
52
ND
Session of the Codex Committee on
FOOD HYGIENE

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JEMRA update on STEC work

Food and Agriculture Organization of the United Nations

World Health Organization

1980

1990

2000

2010

2020

EHEC in beef and sprouts “priority pathogen-commodity”(1999)

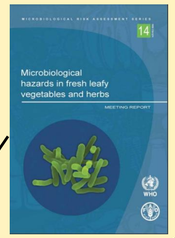
Agree to prepare risk profile for STEC in beef, pork and sprouts (2001)

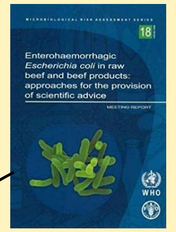
Discussion paper presented at CCFH (2003)

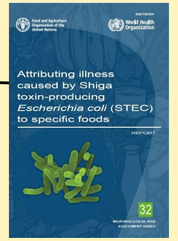
Request for scientific advice (2015)

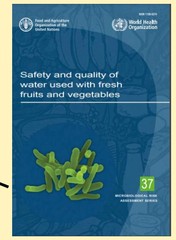
Requested additional scientific advice on STEC (2019)

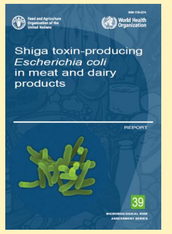
JEMRA, together with the Food Safety Authority of Ireland, convened an inception meeting (2006)

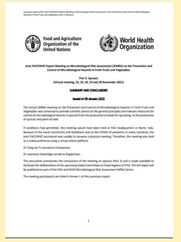












Sources and Reservoirs

TABLE 1 Animal hosts of Shiga toxin-producing *E. coli*

Common Name	Scientific Name	Reference
Cattle	*Bos taurus*	1, 7, 8, 10, 19, 21–23, 27, 29–33
Goats	*Capra aegagrus hircus*	34, 39, 40, 43, 44, 48, 49, 53
Sheep	*Ovis aries*	1, 35, 39, 43–47
Water buffalo	*Bubalus bubalis*	53, 54, 61
White-tailed deer	*Odocoileus virginianus*	62–64, 67–71
Bison	*Bison bison*	74–77
Elk	*Cervus canadensis*	72, 73, 80
Llamas	*Lama glama*	191
Alpaca	*Lama pacos*	83, 192
Yak	*Bos grunniens*	83
Eland	*Taurotragus oryx*	83
Antelope	*Antilope cervicapra*	83
Mountain goat	*Oreamnos americanus*	84
Guanaco	*Lama guanicoe*	79
Horses	*Equus ferus caballus*	85–88, 91
Donkey	*Equus africanus asinus*	84, 89, 90
Domestic swine	*Sus domesticus*	1, 92, 94–96, 101, 102
Feral swine	*Sus scrofa*	103–105
Chicken	*Gallus gallus domesticus*	92, 94, 125, 126
Turkeys	*Meleagris gallopavo*	92, 126
Pigeon	*Columba livia*	111, 116
Starling	*Sturnus vulgaris*	110, 112–114
Geese	*Branta canadensis*	107, 119
Turtle dove	*Streptopelia turtur*	112
Barn swallow	*Hirundo rustica*	112
Dogs	*Canis lupus familiaris*	39, 163, 165
Cats	*Felis catus*	166, 170, 171
Coyote	*Canis latrans*	84
Fox	*Vulpes vulpes*	84
Rabbit	*Oryctolagus cuniculus*	143, 144
Raccoon	*Procyon lotor*	152
Fish and shellfish		129–132
Norway rats	*Rattus norvegicus*	108, 137, 138
Ground hog	*Marmota monax*	84
Patagonian cavy	*Dolichotis patagonus*	83
Frogs		193
Ferrets[a]	*Mustela putorius furo*	172
Mice[a]	*Mus* spp.	114, 142, 180

[a]Experimental infections only.

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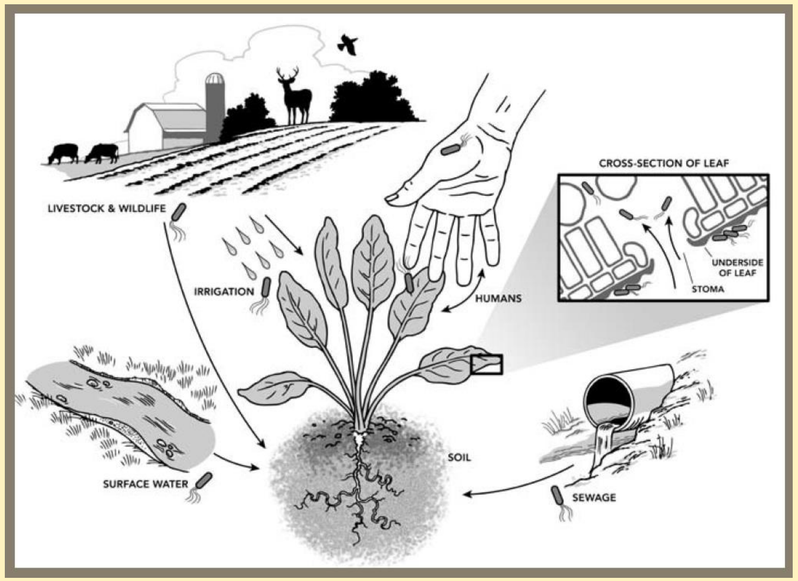

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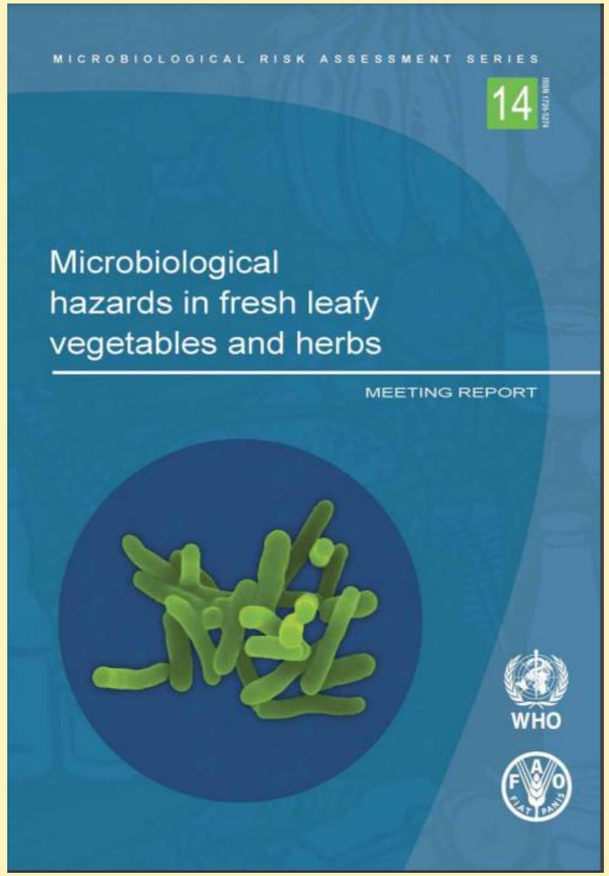
2008

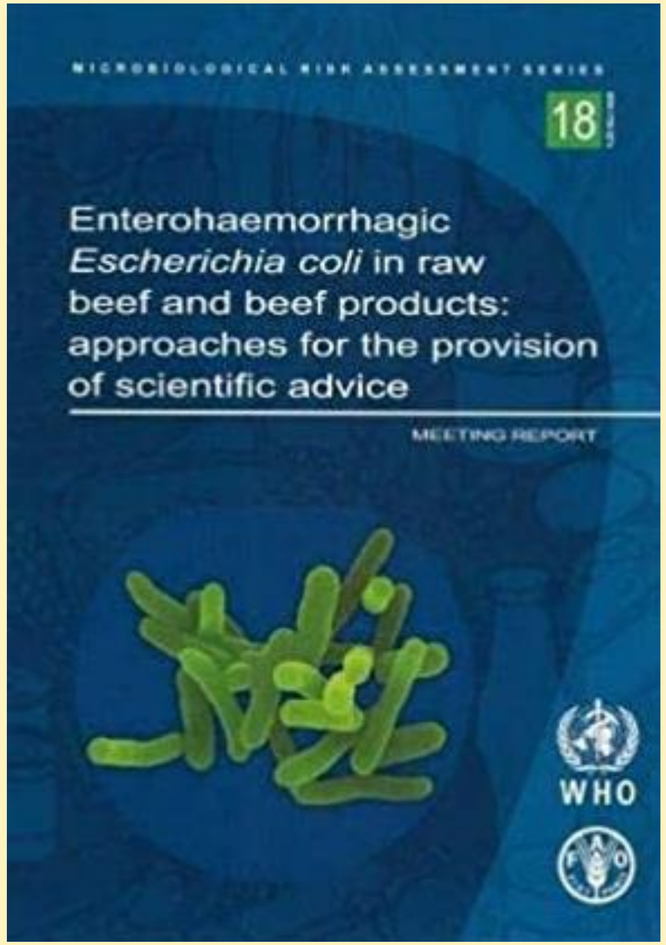


Vegetables important vehicle for STEC infections

Control measures identified in fresh fruits and vegetables

- Irrigation water
- Soil amendments
- Worker Hygiene
- Equipment Sanitation
- Control of wildlife Intrusion

2011



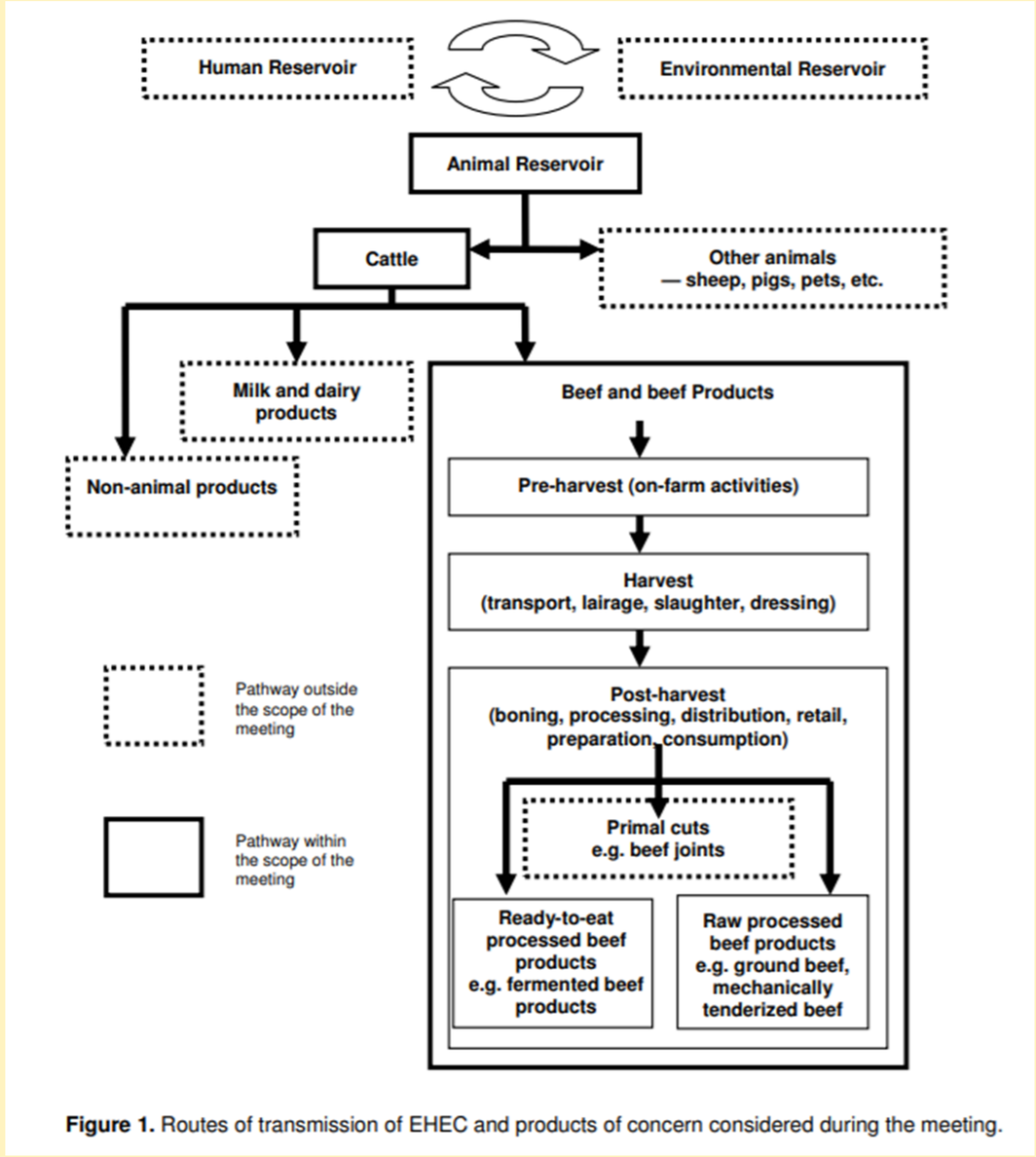
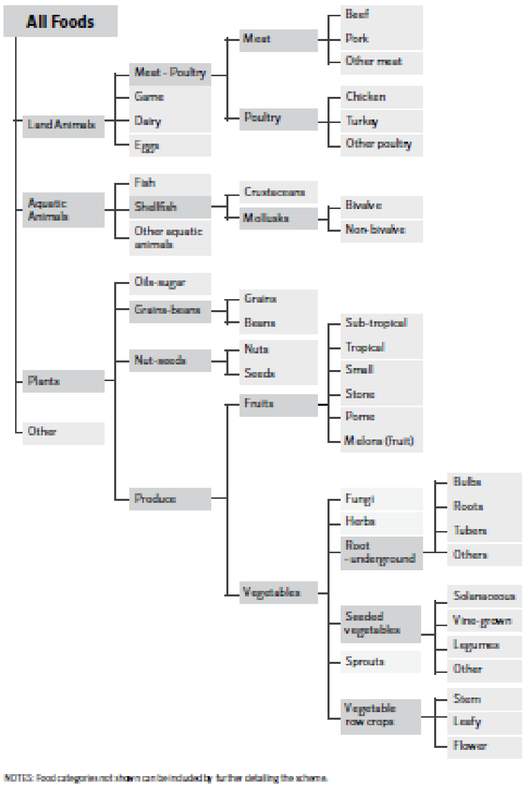


Figure 1. Routes of transmission of EHEC and products of concern considered during the meeting.

Outbreak Data 2018



NOTES: Food categories not shown can be included by further detailing the scheme.

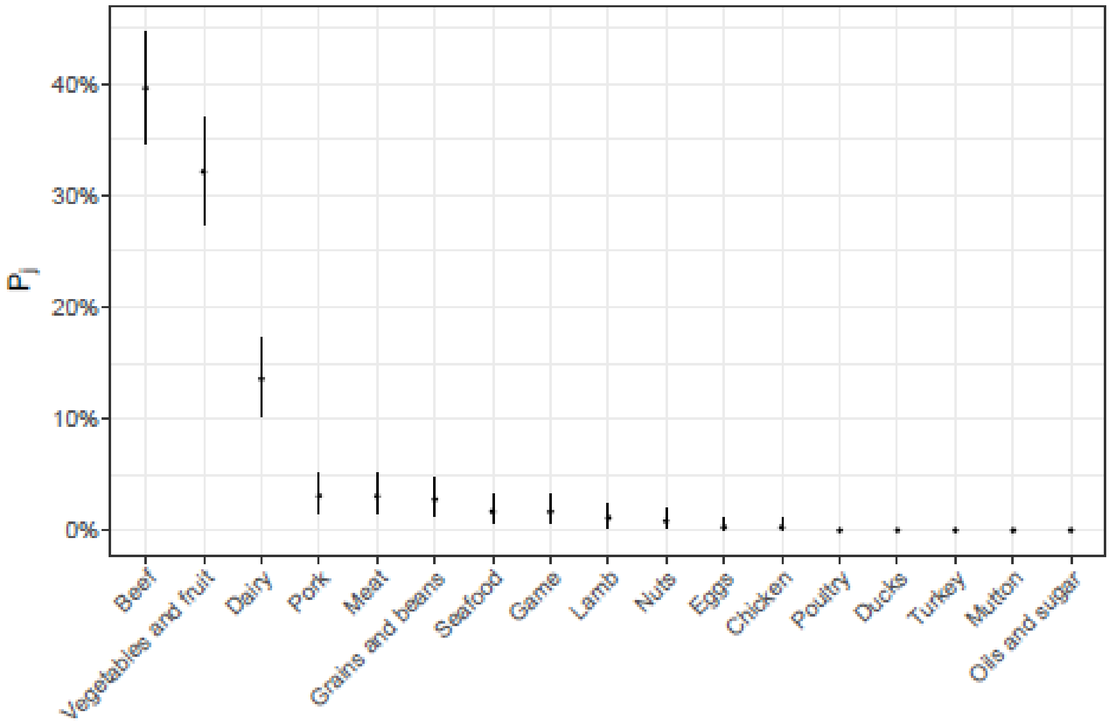


FIGURE 3. Estimates for P_j for food sources (median and 95% uncertainty interval)

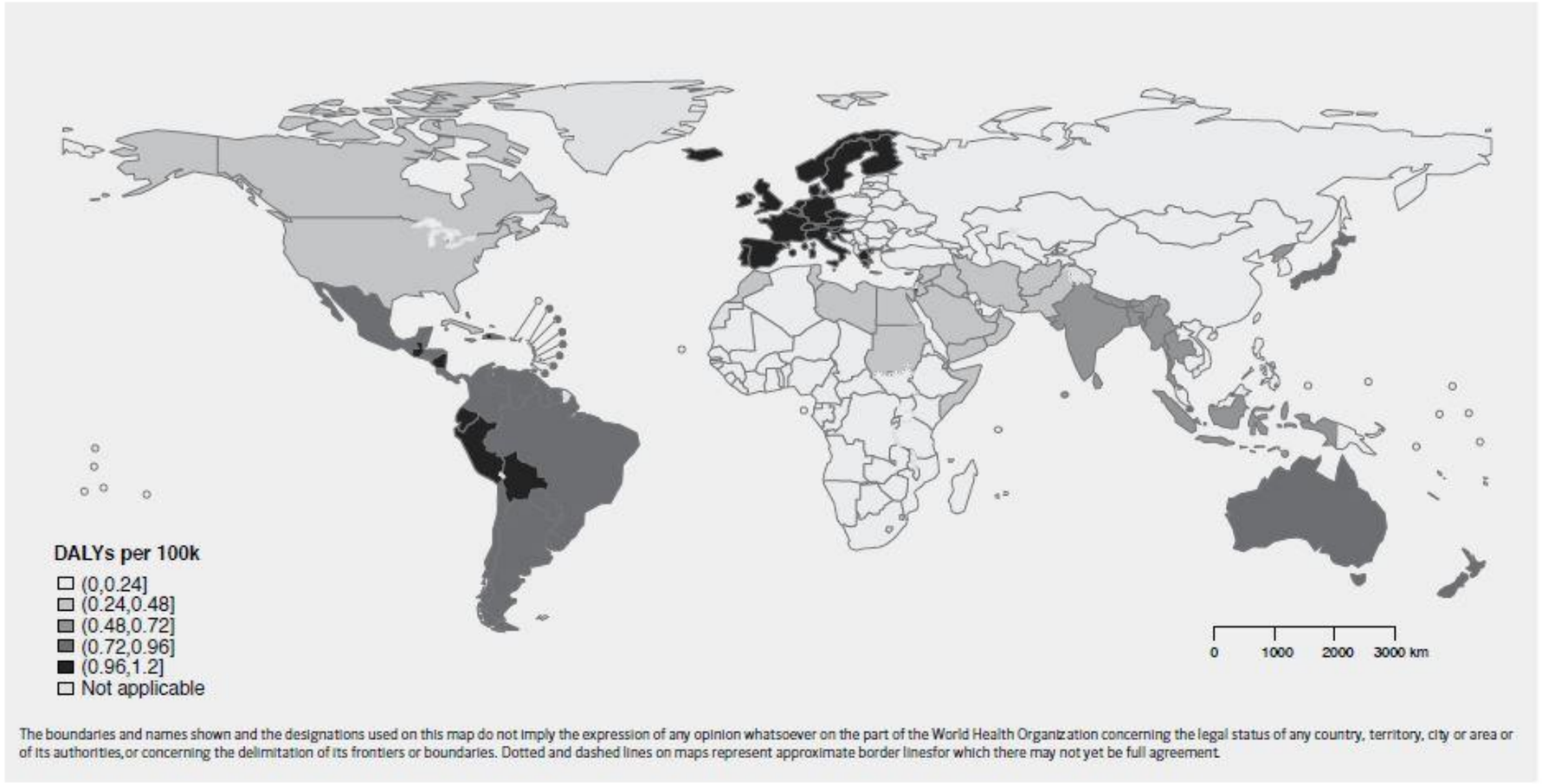
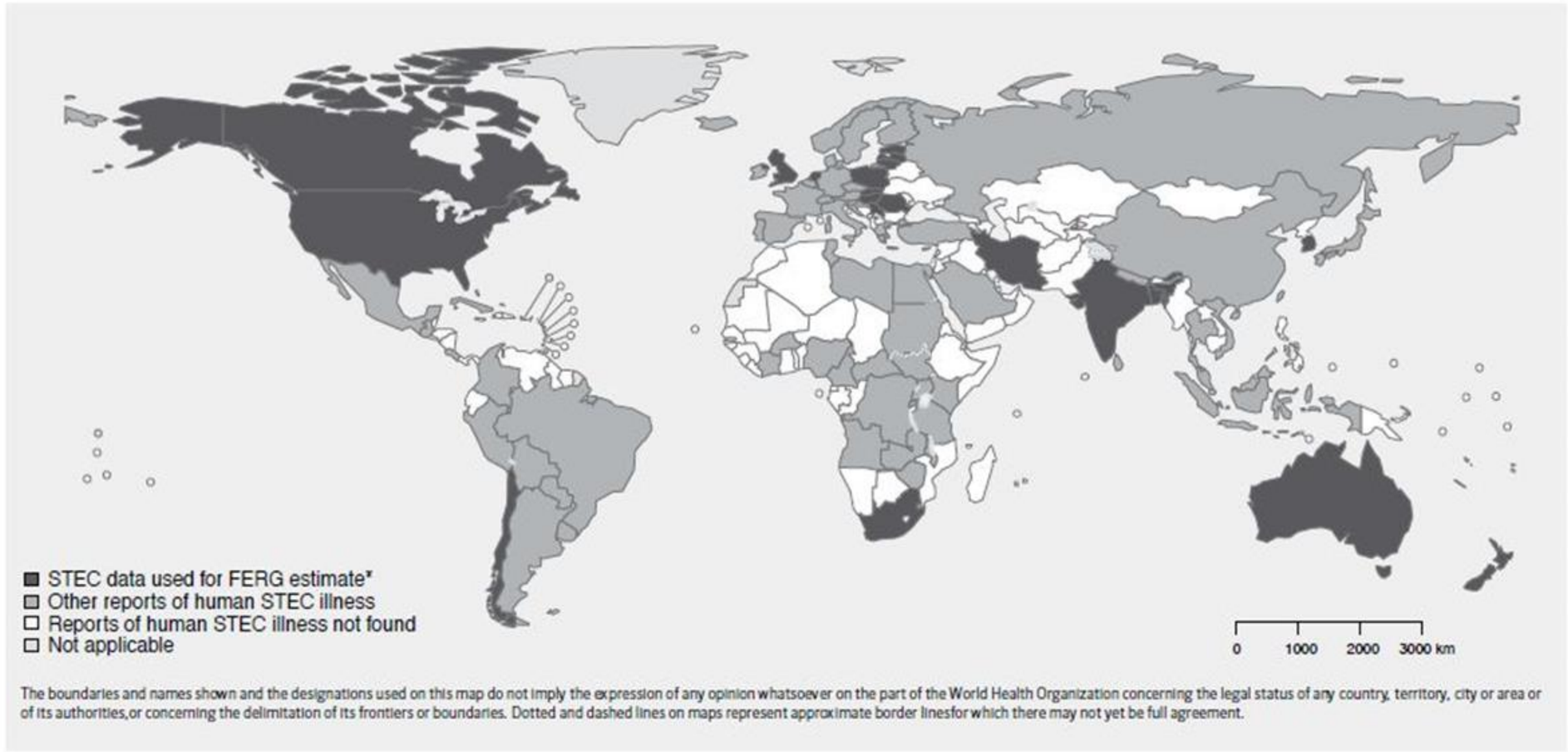


FIGURE 1. Disease burden (DALYs) of STEC by sub-region, 2010 (adapted from Kirk *et al.*, 2015)



NOTES: *21 countries and regions with data on STEC isolated from humans used to develop the FERG estimate of the burden of foodborne illness by region; Majowicz *et al.* (2014).

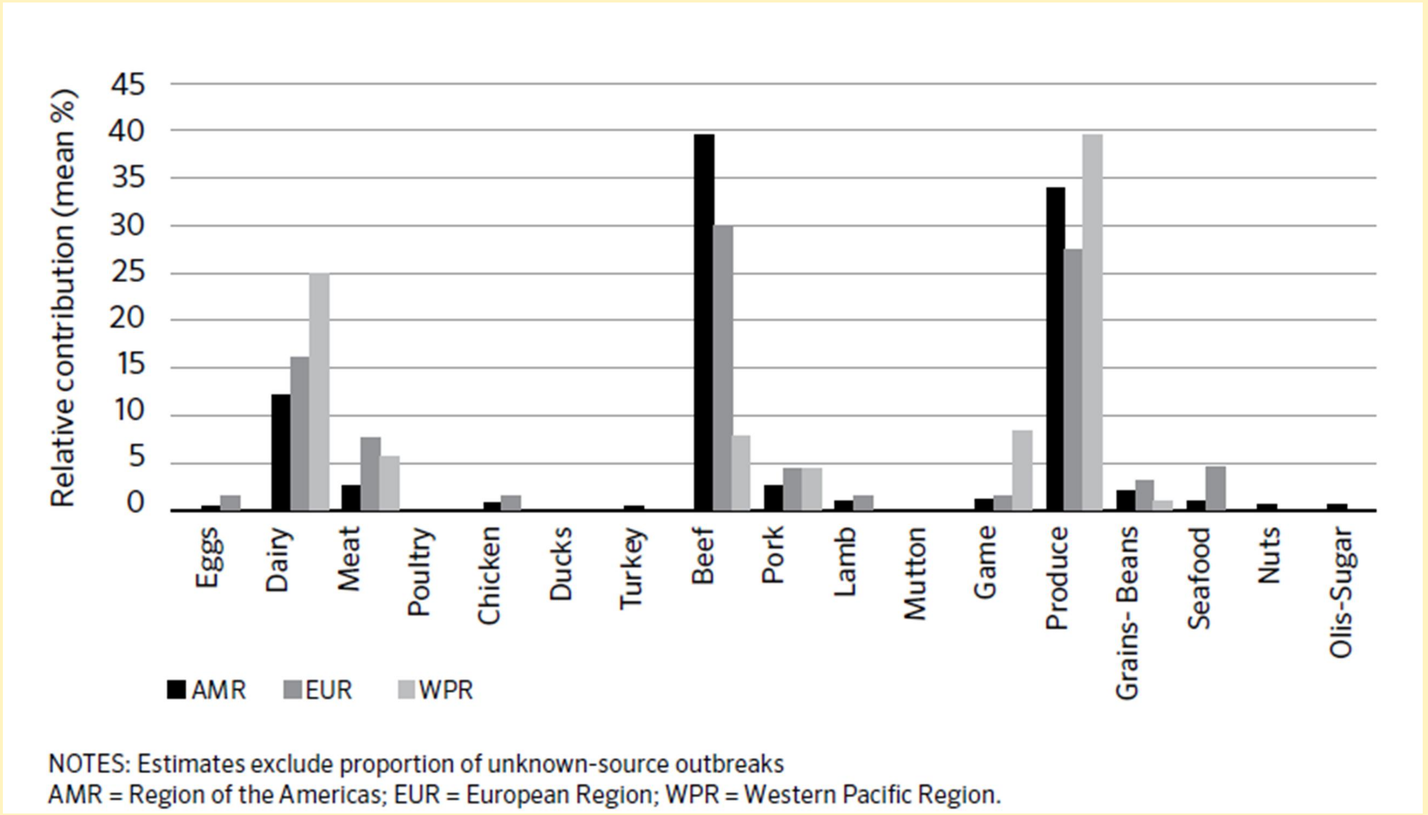
FIGURE 4. Countries with reported human STEC illness.

outbreak

TABLE 2. Proportion of STEC cases attributed to foods in WHO regions (%, mean and 95% uncertainty interval [UI])

	AMR			EUR			WPR		
	Mean	95% UI		Mean	95% UI		Mean	95% UI	
Beef	18.3	17.8	18.6	11.8	10.8	13.1	2.7	0	2.9
Produce (fruits and vegetables)	16.1	15.5	16.5	11.4	10.2	12.5	13.6	11.4	14.3
Dairy	5.5	5.2	5.9	6.2	6.2	6.2	8.6	8.6	8.6
Grains and beans	1.4	1.1	1.7	1.2	1.1	1.7	0.4	0	2.9
Pork	1.2	1.1	1.5	1.7	1.7	1.7	1.6	0	5.7
Meat	1.1	1.1	1.3	2.3	1.7	2.8	1.7	0	5.7
Game	0.5	0.5	0.7	0.6	0.6	0.6	2.9	2.9	2.9
Lamb	0.4	0.4	0.5	0.6	0.6	1.1	0	0	0
Seafood	0.4	0.4	0.4	1.7	1.7	1.7	0	0	0
Nuts	0.4	0.4	0.4	0	0	0	0	0	0
Chicken	0.1	0.1	0.3	0	0	0.6	0	0	0
Eggs	0	0	0.1	0.6	0.6	0.6	0	0	0
Poultry	0	0	0	0	0	0	0	0	0
Ducks	0	0	0	0	0	0	0	0	0
Turkey	0	0	0	0	0	0	0	0	0
Mutton	0	0	0	0	0	0	0	0	0
Oils and sugar	0	0	0	0	0	0	0	0	0
Unknown	54.4	54.4	54.4	61.9	61.9	61.9	68.6	68.6	68.6

*AMR: Region of the Americas; EUR: European Region; WPR: Western Pacific Region.



NOTES: Estimates exclude proportion of unknown-source outbreaks
AMR = Region of the Americas; EUR = European Region; WPR = Western Pacific Region.

Case control

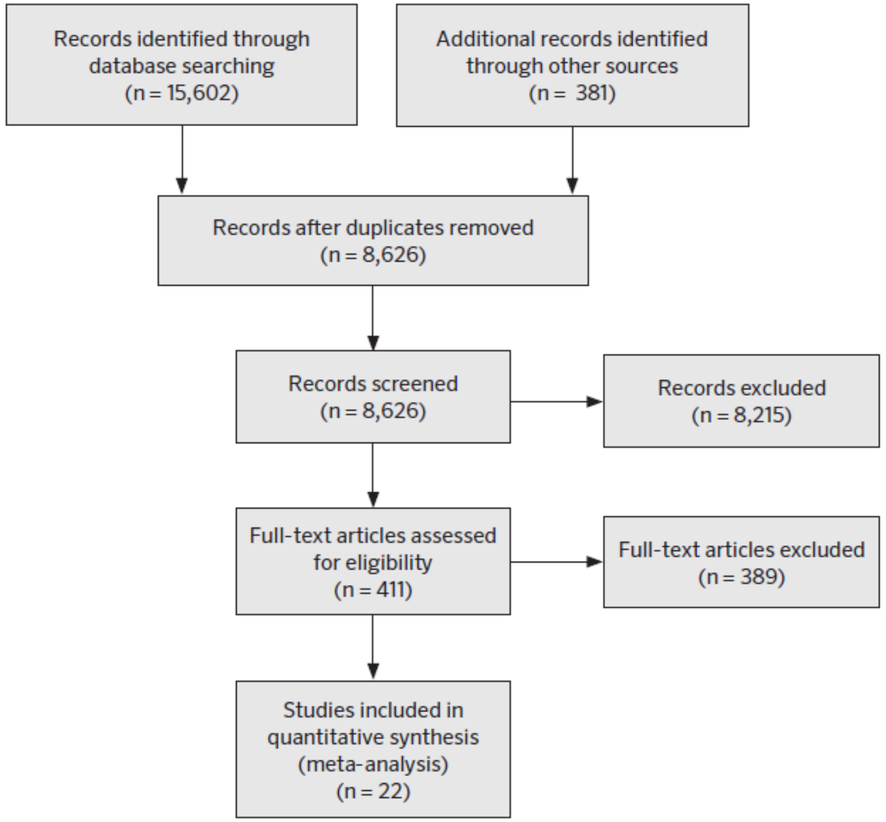
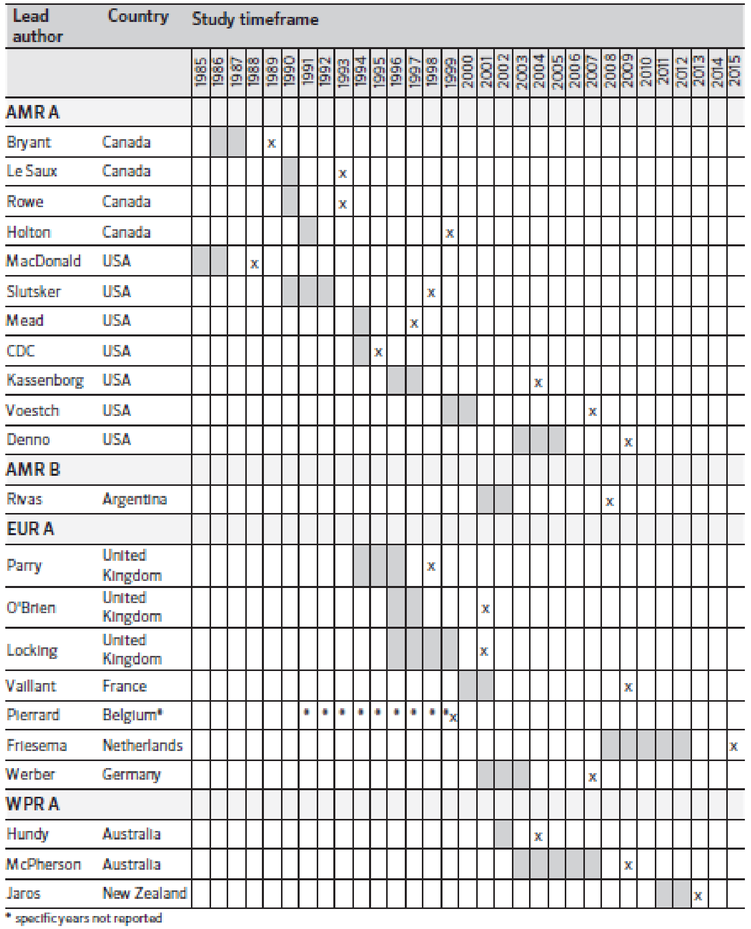


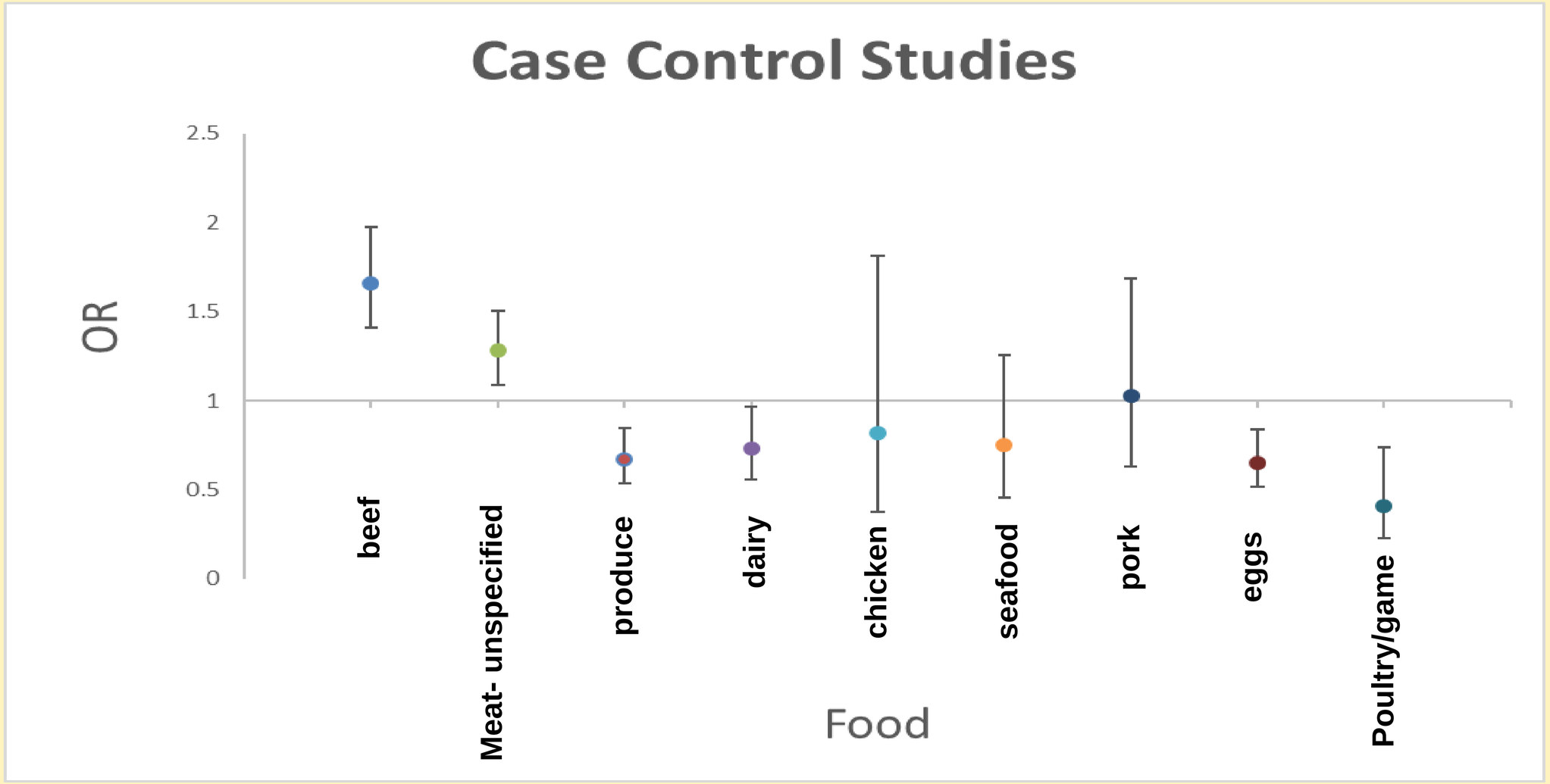
FIGURE 4. PRISMA diagram showing the results of the search for case-control studies of sporadic STEC infections in humans (all dates and locations)



Lead author	Country	Study timeframe
		1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
AMR A		
Bryant	Canada	x
Le Saux	Canada	x
Rowe	Canada	x
Holton	Canada	x
MacDonald	USA	x
Slutsker	USA	x
Mead	USA	x
CDC	USA	x
Kassenborg	USA	x
Voestch	USA	x
Denno	USA	x
AMR B		
Rivas	Argentina	x
EUR A		
Parry	United Kingdom	x
O'Brien	United Kingdom	x
Locking	United Kingdom	x
Vaillant	France	x
Pierrard	Belgium*	* * * * * * * *x
Friesema	Netherlands	x
Werber	Germany	x
WPR A		
Hundy	Australia	x
McPherson	Australia	x
Jaros	New Zealand	x

* specific years not reported

FIGURE 5. Study locations and timeframes for the 22 identified case-control studies of sporadic STEC infections in humans



22 Studies included

Hazard Identification: Virulence

TABLE 5. Combinations of STEC virulence genes and the estimated potential to cause diarrhoea (D), bloody diarrhoea (BD) and haemolytic uraemic syndrome (HUS) [1]

Level	Trait (gene)	Potential for:
1	*stx*$_{2a}$ + *eae* or *aggR*	D/BD/HUS
2	*stx*$_{2d}$	D/BD/HUS[2]
3	*stx*$_{2c}$ + *eae*	D/BD[3]
4	*stx*$_{1a}$ + *eae*	D/BD[3]
5	Other *stx* subtypes	D^

NOTES: 1. depending on host susceptibility or other factors; e.g. antibiotic treatment
2. association with HUS dependent on *stx2d* variant and strain background.
3. some subtypes have been reported to cause BD, and on rare occasions HUS

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4	stx_{1a} + *eae*	D/BD[3]
5	Other *stx* subtypes	D^

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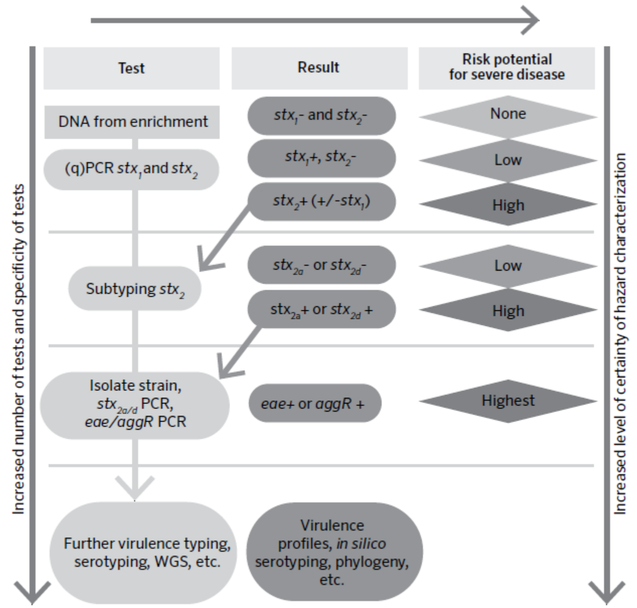

FIGURE 9 Strategy for testing STEC to discern level of health risk based on virulence genes

Monitoring

A variety of monitoring programs are employed globally, with different designs, based upon their respective purpose, including in: Including

- **Beef and other meats**
- **Dairy products**
- **Vegetables and sprouts**

Country	Purpose	Description	Pathogens and bacterial indicators
		NORTH AMERICA	
Canada	Ensure food safety and verify industry compliance with Canadian food safety standards	*E. coli* O157- Finished Raw Ground Beef Products (FRGBP) - Domestic raw ground beef or raw ground veal intended for use as FRGBP	Generic *E. coli*, STEC O157/NM
Canada	Ensure food safety and verify industry compliance with Canadian food safety standards	Pathogens in ready-to-Eat (RTE) Meat Products - Domestic uncooked dry or semi-dry fermented products containing beef	*Salmonella* spp., *Listeria monocytogenes*, STEC O157/NM
Canada	Ensure food safety and verify industry compliance with Canadian food safety standards	Beef/Veal Precursor Material (PM) Intended for Use in FRGBP	STEC O157/NM
Canada	Ensure food safety and verify industry compliance with Canadian food safety standards	RTE Fermented Meat [RTEM-F] Products - Fermented products that contain meat from all sources	*E. coli*, *S. aureus*, *Salmonella*, *L. monocytogenes*, STEC O157 (beef only)
Canada	Market access (Import)	*E. coli* O157- FRGBP - Imported raw ground beef or raw ground veal intended for use as FRGBP /Veal Products	Generic, *E. coli* STEC O157/NM
Canada	Market access (import)	Pathogens in RTE Meat Products - Imported uncooked dry or semi-dry fermented products containing beef	*Salmonella* spp., *Listeria monocytogenes*, STEC O157
	Market access (Import)	Imported PM Intended for Use in FRGBP	STEC O157
	Market access (Export)	PM Intended for export to USA (Industry testing program)	STEC O157:H7, 026, 045, 0103, 0111, 0121, and 0145.
USA	Ensure food safety and verify industry compliance with the USA food safety standards	Sampling verification activities for STEC in raw beef and veal products including trims. Routine testing by FSIS Beef manufacturing trim; raw ground beef components other than trim	STEC O157 Non-O157 STEC for trims including serotypes 026, 045, 0103, 0111. 121, 0145 *Salmonella* spp.
		Bench trim derived from cattle not slaughtered on site Raw ground beef products in establishments that grind and form patties Raw ground or commuted beef or veal retail programme	*E. coli* O157:H7 and *Salmonella*

Detection

Methodologies are constantly evolving.

Pros and cons to various methods.

Purpose	Approach	Example
Identification	Isolation	Culture
		Enrichment
		Immunoconcentration
	Molecular	PCR
		rtPCR
		metagenomics
	Immunological	ELISA
Characterization	Phenotypic	Serotyping
		Stx production
		sorbitol fermentation
		bet-glucuronidase production
	Molecular	PCR
		PFGE
		MLVA
		WGS

Interventions

STEC specific

vaccination, bacteriophage, probiotics

STEC sensitive

GAP, hygiene, temperature control

Scientific inference employed to extrapolate to STEC

Evaluated for:

Primary production, beef and dairy

Beef processing

Post-processing beef

Dairy processing

Highly effective

Increasing efficacy

- Temperature controls
- Irradiation
- Pasteurization
- lairage/bedding hygiene
- Feeding cattle probiotics
- Feed components
- Steam/hot water carcass vacuum
- Udder hygiene
- Stocking density
- Vaccination of cattle against O157
- Closed herds
- Post harvest bacteriophage
- Wildlife exclusion
- Pre-harvest bacteriophage
- Organic acid carcass wash
- Water trough management

Increasing confidence in approach

Stronger Evidence

Less/non-effective

Preliminary Representation

Ten take-home messages

1. STEC remains a public health problem,O157 and non-O157 serotypes
2. New vehicles are emerging
3. Beef, produce, and dairy are primary sources
4. Molecular tools are improving risk assessments
5. Monitoring programmes should be appropriate to answer the risk management questions and the testing programmes should be fit for their purpose
6. Interventions need not be STEC specific to be effective
7. Good Agricultural Practices and Good Manufacturing practices are beneficial control measures
8. Probiotics and non-thermal processing are tools for control
9. No single “silver bullet”. Multi-hurdle approaches needed.
10. Loss of control downstream can abrogate upstream interventions

Existing Codex texts related to STEC

General Principles of Meat Hygiene

Code of Hygienic Practice for Fresh Fruits and Vegetables

Code of Hygienic Practice for Fresh Meat

Code of practice for fish and fishery products

Standard for live and raw bivalve molluscs

Others is development

Thank you!

A special thanks to all the experts!