Canadian Food Inspection Agency | Agence canadienne d'inspection des aliments

CFIA Risk modelling

Examples of food safety Risk assessment

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October 31, 2024

Canada

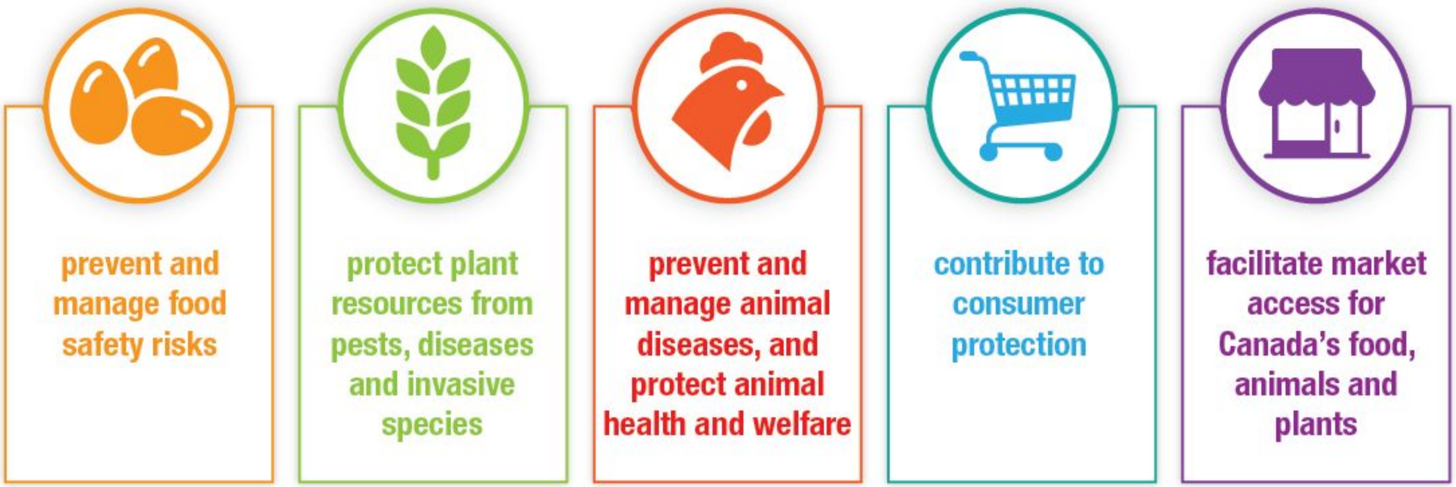
Outline of presentation

Food risk assessment at the Canadian Food Inspection Agency (CFIA)

- Food Import Risk Explorer (FIRE) model for prioritizing imported food risks
  - Using FIRE model results to make decisions to manage food safety risks
- Risk Model to support the development of a Performance Standards
  - *Salmonella* in Poultry (an example)

What CFIA Does

The CFIA develops regulations and delivers inspection and other services to:

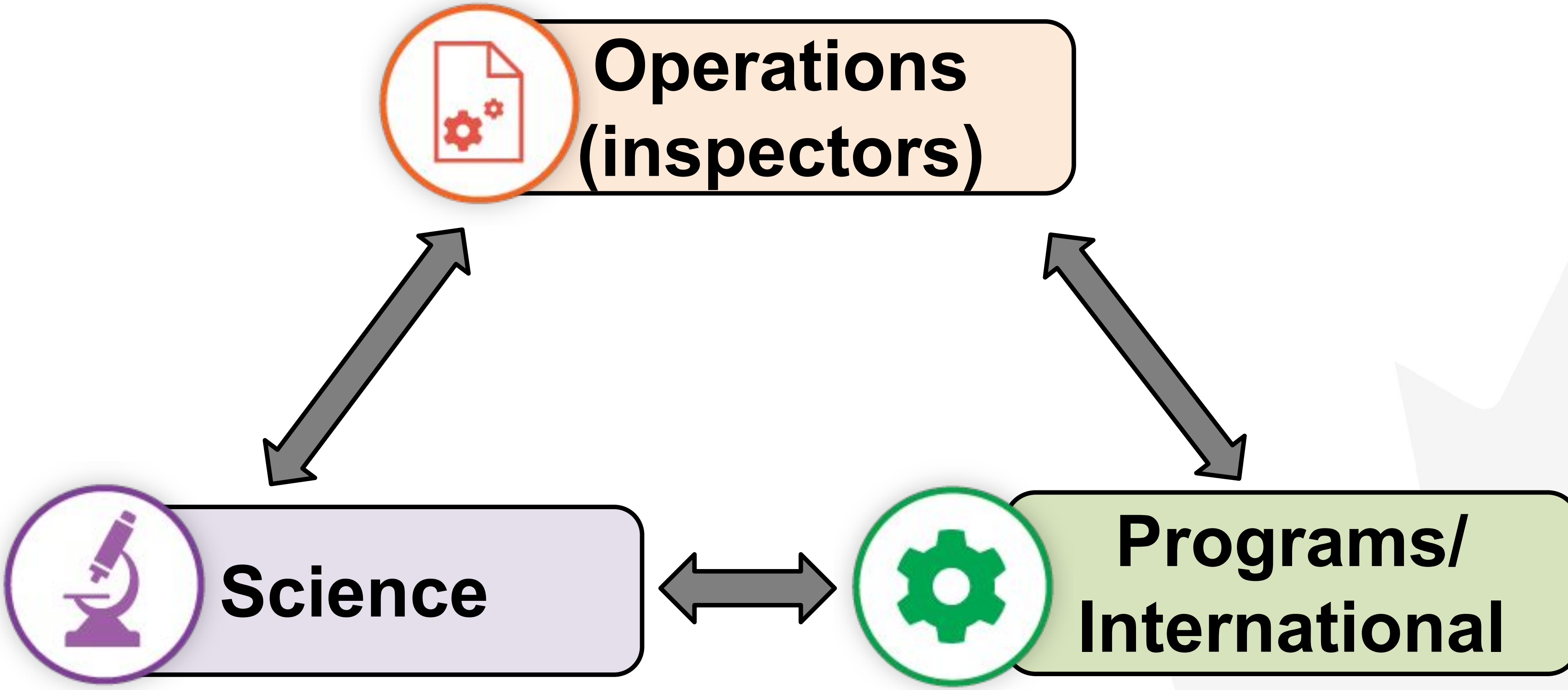


Vision

To excel as a science-based regulator, trusted and respected by Canadians and the international community.

How We Are Organized

CFIA Core Branches Work Together to Support Mandate



Protection of Canada’s food, animal and plant resources

Food Risk Assessments in the Government of Canada

- Health Canada
  - Primarily Qualitative risk assessments
- CFIA
  - Responsible for risk assessments using modelling to inform food risk management priorities, program design & implementation
    - For specific questions such as risk of a food-hazard combination of concern
    - Applies broadly at the program level to inform prioritization and resource allocation
    - Primarily use quantitative risk assessment methodology

Risk Assessments/Modelling in CFIA

- Risk assessment activities conducted by three groups in CFIA's Science Branch:
  - Animal Health Risk Assessment and Intelligence (AHRAI),
  - Plant Health Risk Assessment (PHRA) and
  - Food Advanced Data Analytics and Risk Modelling (FADARM)

Risk Assessment Fundamentals

Identify the hazard

- Identify the hazard (pest, bacteria, virus, etc.) that may cause harm to food safety, animal health or plant health

Determine the likelihood of exposure

- What is the likelihood that the hazard will be introduced into Canada?
- What is the prevalence of the hazard in Canada?
- What is the likelihood of exposure to the hazard in Canada?

Determine the consequence of exposure

- What is the likelihood that the hazard causes harm in Canada?
- How severe are the consequences associated with the hazard in Canada?

Integrate likelihood and consequence to provide a final risk estimate

- Includes an estimation of uncertainty
- Used to inform risk management options and decision-making

Uncertainty in Risk Assessment

- Results from incomplete or conflicting information
- Can be reduced or eliminated with more or higher quality information
- Must be documented in a risk assessment
  - Ensures risk management decisions account for this uncertainty
  - Ensures transparency in the process

Risk Assessors

- Risk assessment is carried out by highly trained subject matter experts in each business line:
  - Plant – Botanists, Plant Pathologists, Entomologists
  - Animal – Veterinarians, Epidemiologists,
  - Food – Food Microbiologists, Epidemiologists, Veterinarians, Statisticians & Toxicologists

Advanced Data Analytics and Risk Modelling Team at the CFIA (Food)

Science-based evaluations and data-driven analytical solutions to support and inform program design and risk management decisions

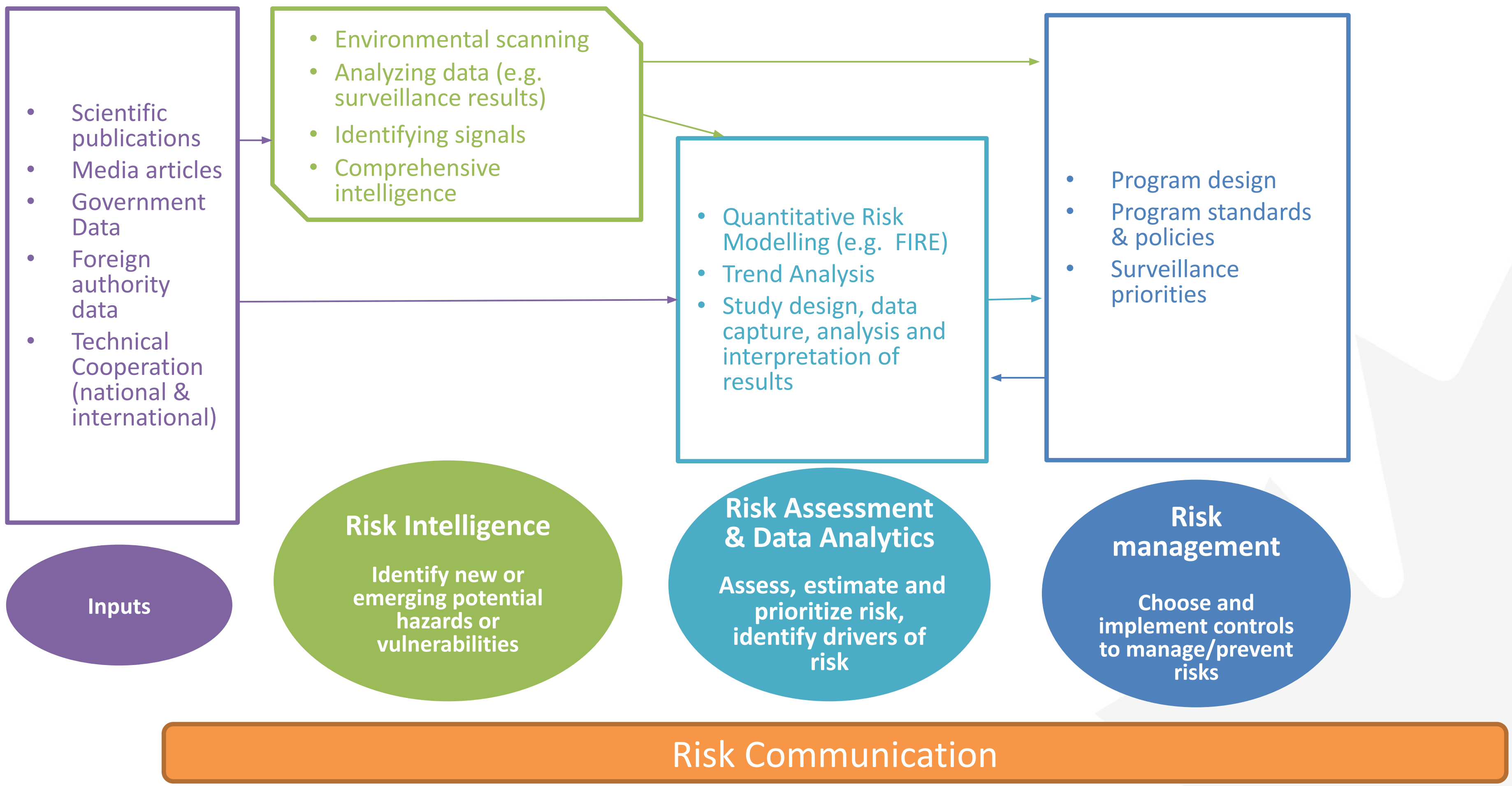
Expertise in:

- Advanced data analytics (artificial intelligence)
- Epidemiology
- Risk modelling
- Statistical services

Examples of analytical and risk modelling solutions:

- Meat Slaughter Program Design
- Trend analysis methodology
- Food Import Risk Explorer (FIRE) model

Managing Food Risks to Canadians



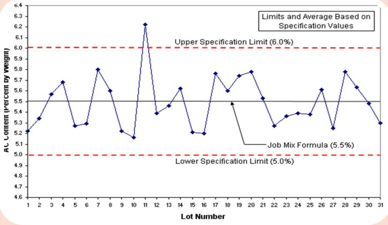
Food Risk Modelling Outputs

Estimate risk (high risk food-hazards combinations)

- e.g., *E. coli* O157:H7 in Raw ground beef

Estimate risk reduction (control or an inspection activity)

- e.g., Food safety defects removal in poultry (Modernized Poultry Inspection Program)



Design Risk-informed performance standards

- e.g., *Salmonella* and *Campylobacter* Performance Standards in poultry (Pathogen Reduction)

Design Risk-based sampling

- e.g., *Listeria monocytogenes* Risk-based Sampling in Ready-To-Eat meat (Weatherill Recommendations)

Contribution to Managing Food Safety risks

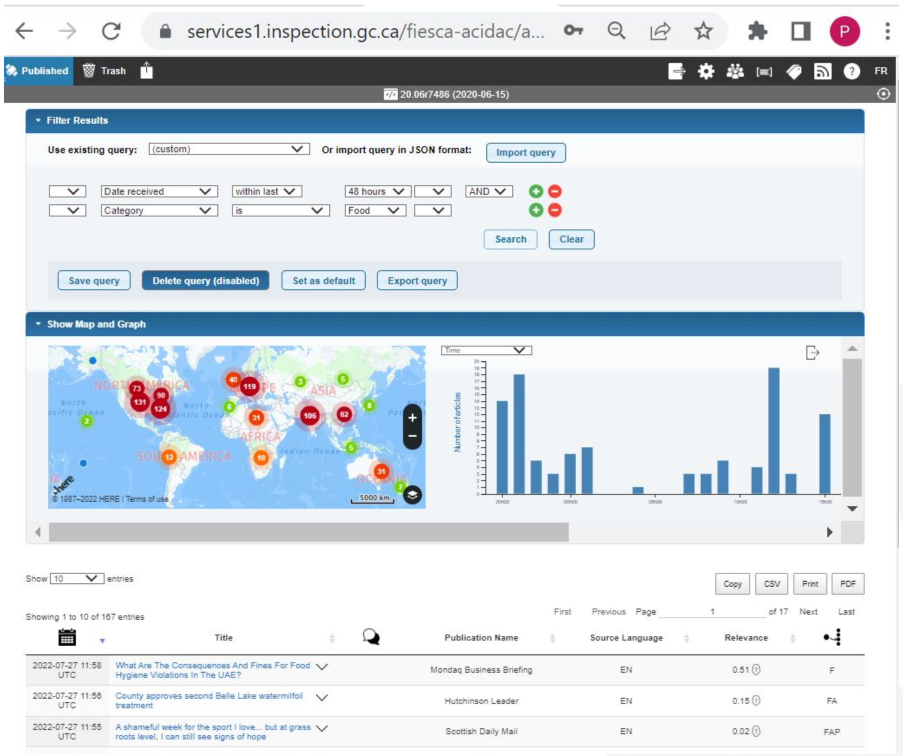
Our products and activities provide scientific evidence to:

- Inform program design
- Develop policies
- Prioritize and manage risks
- Respond to existing and emerging food issues

Tools

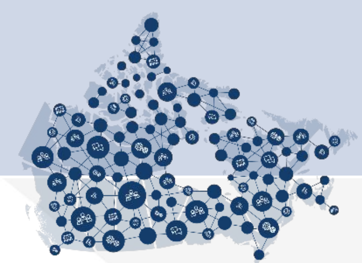
Software

- Literature Review (FIESCA)
- Statistical analysis and data visualization (Stata, SAS, R, Power BI, ArcGIS)
- Risk modelling (FDA-iRisk, Analytica)



Collaboration

Federal/Provincial/ Territorial partners	• Sharing intelligence and signals • Sharing surveillance data, lab information and trend analysis reports • Collaborate on data analysis
International • Organizations • Trading partners	• Bilateral (e.g. US-FDA & USDA-FSIS) • Sharing expertise and information (e.g. FDA-iRisk)
Academia	• Masters Student projects • Consult with academics



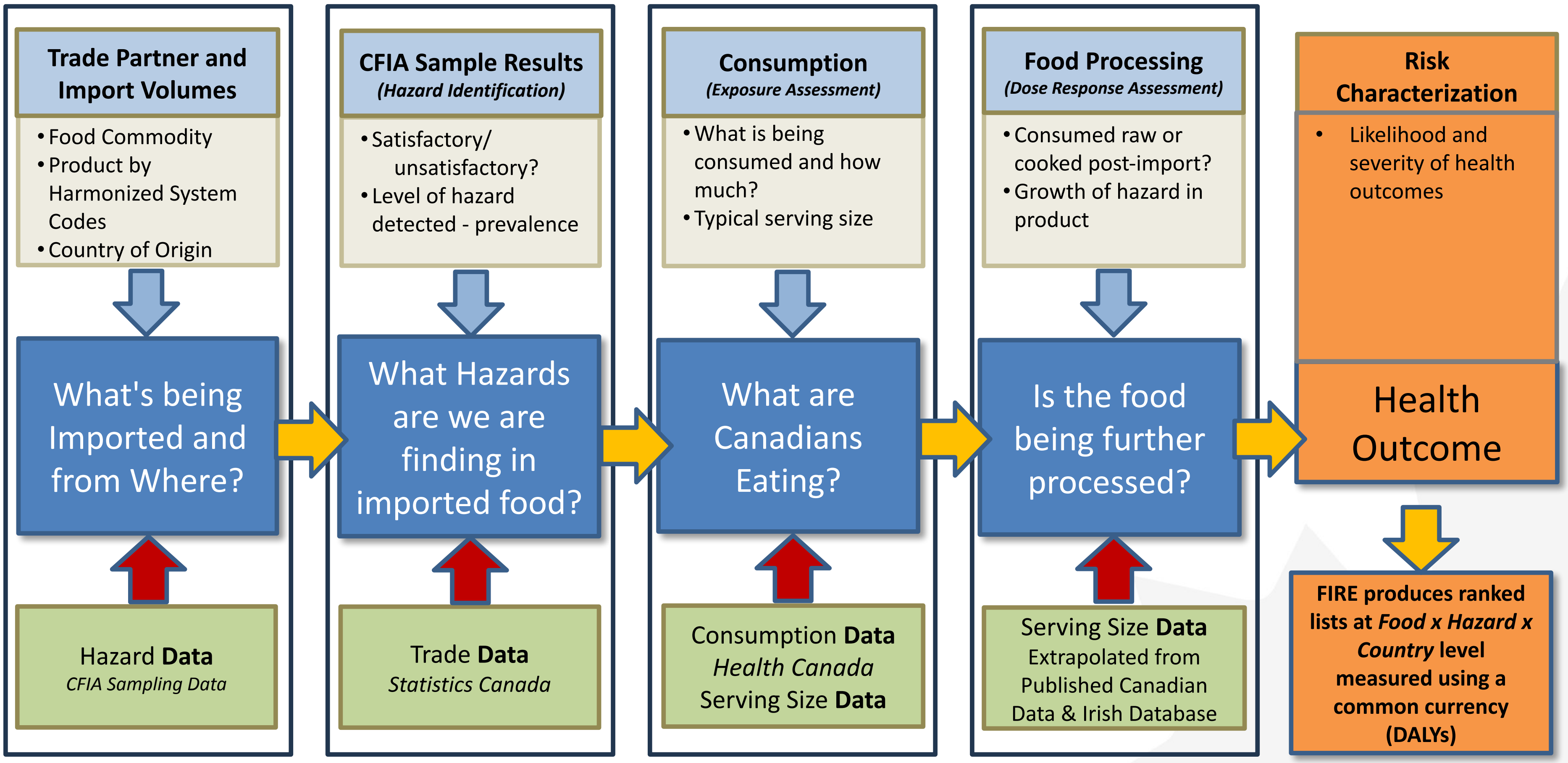
Developing Food Risk Assessment Models

Food Import Risk Explorer (FIRE) Model

Work is underway to develop:
A new innovative model that estimates imported food safety risks in Disability Adjusted Life Years (DALYs)

- Uses food-hazard-country of origin level data
- Able to compare relative risks across different hazard types (microbiological, chemical, allergens)
- Able to rank and prioritizes risk to inform program design and work plans

Model Building Blocks & Architecture



*Model Proof of Concept developed using microbial hazards in Fresh Fruit and Vegetables (FFV)

FIRE Methodology

$$DALYs_{CFH} = \frac{Trade_{CF}}{SS_F} \times P(Exp)_{CFH} \times P(Ill|Exp)_{CFH} \times DALYs_H$$

Where the output ($DALYs_{CFH}$) is **Canadian DALYs** for a food-hazard-country of origin combination, and:

C, F, H - Country, food, and hazard respectively.

$\frac{Trade_{C,F}}{SS_F}$ - Number of servings of the specified food from the specified country.

$P(Exp)_{C,F,H}$ - Probability the food from the given country is contaminated with the hazard (i.e., prevalence).

$P(Ill|Exp)_{C,F,H}$ - Probability of a becoming ill after exposure to a contaminated serving (by country, food and hazard). This value is affected by dose (i.e. dose-response relationship), and incudes consideration of cooking and/or growth.

$DALYs_H$ - DALYs per case for the specified hazard.

Example
Salmonella in Fresh Herbs from Country X

Step 1: Calculate the proportion of imported food consumed.

$$DALYs_{CFH} = \frac{Trade_{CF}}{SS_F} \times P(Exp)_{CFH} \times P(Ill|Exp)_{CFH} \times DALYs_H$$

Amount of Fresh Herbs imported from Country X[1]:
$Trade_{CF}$ = 146,057 kg

Serving size of Fresh Herbs[2]:
$SS_F = 41$ g

[1] Data retrieved from Statistics Canada - Canadian International Merchandise Trade Database.
[2] Lyons, J (2013). *The Irish Food Portion Sizes Database.* Available at: https://www.iuna.net/

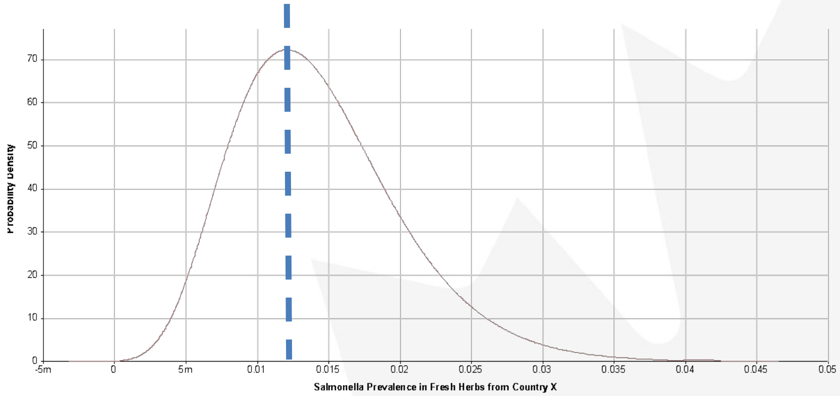
Example
Salmonella in Fresh Herbs from Country X

Step 2: Calculate the probability that food from a given country is contaminated by the hazard.

$$DALYs_{CFH} = \frac{Trade_{CF}}{SS_F} \times P(Exp)_{CFH} \times P(Ill|Exp)_{CFH} \times DALYs_H$$

Beta distribution of *Salmonella* in Fresh Herbs from Country X[1]

Taking the mean value (blue dashed line), the prevalence is about 1.43%



[1] Data from CFIA food surveillance programs.

Example
Salmonella in Fresh Herbs from Country X

Step 3: Calculate the probability that a person will become ill after exposure to the hazard.

$$\boldsymbol{DALYs_{CFH} = \frac{Trade_{CF}}{SS_F} \times P(Exp)_{CFH} \times P(Ill|Exp)_{CFH} \times DALYs_H}$$

$$\begin{aligned} P(Ill|Exp)_{CFH} &= f_H(dose_{CFH}) \\ &= 1 - (1 + (dose_{CFH}/51.45))^{-0.1324} \\ &= 1 - \left(1 + \left(\frac{2.46\ CFU/serving}{51.45}\right)\right)^{-0.1324} \\ P(Ill|Exp)_{CFH} &= 0.0062 \end{aligned}$$

Beta-Poisson model for *Salmonella*[1]:

$f_H(dose_{CFH}) = 1 - (1 + (dose_{CFH}/51.45))^{-0.1324}$

Where,

$$\begin{aligned} dose_{CFH} &= SS_F \times 10^{C_{CFH}+G_{FH}-LR_{FH}} \\ &= 41\ g \times 10^{\log(0.06\frac{CFU}{g})+0-0} \\ dose_{CFH} &= 2.46\ CFU/serving \end{aligned}$$

$f_H(d)$ - Hazard specific dose-response model dependent upon the ingested dose d

C_{CFH} - Concentration of hazard ($\log_{10}$) by country, food, hazard

G_{FH} - Growth of hazard ($\log_{10}$) by food and hazard; 0 for *Salmonella* on Fresh Herbs

LR_{FH} - Reductions in hazard concentration ($\log_{10}$) post sampling, and prior to consumption (e.g., cooking); 0 for Fresh Herbs

[1] World Health Organization. *Risk assessments of Salmonella in eggs and broiler chickens*. Vol. 2. Food & Agriculture Org., 2002.

Example
Salmonella in Fresh Herbs from Country X

Step 4: Multiply by the number of DALYs per case for the specified hazard

$$DALYs_{CFH} = \frac{Trade_{CF}}{SS_F} \times P(Exp)_{CFH} \times P(Ill|Exp)_{CFH} \times DALYs_H$$

Number of DALYs per case of illness for *Salmonella* (non-typhoidal)[1]: 0.049

Table 4
Overall disease burden, disease burden per 100.000 inhabitants and mean disease burden per case of illness in the Netherlands, 2009.

Pathogen	DALY per year		DALY per 100,000 inhabitants		DALY per 1000 cases of illness	
Discount rate	0%	1.5%	0%	1.5%	0%	1.5%
Bacteria – infectious						
Campylobacter spp.	3250	2890	19.8	17.5	41	36
STEC O157	125	98	0.7	0.6	143	113
Salmonella spp.	1270	1100	7.7	6.7	49	41
Listeria monocytogenes (perinatal)	27	16	0.16	0.09	9190	5460
Listeria monocytogenes (acquired)	87	80	0.53	0.49	1140	1050
Listeria monocytogenes (total)	114	96	0.69	0.58	1450	1220
Bacteria-toxin-producing						
Bacillus cereus	112	112	0.7	0.7	2.3	2.3
Clostridium perfringens	536	531	3.3	3.2	3.2	3.2
Staphylococcus aureus	770	761	4.7	4.6	2.6	2.6
Viruses						
Norovirus	1480	1310	8.9	7.9	2.4	2.1
Rotavirus	1820	1630	11.0	9.9	4.9	4.4
Hepatitis A virus	142	123	0.86	0.75	167	145
Hepatitis E virus	24	20	0.15	0.12	460	380
Protozoa						
Cryptosporidium spp.	69	67	0.4	0.4	2.9	2.8
Giardia spp.	162	159	1.0	1.0	2.1	2.1
Toxoplasma gondii (congenital)	2270	1330	13.8	8.1	6360	3730
Toxoplasma gondii (acquired)	1350	1020	8.2	6.2	3170	2400
Toxoplasma gondii (total)	3620	2350	23.0	14.3	4610	2990

[1] Havelaar, Arie H., et al. "Disease burden of foodborne pathogens in the Netherlands, 2009." International journal of food microbiology 156.3 (2012): 231-238.

Example
Salmonella in Fresh Herbs from Country X

Putting it all together…

$$DALYs_{CFH} = \frac{Trade_{CF}}{SS_F} \times P(Exp)_{CFH} \times P(Ill|Exp)_{CFH} \times DALYs_H$$

$$= \frac{146{,}057\ kg}{41\ g} \times 0.0143 \times 0.0062 \times 0.049 \frac{DALYs}{case}$$

$$DALYs_{CFH} = 15\ DALYs$$

Result is 15 DALYs for *Salmonella* in Fresh Herbs from Country X.

Comparative Risks using FIRE Model Results in Fresh Fruits and Vegetables

Countr y	Food	Hazard	Risk (DALYs)
A	Lettuce	*E. coli* O157	820
G	Lettuce	*Salmonella*	658
G	Fresh Herbs	*Salmonella*	262
A	Blackberrie s	Norovirus	136
A	Blackberrie s	E. coli O157	59
M	Blackberrie s	*Salmonella*	51
A	Fresh Herbs	*Salmonella*	39
G	Fresh Herbs	*E. coli* O157	27
A	Lettuce	*Salmonella*	21
A	Fresh Herbs	*Salmonella*	16
G	Blackberrie s	Norovirus	11
M	Lettuce	*E. coli* O157	8
M	Fresh Herbs	*Salmonella*	6
M	Blackberrie s	Norovirus	4

Total DALYs: 2118

Country

Country	Risk (DALYs)
A	1091
G	958
M	69

Country A has a higher relative risk than Country G or M.

Food

Food	Risk (DALYs)
Lettuce	1507
Fresh Herbs	350
Blackberrie s	261

Lettuce has a higher relative risk than Fresh Herbs or Blackberries.

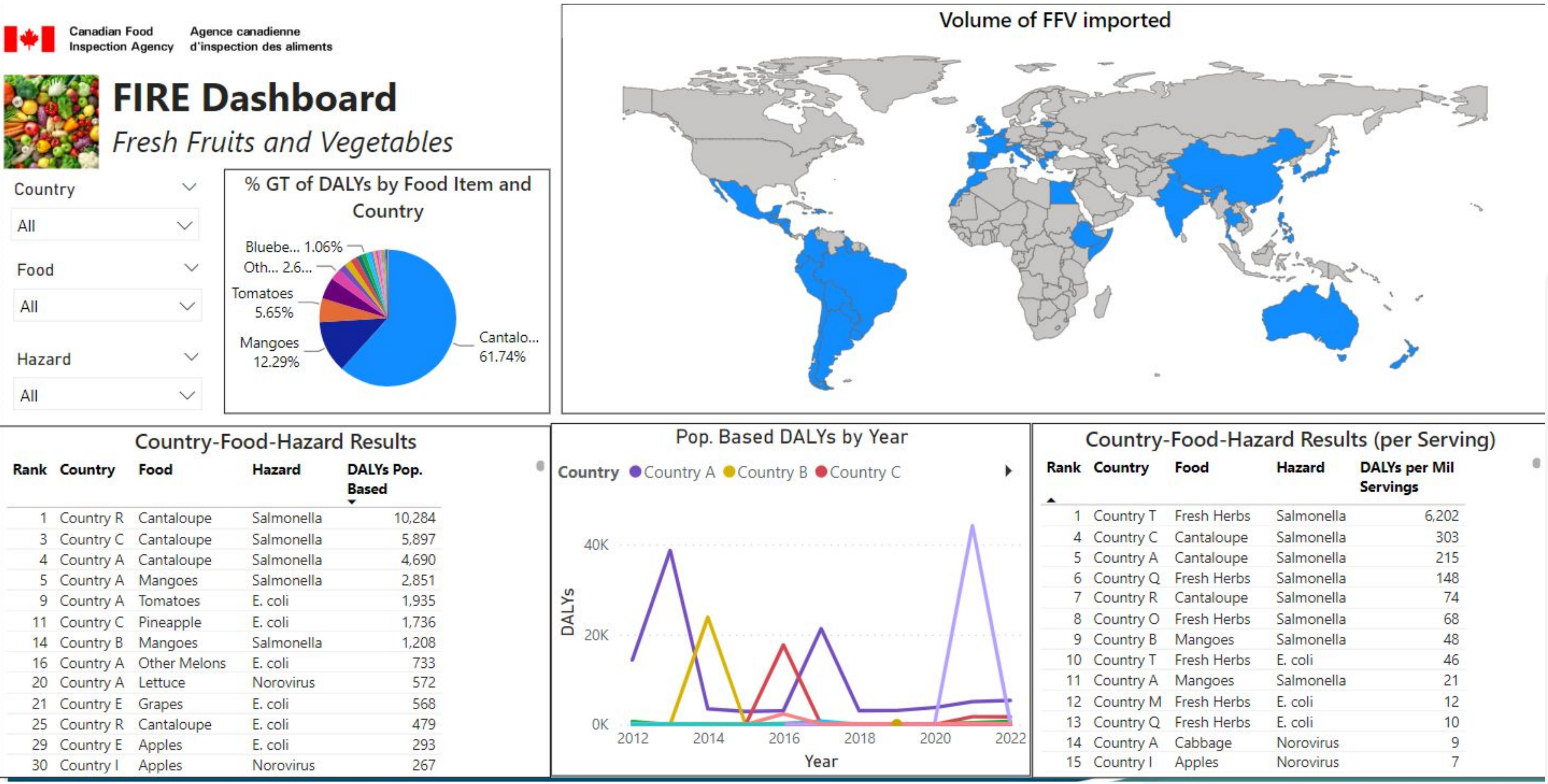
Hazard

	(DALYs)
Salmonella	1053
E. coli O157	914
Norovirus	151

Salmonella has a higher relative risk than *E. coli* O157 or Norovirus.

Risk Profiles (FFV demonstration)

Data Visualization



Country-Food-Hazard Results

Rank	Country	Food	Hazard	DALYs Pop. Based
1	Country R	Cantaloupe	Salmonella	10,284
3	Country C	Cantaloupe	Salmonella	5,897
4	Country A	Cantaloupe	Salmonella	4,690
5	Country A	Mangoes	Salmonella	2,851
9	Country A	Tomatoes	E. coli	1,935
11	Country C	Pineapple	E. coli	1,736
14	Country B	Mangoes	Salmonella	1,208
16	Country A	Other Melons	E. coli	733
20	Country A	Lettuce	Norovirus	572
21	Country E	Grapes	E. coli	568
25	Country R	Cantaloupe	E. coli	479
29	Country E	Apples	E. coli	293
30	Country I	Apples	Norovirus	267

Country-Food-Hazard Results (per Serving)

Rank	Country	Food	Hazard	DALYs per Mil Servings
1	Country T	Fresh Herbs	Salmonella	6,202
4	Country C	Cantaloupe	Salmonella	303
5	Country A	Cantaloupe	Salmonella	215
6	Country Q	Fresh Herbs	Salmonella	148
7	Country R	Cantaloupe	Salmonella	74
8	Country O	Fresh Herbs	Salmonella	68
9	Country B	Mangoes	Salmonella	48
10	Country T	Fresh Herbs	E. coli	46
11	Country A	Mangoes	Salmonella	21
12	Country M	Fresh Herbs	E. coli	12
13	Country Q	Fresh Herbs	E. coli	10
14	Country A	Cabbage	Norovirus	9
15	Country I	Apples	Norovirus	7

Applications:Putting the model to work

FIRE will help the CFIA….

1 Identify and prioritize food safety risk management reviews, which can trigger changes to program design (risk control measures in place).
2 Identify offshore workplan priorities i.e. which countries/commodities/products/systems could be subject to offshore activities.
3 Identify if importers of certain foods from a specific country/region require a targeted Preventive Control Inspection (PCI) above and beyond the frequency prescribed by Importer Risk Assessment model, and/or a targeted communication.
4 Identify sampling gaps.
5 Identify signals e.g. changes to risk levels, emerging issues etc.

FIRE will become a hub that connects diverse datasets (trade, sampling, incident/recall, illness etc.) and generates reports that many other groups can use to support their work and decision-making

The Road Ahead

FIRE+

Included Canadian illness and outbreak data

Applied to foodborne pathogens in FFV

Onboard additional food commodities & hazard types

E.g., Dairy, Fish & Seafood and others; chemical, allergens

Explore Artificial Intelligence tools for automation

Integration with FishNet & MIST

Continue to work on predictive risk analytics

Using Canadian Food Surveillance Information Network (CFSIN) FPT data

- Continue to onboard more food commodities (e.g. fish and seafood & dairy) and include chemical hazards
- Add new data elements to enhance the food safety story (incident/recall, outbreak, other government department data)
- Explore Artificial Intelligence tools for automation

Continue to collaborate with internal, external and international partners….

Break/Questions ?

Canadian Food Inspection Agency | Agence canadienne d'inspection des aliments

Risk Model to Support the Development of a Performance Standards (e.g.*Salmonella* in Poultry)

Canada

Overview

- Pathogen Reduction Program
- Risk model
  - Objectives and expected outcome
  - FDA-iRISK software
  - Process model elements
  - Performance standards scenarios (microbial sampling plans)
  - Scenario outputs
- Next steps

Pathogen Reduction Program Past, Present and Future

Exports based Model

(Export requirement using FSIS standards)

(1998-2016)

Hybrid Model

(Domestic requirement using FSIS Standards)

2017 - Present

Canadian Model

(Domestic requirement using Domestic Standards)

Moving Forward

CFIA is working on modernizing the poultry pathogen reduction program by expanding its scope and developing Canadian standards.

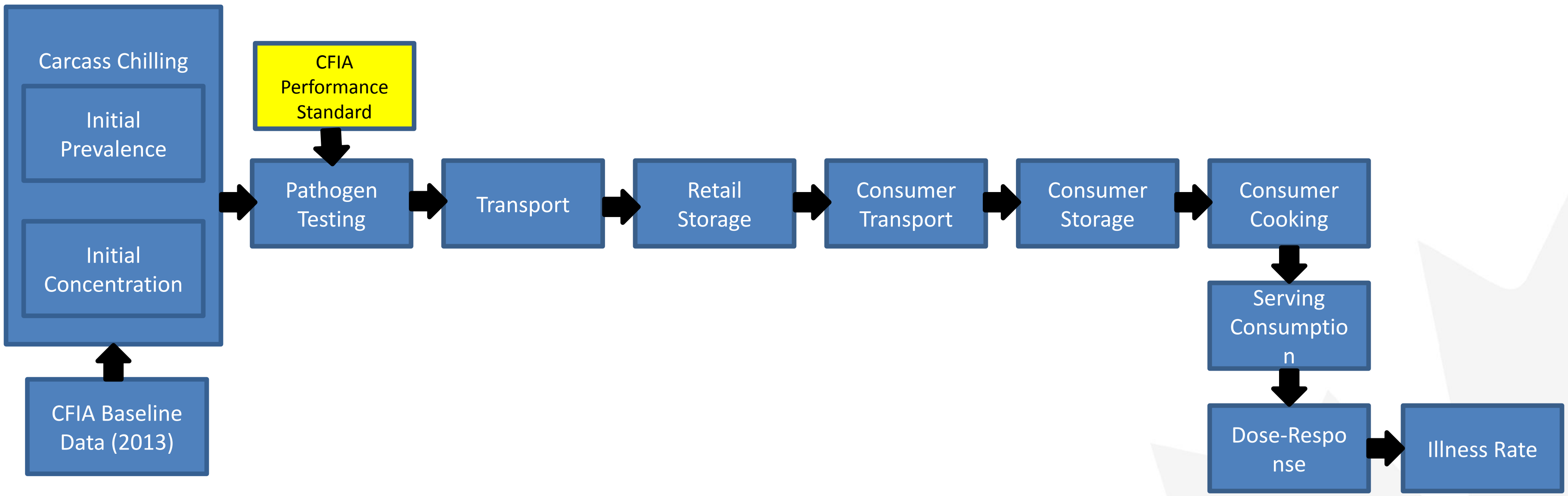
Objective of Risk Model

1. Provide a "proof of concept" for the use of risk modeling to estimate the population level health burden, and
2. Demonstrate the use of these risk models to compare the predicted reduction in health burden associated with a series of hypothetical performance standards for *Salmonella* in broiler chickens.

Expected Outcome:

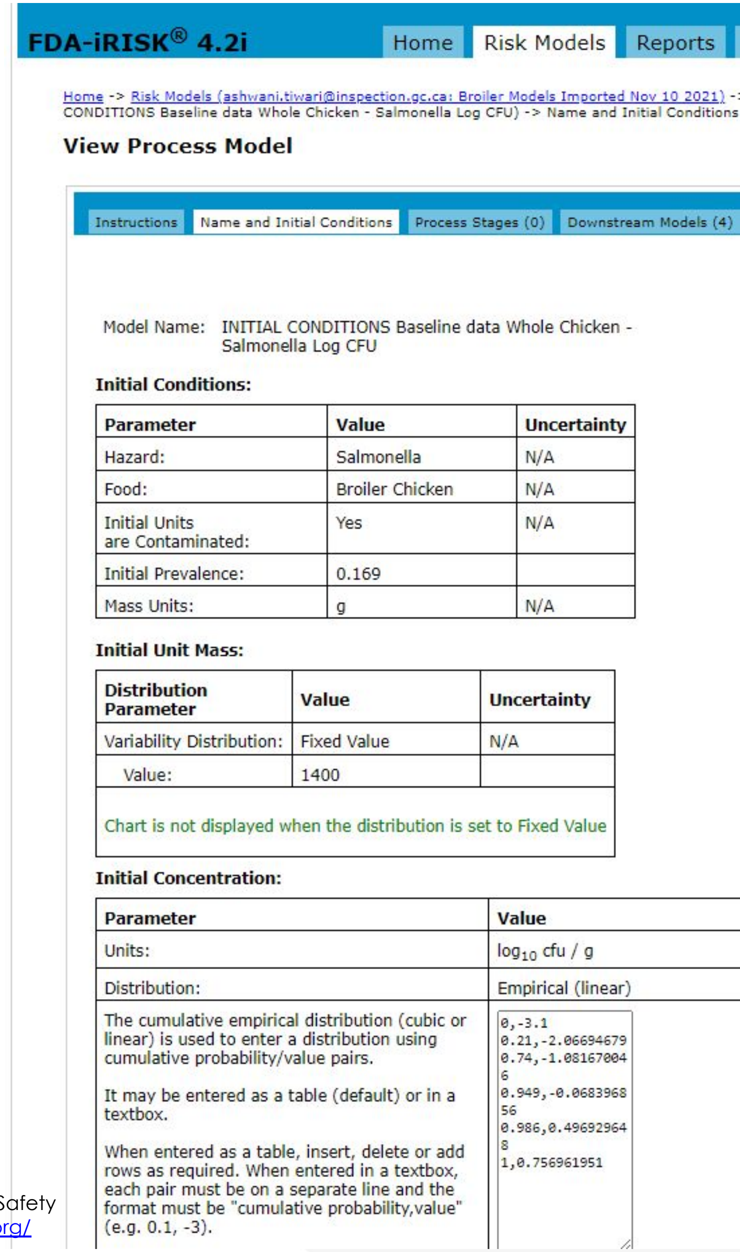
Guide the design of Canadian performance standards for *Salmonella* in raw poultry products.

Process model elements



FDA-iRISK

- Web-based tool[1]:
  - Developed by US Food & Drug Administration (FDA).
  - Provides structure for creating multi-process food safety risk models.
  - Population level health burden as the output


FDA-iRISK® 4.2i

Home | Risk Models | Reports

Home -> Risk Models (ashwani.tiwari@inspection.gc.ca: Broiler Models Imported Nov 10 2021) -> CONDITIONS Baseline data Whole Chicken - Salmonella Log CFU) -> Name and Initial Conditions

View Process Model

Instructions | Name and Initial Conditions | Process Stages (0) | Downstream Models (4)

Model Name: INITIAL CONDITIONS Baseline data Whole Chicken - Salmonella Log CFU

Initial Conditions:

Parameter	Value	Uncertainty
Hazard:	Salmonella	N/A
Food:	Broiler Chicken	N/A
Initial Units are Contaminated:	Yes	N/A
Initial Prevalence:	0.169	
Mass Units:	g	N/A

Initial Unit Mass:

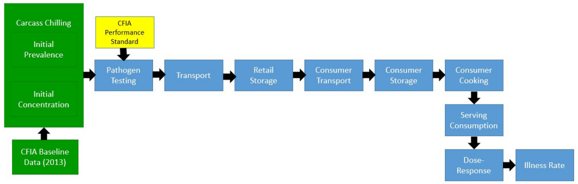
Distribution Parameter	Value	Uncertainty
Variability Distribution:	Fixed Value	N/A
Value:	1400	

Chart is not displayed when the distribution is set to Fixed Value

Initial Concentration:

Parameter	Value
Units:	$\log_{10}$ cfu / g
Distribution:	Empirical (linear)
The cumulative empirical distribution (cubic or linear) is used to enter a distribution using cumulative probability/value pairs. It may be entered as a table (default) or in a textbox. When entered as a table, insert, delete or add rows as required. When entered in a textbox, each pair must be on a separate line and the format must be "cumulative probability,value" (e.g. 0.1, -3).	0,-3.1 0.21,-2.06694679 0.74,-1.08167004 6 0.949,-0.0683968 56 0.986,0.49692964 8 1,0.756961951

1. Food and Drug Administration Center for Food Safety and Applied Nutrition (FDA/CFSAN), Joint Institute for Food Safety and Applied Nutrition (JIFSAN), & (RSI), R. S. I. (2020). FDA-iRISK® version 4.2i. from FDA CFSAN https://irisk.foodrisk.org/



Prevalence & concentration

2013 CFIA Baseline Survey[1]

- Whole chicken carcass (~1.7 Kg)
- Prevalence of *Salmonella* = 16.9%
- Concentration = -0.67 log CFU/g
  (-3.1 log CFU/g – 0.76 log CFU/g)

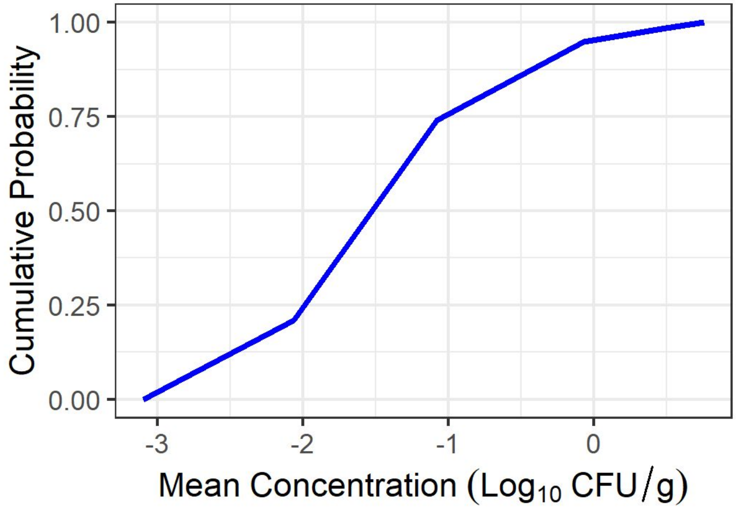
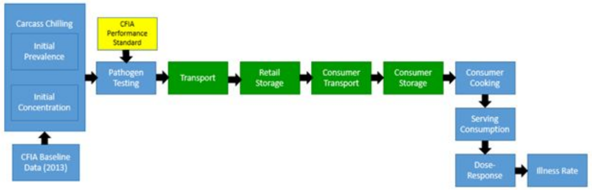


Figure. Empirical cumulative probability distribution of the initial concentration of *Salmonella* in fresh broiler carcasses.

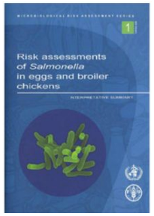
1. Canadian Food Inspection Agency. (2016). National Microbiological Baseline Study in Broiler Chicken 2012-2013.

Growth Models for Transport & Storage Stages



Growth model for *Salmonella* Typhimurium in cooked chicken breast[1,2].

Parameter	Value
pH:	6
a_W:	0.99
NaCl:	1.9
$NaNO_2$:	0



World Health Organization

Time and temperature during storage and transport estimated from previous JEMRA[2] and Audits International[3] reports.

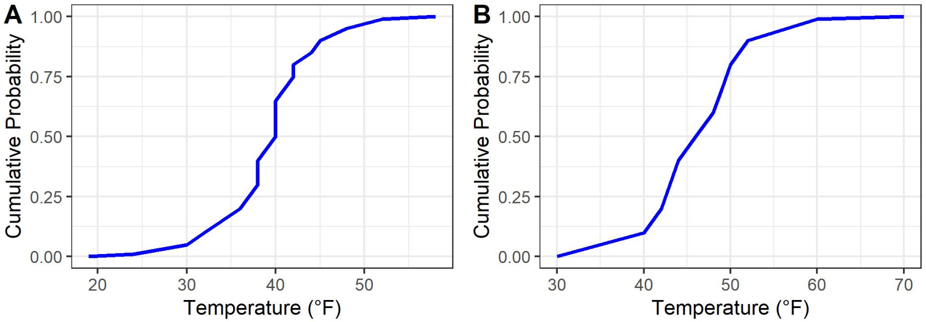
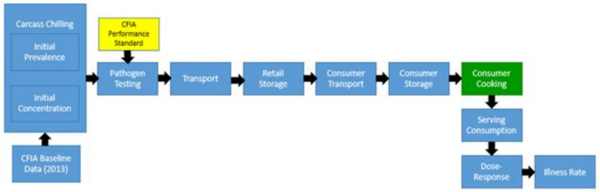


Figure. Empirical cumulative probability distributions of the temperature profiles use for storage at retail (A) and transport from retail to consumer (B) created from Audits International survey data[3].

1. Oscar, T. P. (1999). Response surface models for effects of temperature and previous growth sodium chloride on growth kinetics of Salmonella typhimurium on cooked chicken breast. *J Food Prot, 62*(12), 1470-1474. doi:10.4315/0362-028x-62.12.1470
2. Food and Agriculture Organization of the United Nations. (2002). Risk assessments for salmonella in eggs and broiler chickens: interpretative summary. In. Rome: World Health Organization
3. Audits International, & FDA. (1999). U.S. Food Temperature Evaluation. Retrieved from http://foodrisk.org/resources/display/20

Inactivation of Salmonella (Consumer Cooking)



- Temperature-dependent *D*-value calculated from thermal inactivation data of *Salmonella* in chicken matrices[1,2,3].

- Maximum internal temperature distribution modelled from Ecosure 2007 survey data[4].

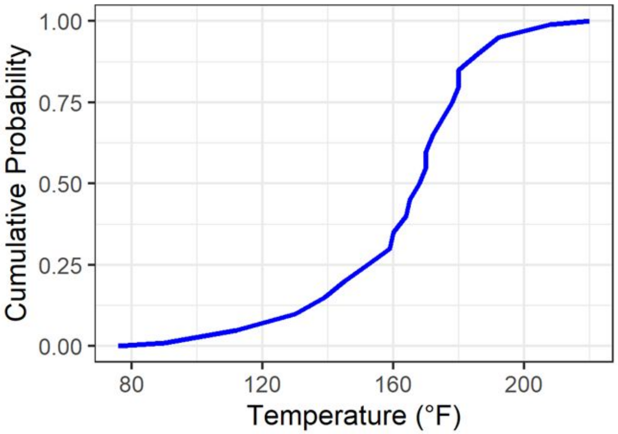
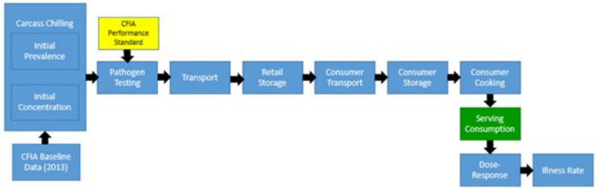


Figure. Empirical cumulative probability distributions of the temperature profiles use for consumer cooking, created from Ecosure survey data[4].

1. Murphy, R. Y., Duncan, L. K., Johnson, E. R., Davis, M. D., & Smith, J. N. (2002). Thermal inactivation D- and z-values of Salmonella serotypes and listeria innocua in chicken patties, chicken tenders, franks, beef patties, and blended beef and turkey patties. J Food Prot, 65(1), 53-60. doi:10.4315/0362-028x-65.1.53.
2. Murphy, R. Y., Marks, B. P., Johnson, E. R., & Johnson, M. G. (1999). Inactivation of Salmonella and Listeria in ground chicken breast meat during thermal processing. J Food Prot, 62(9), 980-985. doi:10.4315/0362-028x-62.9.980.
3. Murphy, R. Y., Osaili, T., Duncan, L. K., & Marcy, J. A. (2004). Thermal inactivation of Salmonella and Listeria monocytogenes in ground chicken thigh/leg meat and skin. Poult Sci, 83(7), 1218-1225. doi:10.1093/ps/83.7.1218.
4. EcoSure, & FDA. (2008). 2007 U.S. Cold Temperature Evaluation. Retrieved from https://www.foodrisk.org/resources/display/21.

Serving Consumption



- Model is based on 1,000,000 servings of each type of poultry product.
- Distribution of consumer serving size (grams)
  - from US-CDC Nutritional Health and Nutrition Examination Survey (NHANES)[1].

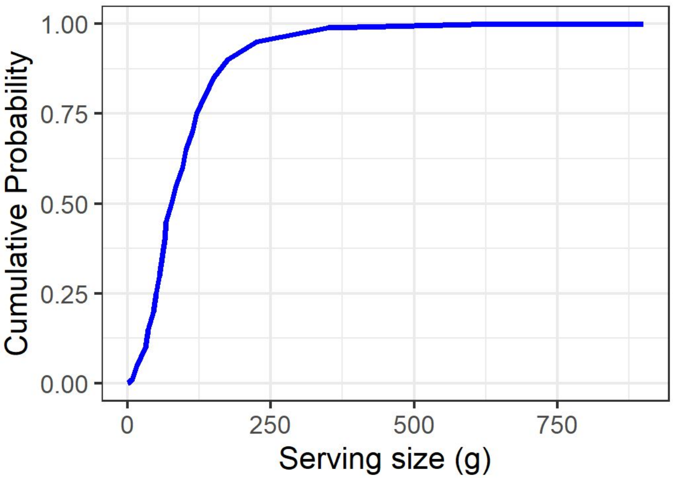
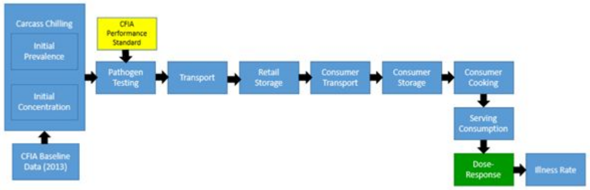


Figure. Empirical cumulative probability distribution of the average serving size of chicken per eating occasion.

1. National Center for Health Statistics. (2022). National Health and Nutrition Examination Survey. Retrieved from https://www.cdc.gov/nchs/nhanes/index.htm

Salmonella Dose-Response Model



- Describes the relationship between the ingested dose and the probability of illness
- Beta-Poisson model used by FAO/WHO in 2002 Salmonella in broilers risk assessment[1].
  - No minimum infectious dose (note the $\log_{10}$ scale)
- DALYs/illness estimated as 0.051[2,3].

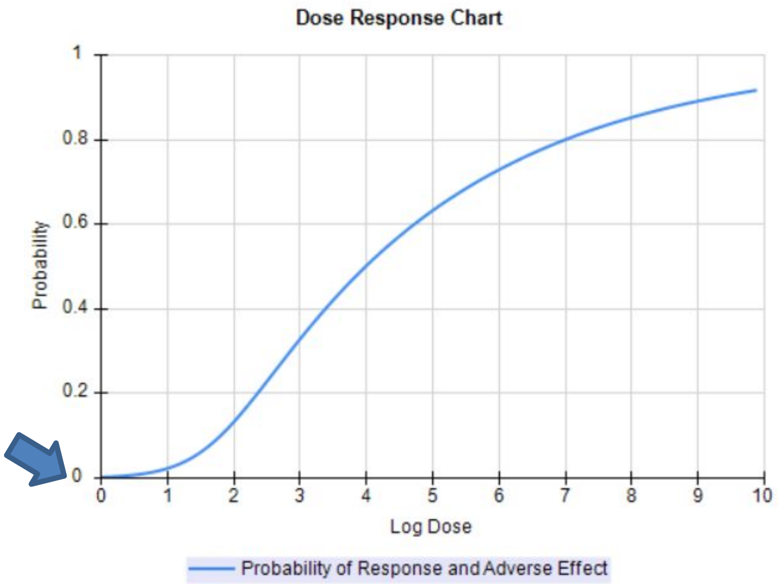
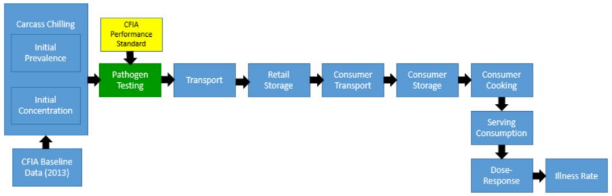


Figure. Empirical cumulative probability distribution of the average serving size of chicken per eating occasion.

1. Food and Agriculture Organization of the United Nations. (2002). Risk assessments for salmonella in eggs and broiler chickens: interpretative summary. In. Rome: World Health Organization.
2. Gibney, K. B., O'Toole, J., Sinclair, M., & Leder, K. (2014). Disease burden of selected gastrointestinal pathogens in Australia, 2010. Int J Infect Dis, 28, 176-185. doi:10.1016/j.ijid.2014.08.006.
3. Havelaar, A. H., Haagsma, J. A., Mangen, M.-J. J., Kemmeren, J. M., Verhoef, L. P. B., Vijgen, S. M. C., . . . van Duynhoven, Y. T. H. P. (2012). Disease burden of foodborne pathogens in the Netherlands, 2009. International journal of food microbiology, 156(3), 231-238 %@ 0168-1605.

Microbiological Sampling Plan Analysis Tool

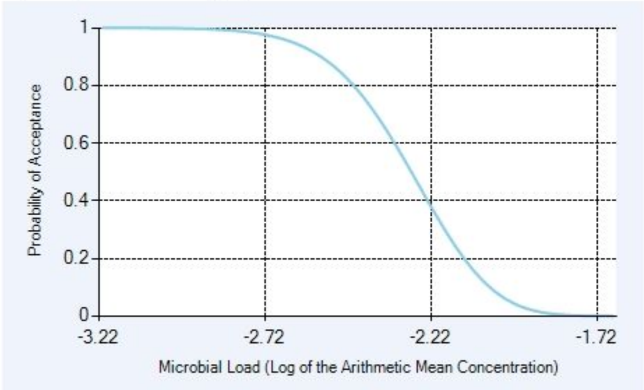


FAO Microbial Sampling Plan Analysis Tool[1].

– Assess the performance of a range of sampling plans, independent of the pathogen or commodity.

<u>Sample Volume = **25 ml**; Number of Samples (n) = **51**; Max. Unacceptable (c) = **5**</u>

Operating Characteristic (OC):

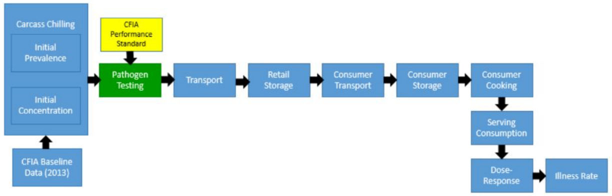


Note: All concentrations reported in log_{10} cfu/g or log_{10} cfu/ml as appropriate

Probability of Rejection (%)	Probability of Acceptance (%)	Detectable Microbial Load (log_{10})
1	99	-2.81
2	98	-2.74
3	97	-2.70
4	96	-2.66
5	95	-2.64
6	94	-2.62
7	93	-2.60
8	92	-2.58
9	91	-2.57
10	90	-2.55
11	89	-2.54

1. Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment. (2022). Microbiological Sampling Plan Analysis Tool. http://tools.fstools.org/Samplingmodel/

Operating Characteristic Curve
(OC curve)



- Describes the relationship between mean concentration and probability of lot rejection
- Each sampling plan has a specific OC curve
- 4 curves with decreasing stringency (from left to right) as number of acceptable positive samples increases

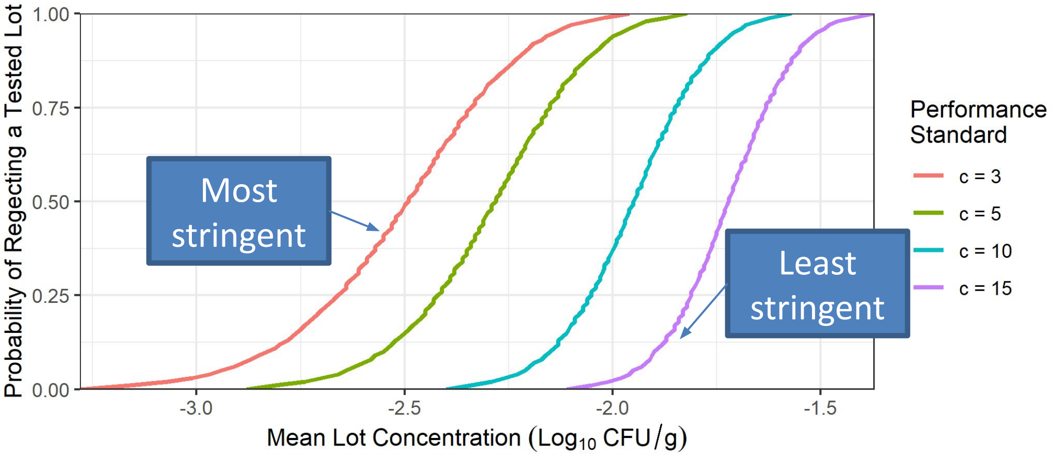
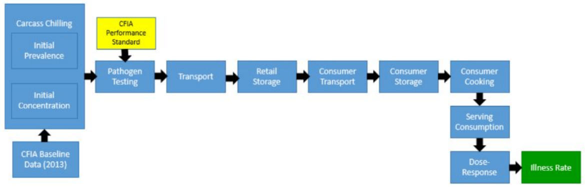


Figure. Operating characteristic curves describing the relationship between mean concentration of Salmonella in a lot and the probability of rejecting that lot. Each curve represents a unique scenario where n = 51 samples are collected from the lot, and a performance standard representing the maximum allowable number of unacceptable samples (i.e., positive for Salmonella; c = 3, 5, 10, 15) before rejecting the lot.

FDA-iRISK Output Reports



FDA-iRISK® 4.0

Report Title: Salmonella Whole Chicken PS analysis

Report Date: 2

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Report Title: FDA-iRISK Risk Estimates and Scenario Ranking Report

Ranking Summary

All reported summary values are per year. For chronic scenarios, results for the total lifecourse have been divided by the lifecourse duration (e.g. 70 years) specified for the life stages included in the scenario.

Scenario or Scenario Group	Total DALYs per Year	Uncertainty Results
_Salmonella Whole Chicken No PS	62.1	N/A
_Salmonella Whole + PS 1ml n=51 c=15	30.9	N/A
_Salmonella Whole + PS 1ml n=51 c=10	21.5	N/A
_Salmonella Whole + PS 1ml n=51 c=5	13.3	N/A
_Salmonella Whole + PS 1ml n=51 c=3	10.3	N/A

Scenario	Lifecourse Duration	Eating Occasions or Consumers	Total Illnesses	Mean Risk of Illness	Total DALYs per Year	DALYs Per EO or Consumer	Total DALYs per Year (Weighted)
_Salmonella Whole Chicken No PS	N/A	1.00E+6	1220	0.00122	62.1	0.0000621	62.1
_Salmonella Whole + PS 1ml n=51 c=15	N/A	1.00E+6	605	0.000605	30.9	0.0000309	30.9

Risk scenarios
(without & with performance standards testing)

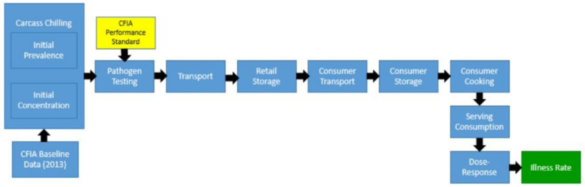

Table. Predicted public health burden of Salmonella under a various performance standards scenarios. Each scenario represents a collection of 51 samples from each establishment over 52 weeks, and a performance standard of the maximum number of unacceptable samples allowed (c) before failure of the establishment.

Increasing Stringency ↓

Scenario	Total Illnesses/million servings	Total DALYs/million servings
No Standards	1250	64.0
c = 15	37.6	1.92
c = 10	17.6	0.90
c = 5	5.91	0.30
c = 3	3.36	0.17

Next Steps

- Improve the current *Salmonella* risk model,
  - Include uncertainties
  - Improve time/temperature
  - Include cross-contamination
- Collaborate with stakeholders to guide the development of Canadian performance standards for *Salmonella* in fresh poultry,
- Adapt the current risk model to *Campylobacter* in raw poultry, and
- Adapt the current risk model to other raw poultry products
  - Frozen breaded and/or stuffed raw chicken products

Thanks & Questions ?

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