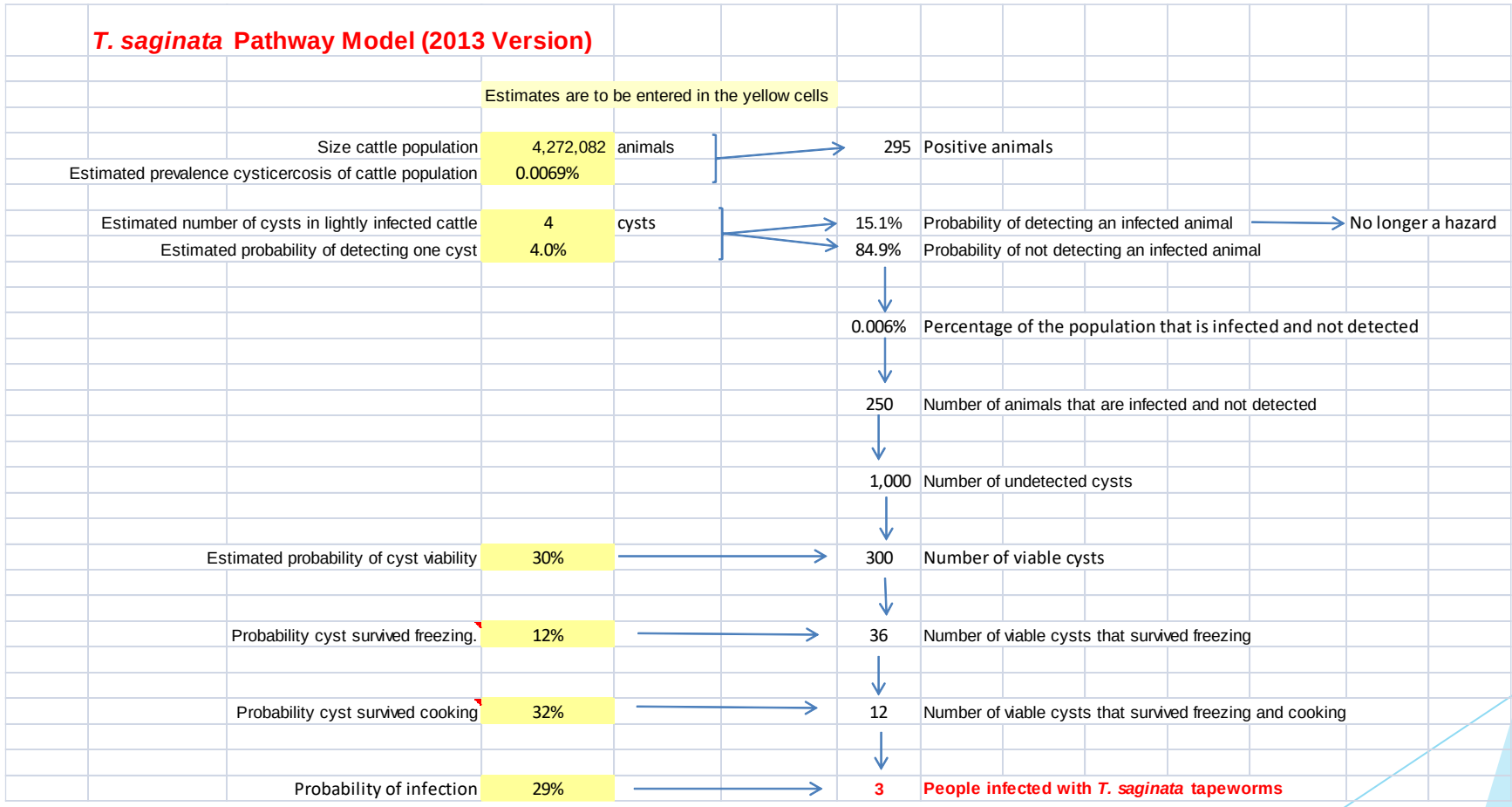
Taenia saginata

- "Traditional" post-mortem meat inspection is highly resource intensive but sensitivity for detecting a cyst in low prevalence / lightly infected cattle is very low

Benchmark - traditional inspection	4.7%
Delete superficial masseters cuts (left and right)	4.4%
Also delete deep masseters cuts (left and right)	4.1%
Also delete pterygoids cuts (left and right)	3.9%

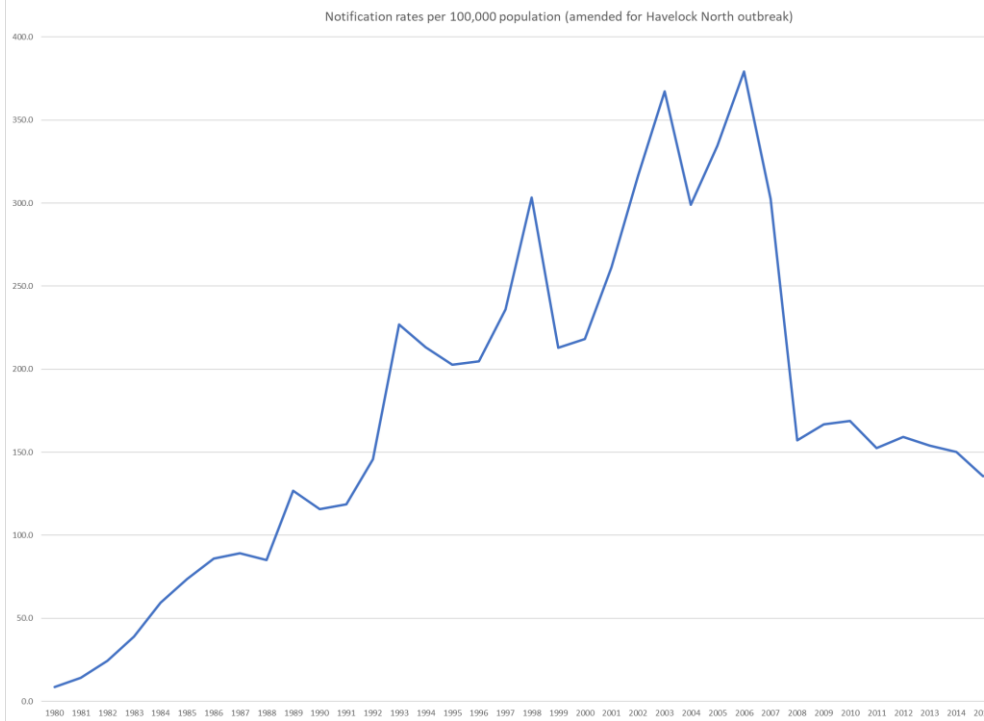
- The outcome of fewer incisions can be readily modelled
- EU: Less routine incisions from cattle of known age and/or provenance, where the CA has determined that the prevalence is less than 1 in 1m with 95% certainty (or no cases in last five years)
- Gradual moves towards international risk-based harmonisation

Risk model for *T. saginata:* Simulation run



Microbial hazards: *Campylobacter* in fresh poultry meat

- A priority foodborne risk in NZ
- 10% public health improvement target 2015 – 2020; squeaked in !
- Foodborne risk at approx. 70 cases per 100 000 population remains unacceptable
- New target for 20% reduction 2021 - 2024
- Regulated moving window standard at end of chill is primary CA risk management tool



Risk modelling of the poultry pathway

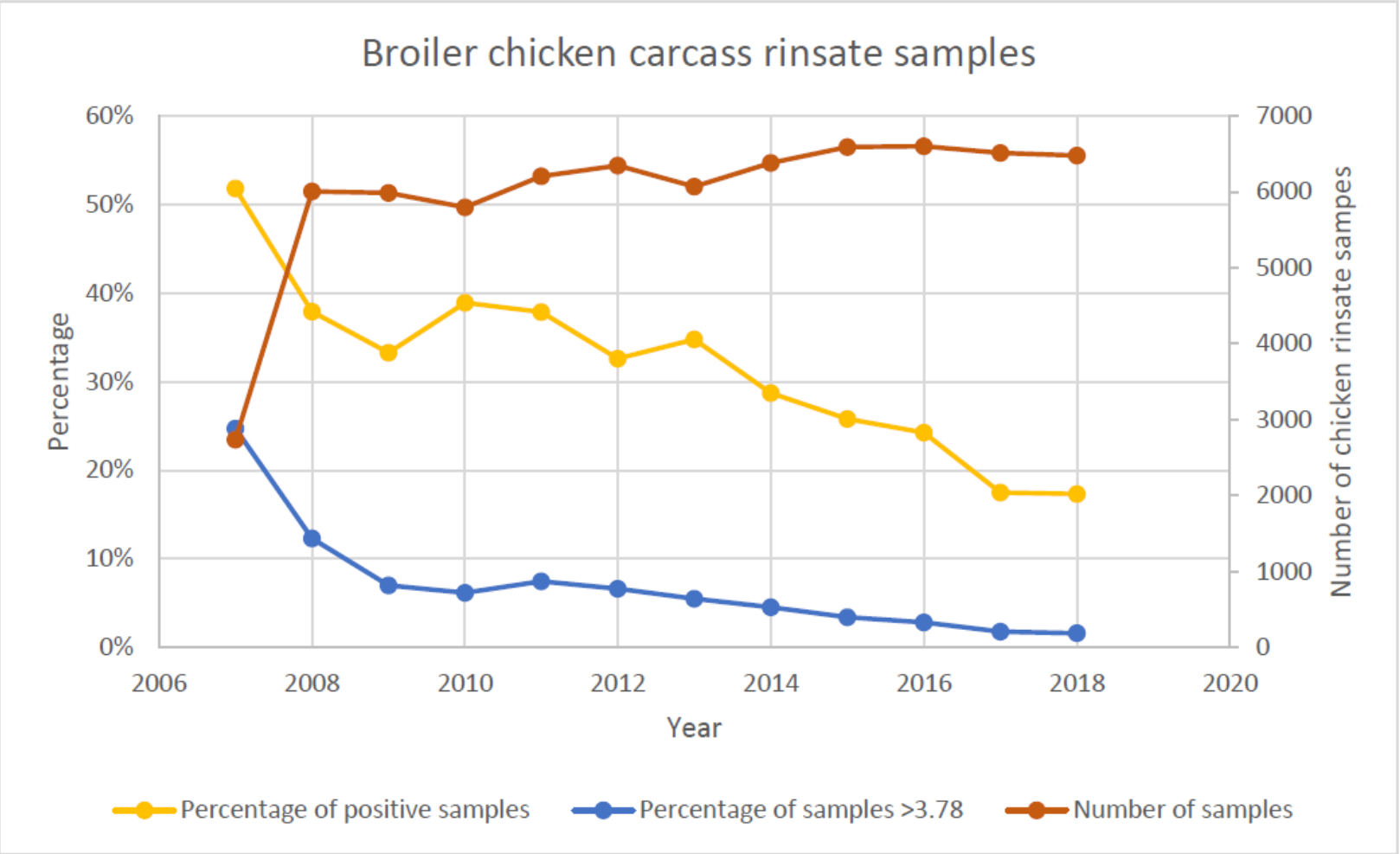
	20% ccs. positive but < 3.78 $\log_{10}$ cfu	15% ccs. positive but < 3.78 $\log_{10}$ cfu	10% ccs. positive but < 3.78 $\log_{10}$ cfu
2% ccs. > 3.78 $\log_{10}$ cfu	40	32	24
1% ccs. > 3.78 $\log_{10}$ cfu	36	28	20

- Prevalence of contamination and concentration levels on broiler carcasses work together to generate risks to consumers
- Predicted notification rates per 100 000 population reduce as contamination decreases
- Regression modelling more uncertain as levels decrease
- More sensitive test needed! (2022)

- EFSA 2020 – “A 3log10 reduction in broiler caecal concentrations was estimated to reduce the relative EU human risk attributable to broiler meat by 58%, compared to an estimate larger than 90% in the previous opinion”

Practicality of a tighter regulatory target

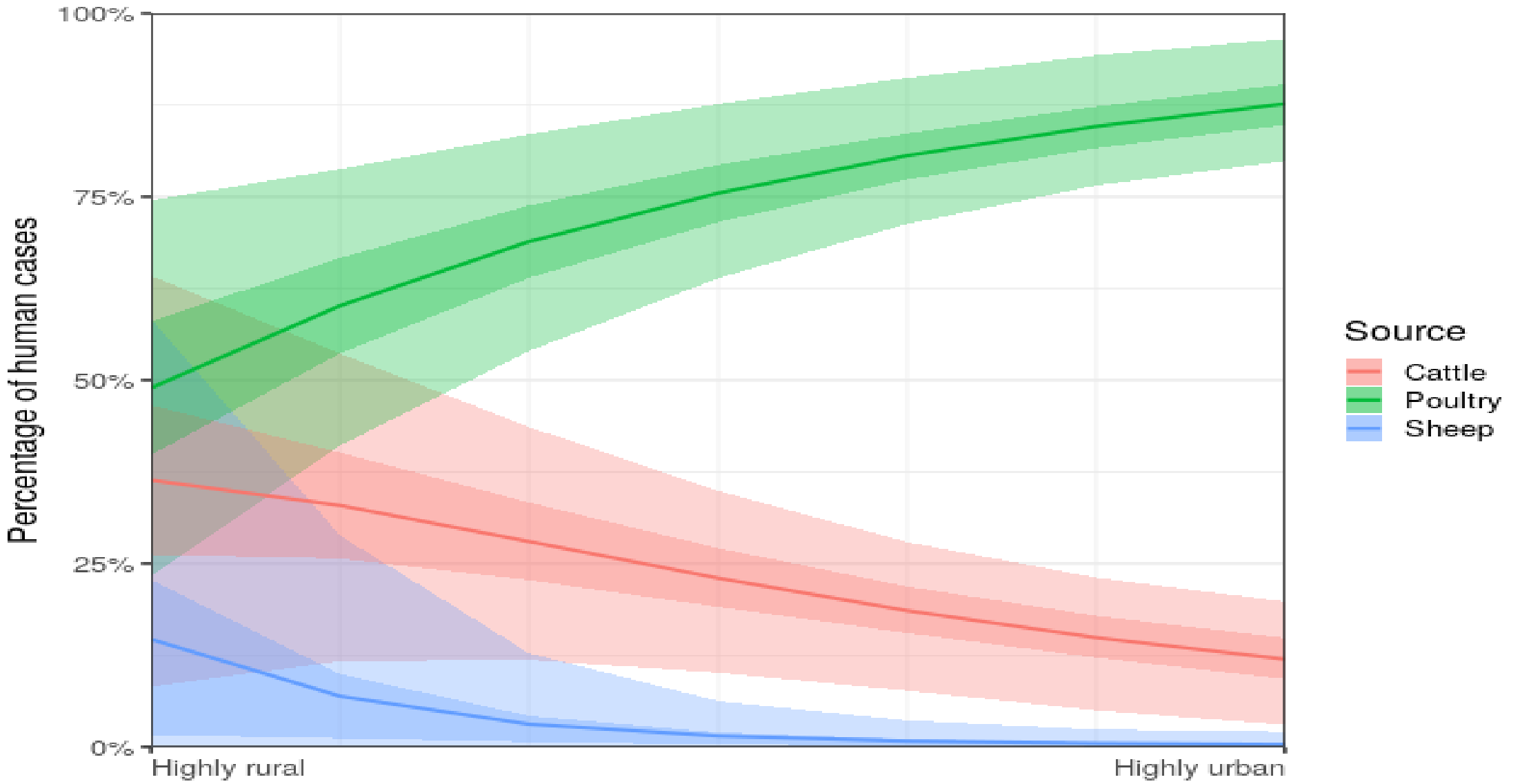
Figure 1: Percentage of chicken carcass samples where *Campylobacter* has been detected or exceeds the enumeration limit.



Source assigned case control study using whole genome sequencing (Lake *et al*., 2020)

- 600 cases and controls for the interviews; 200 samples (poultry, cattle, sheep) for the nested source attribution study
- Source assignment modelling (Island):
  - poultry 84%
  - cattle 14%
  - sheep 0%
  - unassigned 2%
- Significant risk factors for poultry cases included: consumption of undercooked chicken, consumption of chicken outside the home, use of proton pump inhibitors as a medication

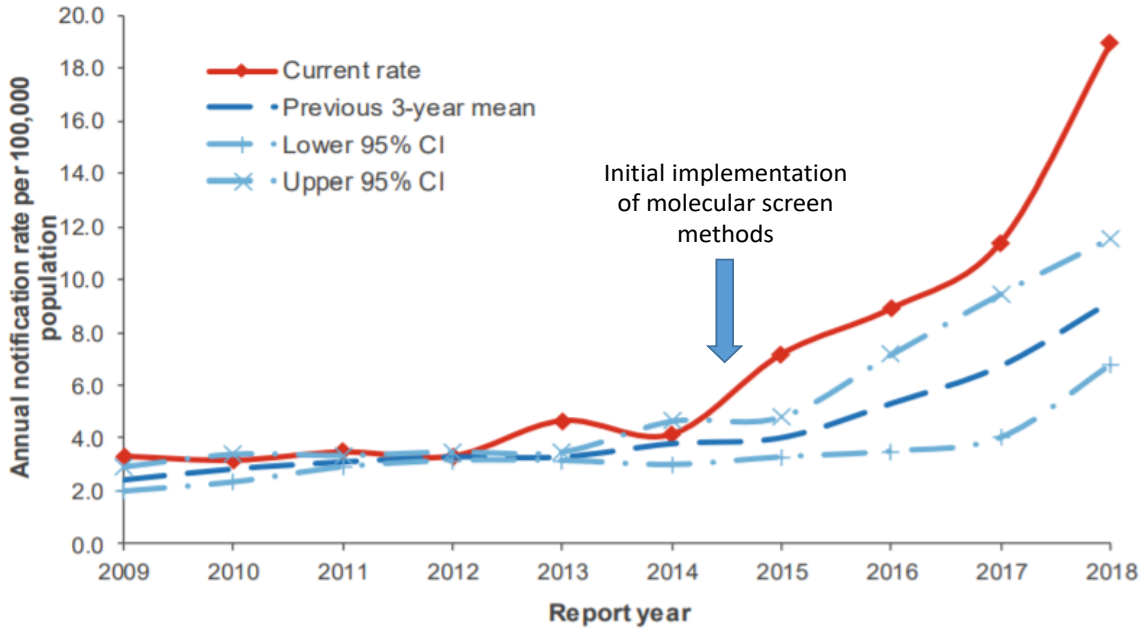
Urban / rural attribution (Liao *et al*., 2019)



Shiga toxin-producing *E. coli* (STECs); divergent evidence and action in New Zealand

- Large variety of ruminant strains in different countries with continually emerging science on virulence factors for humans
- Hygiene requirements for the ground beef supply chain have resulted in strict domestic regulatory controls and import testing requirements in the US
- Notified human illnesses in NZ increasing year-by-year but only food implicated is raw milk
- NZ red meat regulatory controls incorporate good hygienic practice, with special market access testing for the US
- Specific focus on very young calves

STEC infection notification rate by year, 2009–2018



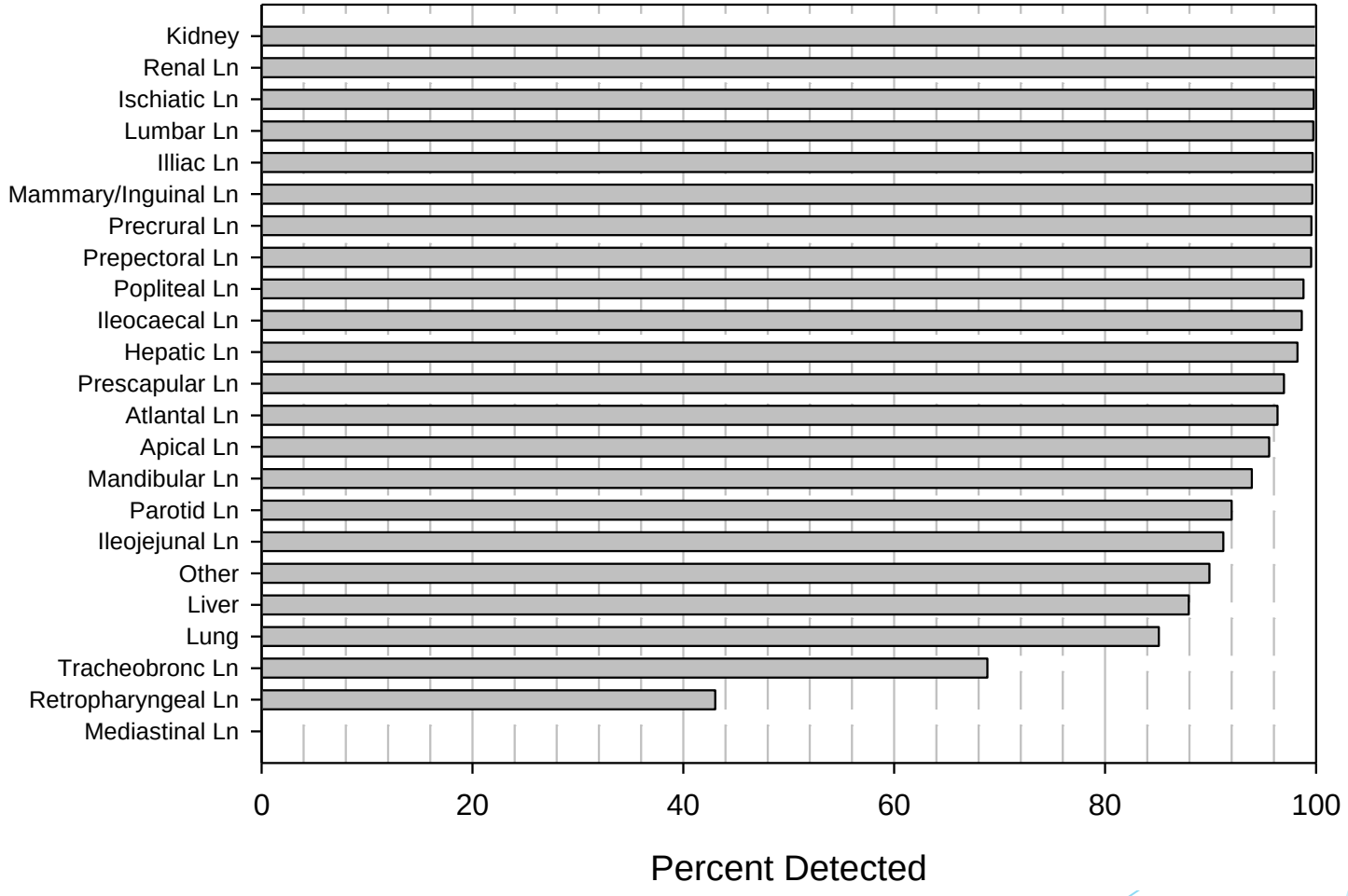
“Risk-based” post mortem inspection

- Major global advances over the last two decades, with different patterns of implementation in different countries
- Mainly reliant on risk profiles and comparative outcomes for gross abnormalities
- Lack of risk models for unseen microbiological contaminants limits comparative judgements on proportional reduction in risk
- Several countries introducing Company inspectors for non-food safety roles, with performance verified by the CA

Improved presentation of lambs for visual inspection

Improved presentation of lambs for visual inspection

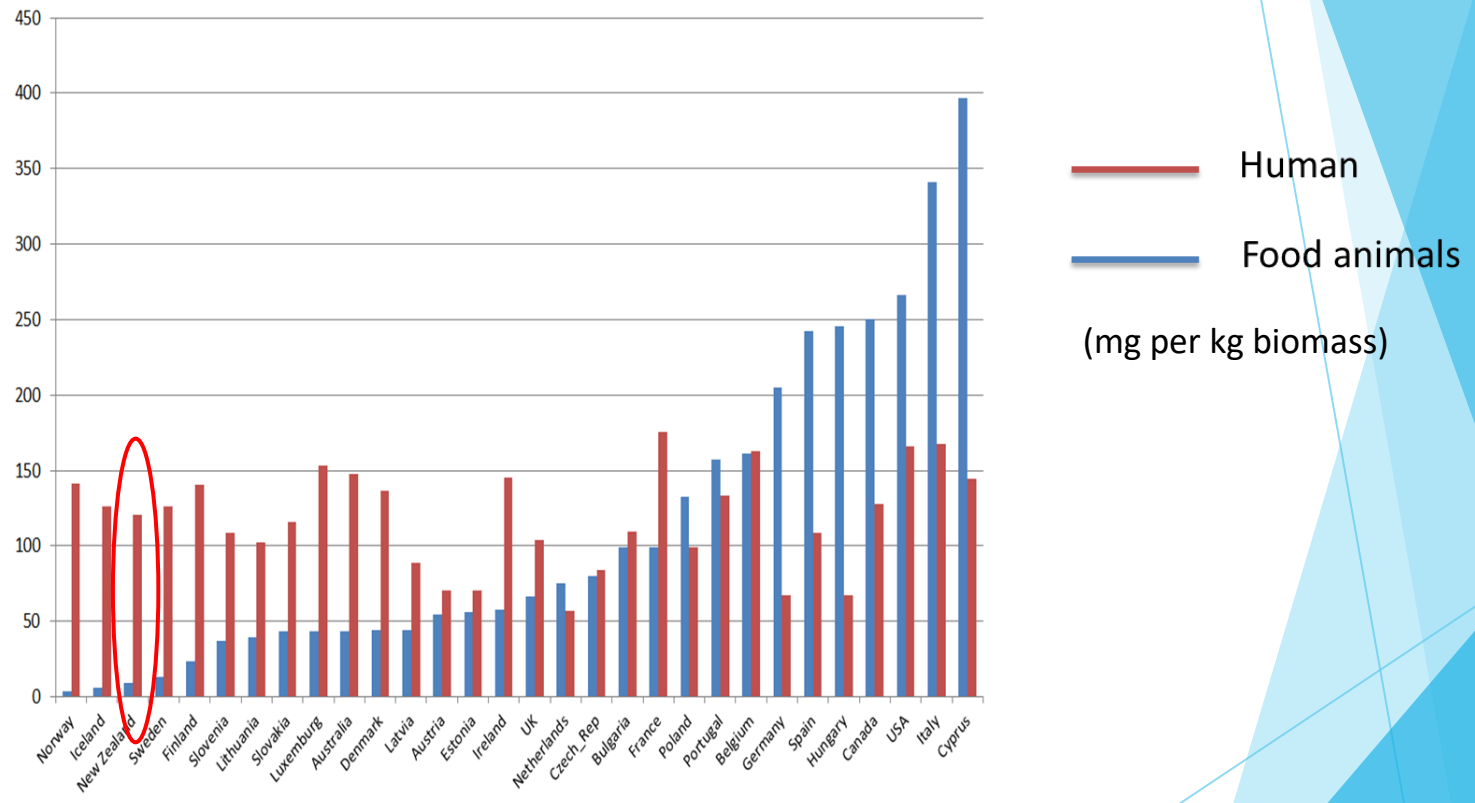
Probability of detection of *M. bovis* infection after sequentially dropping out inspection of a tissue



Recent changes in inspection of cattle in NZ

- Reflect greatly reduced prevalence of *M. bovis* in recent years
- Several carcass lymph nodes now not routinely examined e.g. lumbar chain, renal, atlantal, subiliac and superficial cervical
- Reduced level of palpation e.g. oesophagus, spleen and thick skirt
- Removal of routine examination of some organs e.g. gall bladder
- Modified incisions for *C. bovis*
- Visual-only inspection of very young calves
- More work to do!

Antimicrobial resistance and the public health importance of the food pathway?



Use of antimicrobials for animals in New Zealand compared with other countries
JE Hillerton, CR Irvine, MA Bryan, D Scott & SC Merchant, NZVJ, 2017

The microplastic food safety puzzle

The potential hazard

- macroplastics >20 mm
- mesoplastics 5 - 20 mm
- microplastics 0.1 - 5 mm
- nanoplastics <1 µm

Contamination pathways

- waste-water treatment plants
- biosolids
- plastics foils, clips and netting
- marine pollution
- food vs. environmental exposure

Very limited uptake data

- some foods (honey, sugar, salt)	+
- food plants	?
- food animals	x
- crustaceans, molluscs	?
- drinking water	x

No standard monitoring tests

Presence of manufacturing and environmental chemicals

e.g. flame retardants, plasticisers, DDTs, pesticides, heavy metals

Presence of microbial pathogen communities

e.g. *Vibrio, Campylobacter*

Almost no data on nanoplastics!

Very limited toxicokinetic data

- bioavailability in the gut
- cell metabolism
- cell toxicity
- associated chemicals / microbes

“The number of papers is growing exponentially in this field, but knowledge is not growing at the same rate”

Science Advice for Policy by European Academies. (2019). A Scientific Perspective on Microplastics in Nature and Society. Berlin: SAPEA. https://doi.org/10.26356/microplastics

5. Risk-based MSAS: A work in progress

Clarifying meat hygiene goals

- Animal welfare and animal health remain clear goals of AM inspection
- Strong evidence from risk-based approaches that differences in levels of control of faecal contamination of fresh meat result in measurable differences in public health outcomes
- Much less evidence that differences in PM inspection in modern MSAS systems result in measurable differences in public health outcomes
- Is risk-based innovation the role of government or industry?

Trade aspects

- Countries increasingly setting performance standards for priority pathogens that “are reasonably likely to occur”, e.g.
  - US – poultry - *Campylobacter* - continuous moving window as a process standard
  - EU - continuous testing for Salmonella as a safety standard
  - NZ - poultry - *Campylobacter* - moving window as a regulated safety standard
  - Canada / NZ - poultry - Salmonella - sets of testing with step down if compliant
  - US – beef - import testing for STECs as a regulated safety standard
- However, risk-based harmonisation of microbiological standards for fresh meat in trade remains problematic because comparison of data is difficult - legislation, sampling methods, availability, and allowable use of decontaminants (UK Chipping Campden report, 2021)
- Reported rates:
  - Salmonella for fresh beef/lamb/pork from different countries is 0 - 5%, with broiler meat as high as 25%
  - STEC in beef is 1 - 5%
  - *Campylobacter* for broilers has huge variability

Acknowledging the complexity of risk-based outcomes / use of fit-for-purpose tools

- Different end uses of meat (rather than meat type!)
- Different dietary exposure and public health profiles at the national level
- Ever-developing knowledge on adverse heath effects of chemical hazards e.g. acute reference doses, admixtures of residues
- Ever-developing knowledge on pathogenicity of microbial agents e.g. genomic makeup and virulence factors for STEC
- Integrating suitability expectations of consumers
- Need for innovation e.g. AMR
- Addressing the wider domain of “food-related health and well-being outcomes”

Risk- based MSAS for fresh meat: Do we need it?

- YES!
- Remarkable global buy-in to risk-based frameworks
- Value is clear for risk management of a range of hazard types and achieving continuous improvement
- Risk-based approaches for AM/PM procedures have fuelled steadily increasing global harmonisation, whereas microbiological criteria present considerable challenges
- More work is needed on links between indicator systems for faecal contamination and risks to human health but these are difficult to establish for low-level pathogens
- New and emerging issues (AMR, microplastics) demand focus and agility in gathering a sufficiency of evidence to guide risk-based action
- We need gradual and global change in the allocation of effort in MSAS, taking evidence- and risk-based opportunities as they arise (Blagojevich et al., Food Control 2021)

Thank you