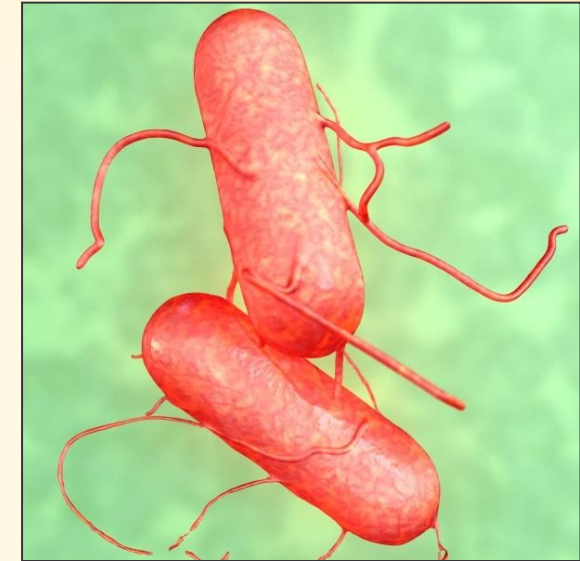




Microbiological Safety of Chicken Sold in Flow Pack Wrappers

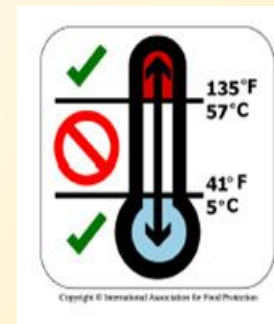
Thomas P. Oscar, PhD
USDA, ARS
Princess Anne, MD

Oscar, T. P. 2017. Risk of Salmonellosis from Chicken Parts Prepared from Whole Broiler Chickens Sold in Flow Pack Wrappers and Subjected to Temperature Abuse. J. Food Prot. (in press).



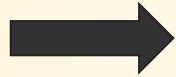
Flow Pack Wrapper

Growth and spread of *Salmonella*?

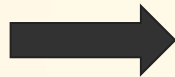


Whole Sample Enrichment Real-time Polymerase Chain Reaction (WSE-qPCR)

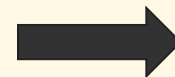
Whole chicken ($n = 52$)
Proper (4 h, 6°C)
Improper (72 h, 15°C)



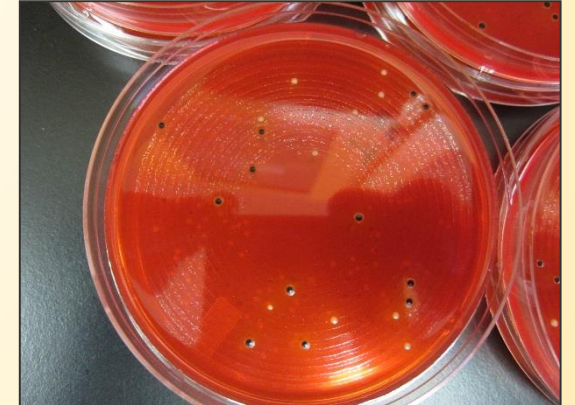
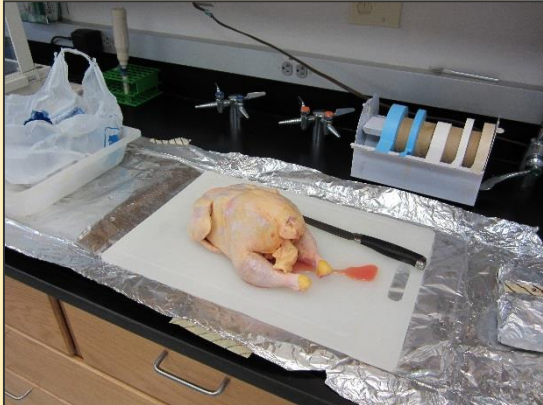
Parts
wings
breasts
thighs
drumsticks
cooked



WSE
400 ml BPW
8 h
40°C
80 rpm



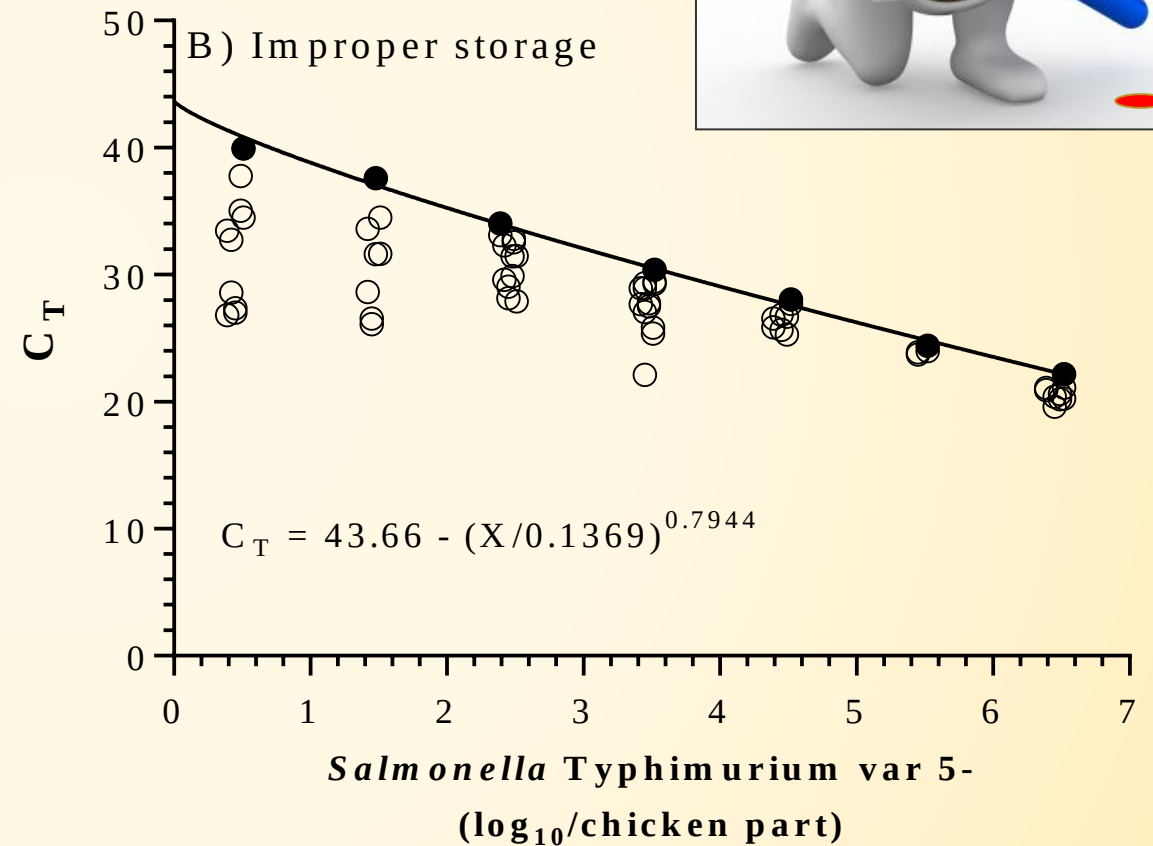
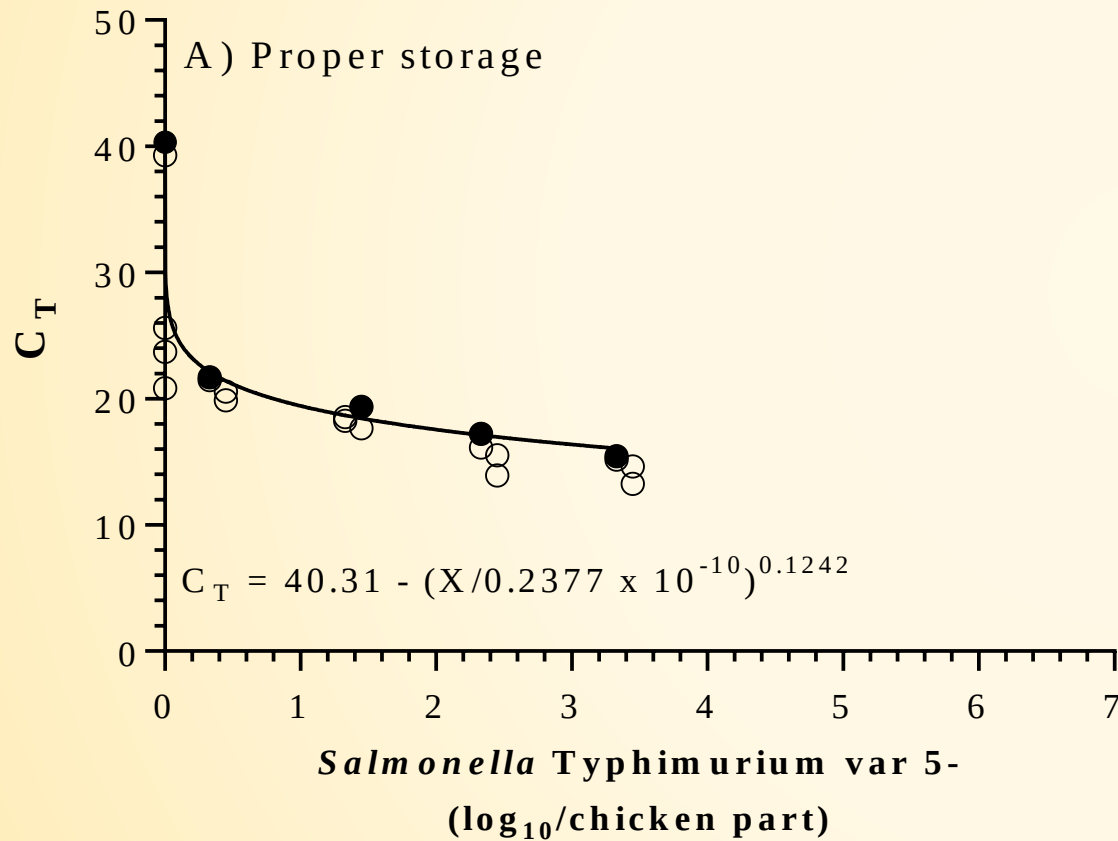
Samples (1ml)
a) qPCR (iQ Check)
b) cultural isolation
BPW, RVB, XLT4
serotyping (NVSL)



WSE-qPCR

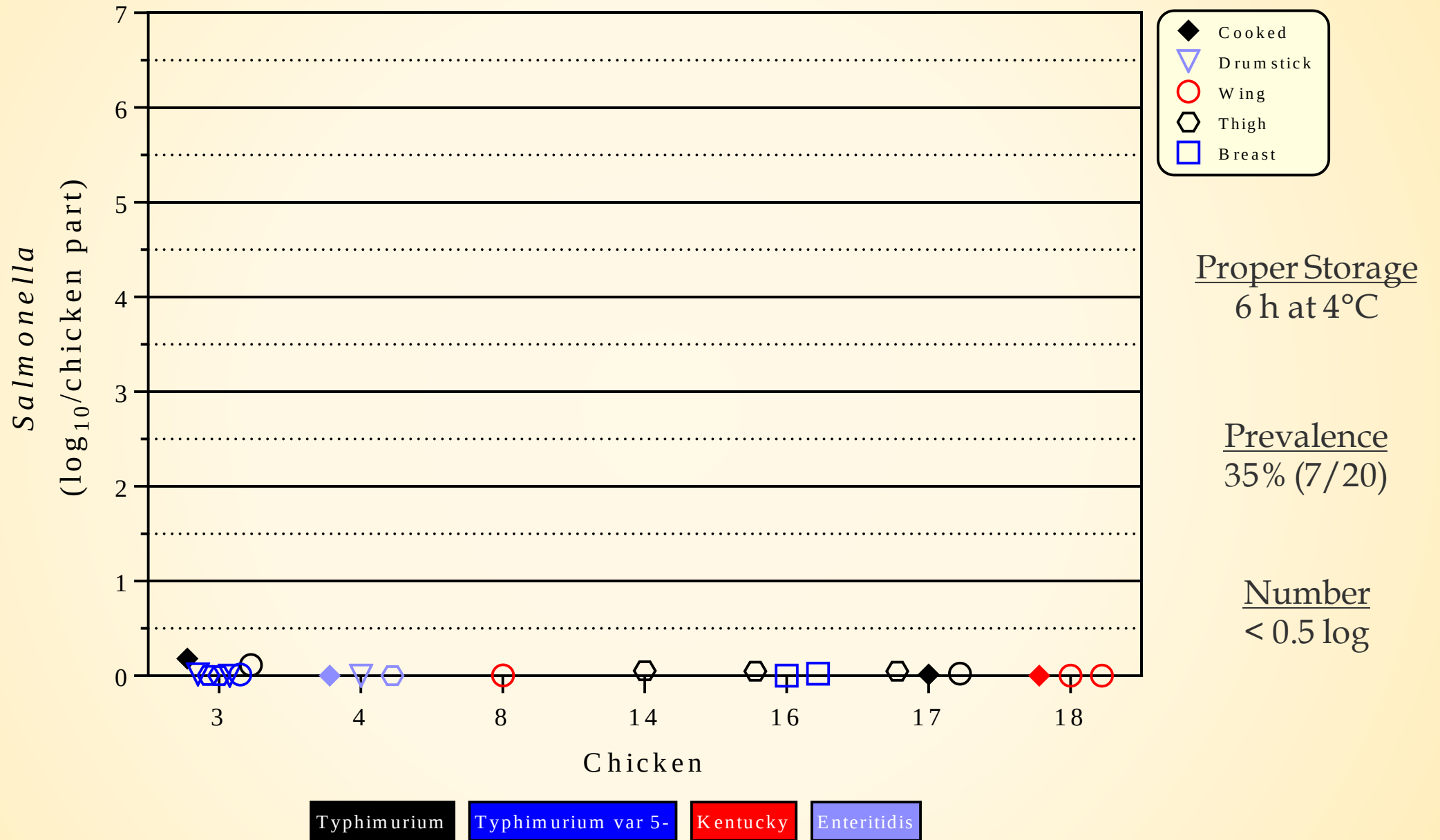
Standard Curves

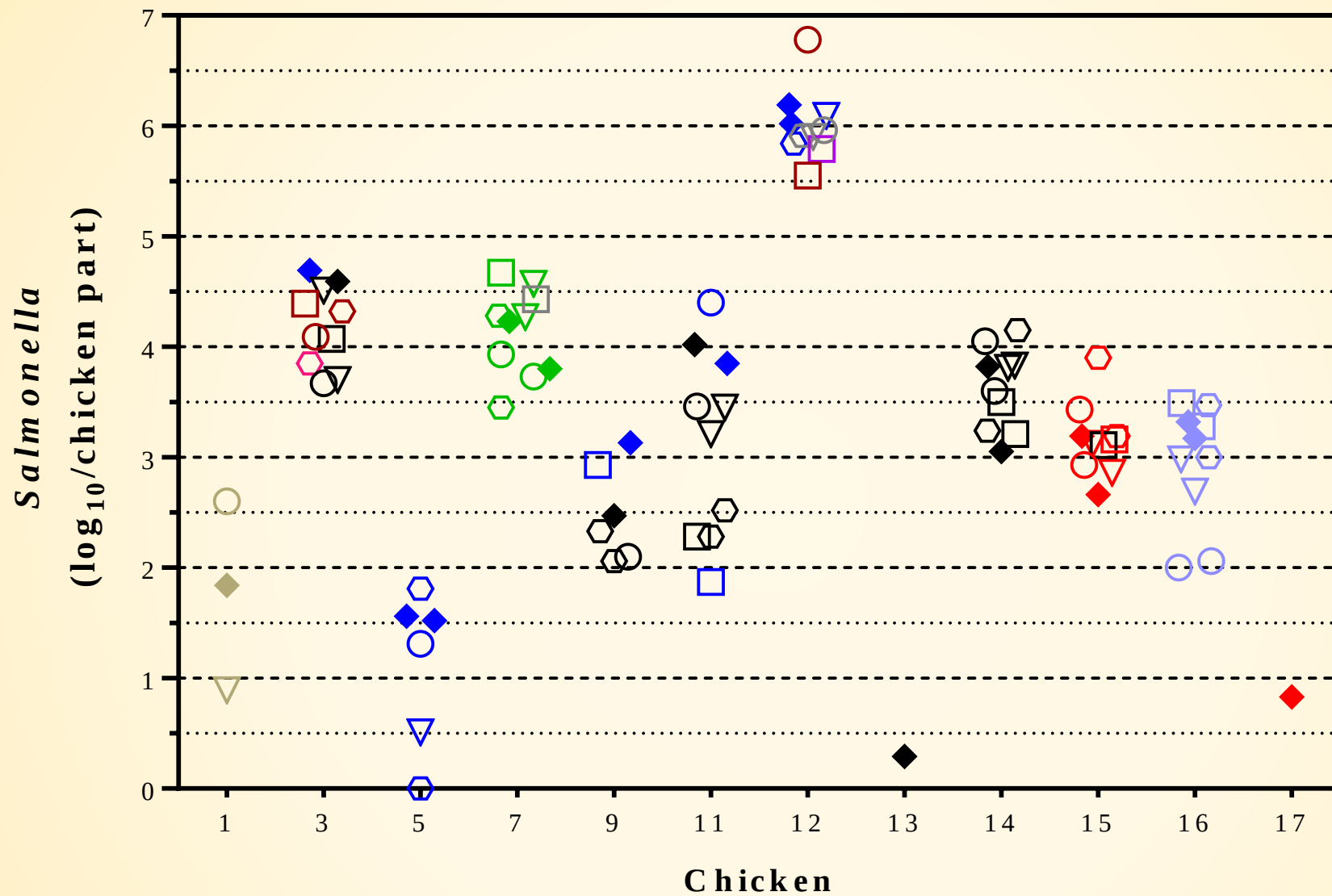
Growth-based assay



WSE-qPCR
prevalence
number
serotype

Date	Chicken	Part	Weight (g)	C _T	Log ₁₀	Serotype
7/23/2013	3	Wing, left	88	24.36	0.114	Typhimurium
7/23/2013	3	Thigh, left	151	31.09	0.001	Typhimurium var 5-
7/23/2013	3	Drumstick, left	125	28.03	0.014	Typhimurium var 5-
7/23/2013	3	Wing, right	88	28.26	0.012	Typhimurium var 5-
7/23/2013	3	Thigh, right	146	29.84	0.004	Typhimurium var 5-
7/23/2013	3	Drumstick, right	120	36.99	0.000	Typhimurium var 5-
7/23/2013	3	Cooked	72	23.42	0.181	Typhimurium
7/30/2013	4	Cooked	69	31.67	0.001	Enteritidis
7/30/2013	4	Thigh, right	114	31.18	0.001	Enteritidis
7/30/2013	4	Drumstick, right	100	40.31	0.000	Enteritidis
9/17/2013	8	Wing, left	75	30.03	0.003	Kentucky
1/7/2014	14	Thigh, right	132	25.82	0.053	Typhimurium
1/28/2014	16	Breast, left	203	36.40	0.000	Typhimurium var 5-
1/28/2014	16	Breast, right	165	27.31	0.022	Typhimurium var 5-
1/28/2014	16	Thigh, right	137	25.97	0.048	Typhimurium
2/4/2014	17	Cooked	98	28.26	0.012	Typhimurium
2/4/2014	17	Wing, right	89	27.30	0.022	Typhimurium
2/4/2014	17	Breast, right	269	37.75	0.000	Typhimurium
2/19/2014	18	Wing, left	76	37.21	0.000	Kentucky
2/19/2014	18	Wing, right	75	32.72	0.000	Kentucky
2/19/2014	18	Cooked	73	36.82	0.000	Kentucky





Improper Storage

72 h at 15°C

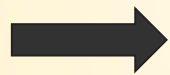
Prevalence

60% (12/20)

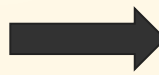
Number

3.5 log
(0 to 6.8 log)

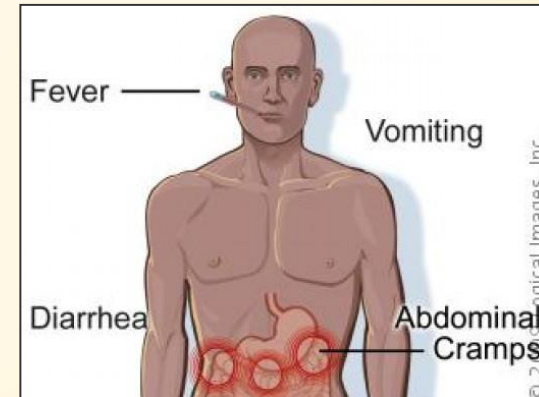
Storage	Part	Prevalence			Number (log ₁₀ /chicken part)		
		Positive	Total	%	Minimum	Median	Maximum
Proper	Raw	17	160	10.63	0.000	0.003	0.114
	Cooked	4	40	10.00	0.000	0.006	0.181
Improper	Raw	66	160	41.25	0.000	3.466	6.778
	Cooked	24	46	52.17	0.291	3.148	6.192



Process Risk Model



Risk of salmonellosis



D

Node	Unit Operation	Pathogen Event	Consumer Event	Discrete	Pert	Salmonella
0	Refrigeration	Growth/Spread	Proper Storage	0		
1	Meal Preparation	Contamination	Proper storage test results	0	0.05	0
			Improper storage test results	1	4.07	11,665
						0
2	Cooking	Death	Proper Cooking	0	-6.38	0
3	Serving	Cross-contamination	Proper storage test results	1	0.05	1
			Improper storage test results	1	4.76	57,622
			Improper handling	1		1
4	Consumption	Salmonellosis	Dose			1
			Illness Dose		2.90	793
			Meal	high		
			Salmonella	high-high		
			Consumer	normal		
			No Illness			0

Node	Unit Operation	Pathogen Event	Consumer Event	0 = no	1 = yes	minimum	median	maximum
------	----------------	----------------	----------------	--------	---------	---------	--------	---------

1	Meal Preparation	Contamination	Proper storage test results	89.37	10.63	0.000	0.003	0.114
			Improper storage test results	58.75	41.25	0.000	3.466	6.778
			Improper storage	99.80	0.20			
2	Cooking	Death	Improper cooking	90.00	10.00	-7	-6	0
3	Serving	Cross-contamination	Proper storage test results	90.00	10.00	0.000	0.006	0.181
			Improper storage test results	47.83	52.17	0.291	3.148	6.192
			Improper handling	72.00	28.00			

Process Risk Model Salmonella and Chicken Parts



!

!

Illness dose (log₁₀) sub-model

Discrete distribution (porportion, outcome value)

Proportion per risk category					
Factor	low-low	low	normal	high	high-high
Meal	5.00	15.00	30.00	40.00	10.00
Salmonella	0.00	22.50	0.00	8.10	69.40
Consumer	5.00	15.00	60.00	15.00	5.00
Outcome value per risk category					
Factor	low-low	low	normal	high	high-high
Meal	0.5	1	1.5	2	2.5
Salmonella	1	2	3	4	5
Consumer	1	2	3	4	5
lookup value →					
10.0					
lookup value	Pert output	Pert distribution (log ₁₀)			
		minimum	median	maximum	
12.5	1.44	0.0	1.0	2.0	
12.0	1.86	0.4	1.4	2.4	
11.5	1.60	0.8	1.8	2.8	
11.0	2.20	1.2	2.2	3.2	
10.5	3.12	1.6	2.6	3.6	
10.0	2.90	2.0	3.0	4.0	
9.5	3.59	2.4	3.4	4.4	
9.0	4.54	2.8	3.8	4.8	
8.5	3.80	3.2	4.2	5.2	
8.0	4.67	3.6	4.6	5.6	
7.5	5.03	4.0	5.0	6.0	
7.0	5.47	4.4	5.4	6.4	
6.5	6.01	4.8	5.8	6.8	
6.0	6.81	5.2	6.2	7.2	
5.5	6.65	5.6	6.6	7.6	
5.0	6.36	6.0	7.0	8.0	
4.5	7.78	6.4	7.4	8.4	
4.0	7.71	6.8	7.8	8.8	
3.5	7.68	7.2	8.2	9.2	
3.0	9.07	7.6	8.6	9.6	
2.5	9.09	8.0	9.0	10.0	

B

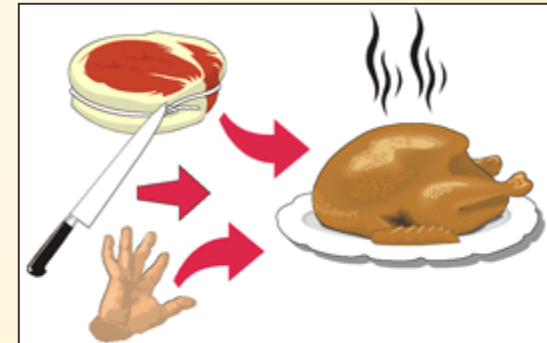
C



	A	B	C	D	E	F	G	H	I
17					Discrete		Pert (log ₁₀)		
18	Node	Unit Operation	Pathogen Event	Consumer Event	0 = no	1 = yes	minimum	median	maximum
19	1	Meal Preparation	Contamination	Proper storage test results	89.37	10.63	0.000	0.003	0.114
20				Improper storage test results	58.75	41.25	0.000	3.466	6.778
21				Improper storage	99.80	0.20			
22	2	Cooking	Death	Improper cooking	90.00	10.00	-7	-6	0
23	3	Serving	Cross-contamination	Proper storage test results	90.00	10.00	0.000	0.006	0.181
24				Improper storage test results	47.83	52.17	0.291	3.148	6.192
25				Improper handling	72.00	28.00			

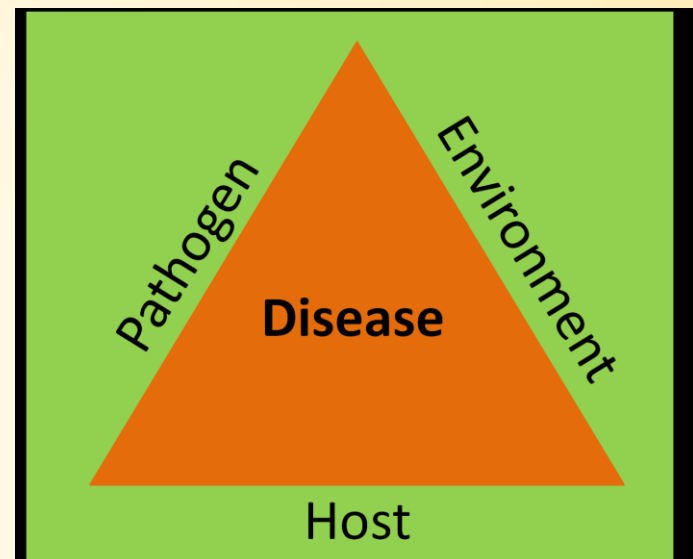
WSE-qPCR
prevalence
number
serotype

Legend
Purple = real data
Red = scenario analysis
Blue = formula
Black = fixed



Disease Triangle Dose-Response Model

Disease triangle factor	Risk factor	Risk category
Host	Very young	high
	Very old	high
	Diabetic	high
	Liver Disease	high
	Immunocompromised (e.g. HIV/AIDS)	high
	Pregnant	high
	Malnutrition	high
	Stress	high
	Healthy Teen to Middle Aged Adult	normal
	Vaccination (natural or man-made)	low
Pathogen	Probiotic	low
	Top Human Clinical Isolate	
	1 to 5	high-high
	6 to 10	high
	11 to 20	normal
Food	> 20	low
	Animal Host Adapated (e.g. Pullorum, Gallinarum)	low-low
	High fat	high
	Acidic beverage	low
	Alcoholic beverage	low
	Anti-acid pill	high



high-high = high + high



low-low = low + low

B

Serotype	Risk	Number	Percentage
Typhimurium	High-High	38	34.23
Typhimurium var 5-	High-High	23	20.72
Newport	High-High	3	2.70
Enteritidis	High-High	13	11.71
Heidelberg	High	9	8.11
4,5,12:-:1,2	Low	1	0.90
Kentucky	Low	14	12.61
4,5,12:Nonmotile	Low	5	4.50
4,12:Nonmotile	Low	1	0.90
8,20:-:z ₆	Low	4	3.60
Total		111	100.00

High-High Risk = Top 5 Human Clinical Isolate



Clinical Rank	Risk	Number	Percentage
1 to 5	High-High	77	69.37
6 to 10	High	9	8.11
11 to 20	Normal	0	0.00
> 20	Low	25	22.52
animal host adapted	Low-Low	0	0.00

Illness dose ($\log_{10}$) sub-model

Discrete distribution (porportion, outcome value)

	Proportion per risk category					
Factor	low-low	low	normal	high	high-high	
Meal	5.00	15.00	30.00	40.00	10.00	
<i>Salmonella</i>	<u>0.00</u>	<u>22.50</u>	<u>0.00</u>	<u>8.10</u>	<u>69.40</u>	
Consumer	5.00	15.00	60.00	15.00	5.00	
	Outcome value per risk category					Discrete output
Factor	low-low	low	normal	high	high-high	
Meal	0.5	1	1.5	2	2.5	1.5
<i>Salmonella</i>	1	2	3	4	5	5.0
Consumer	1	2	3	4	5	2.0
				lookup value →		8.5

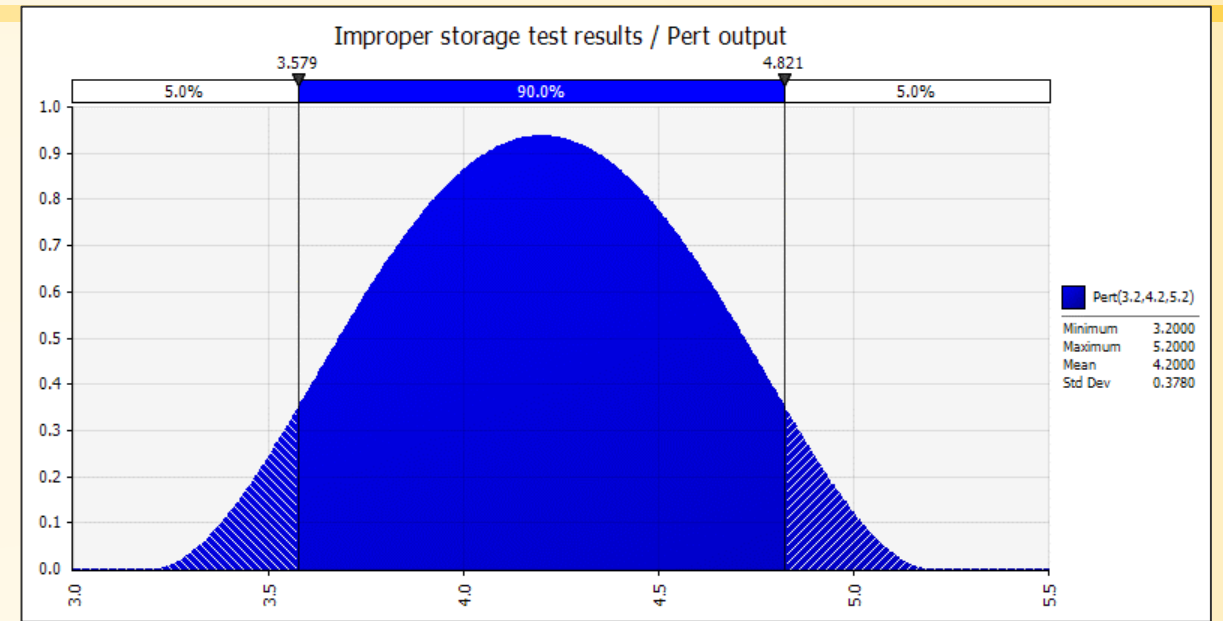
B



Legend

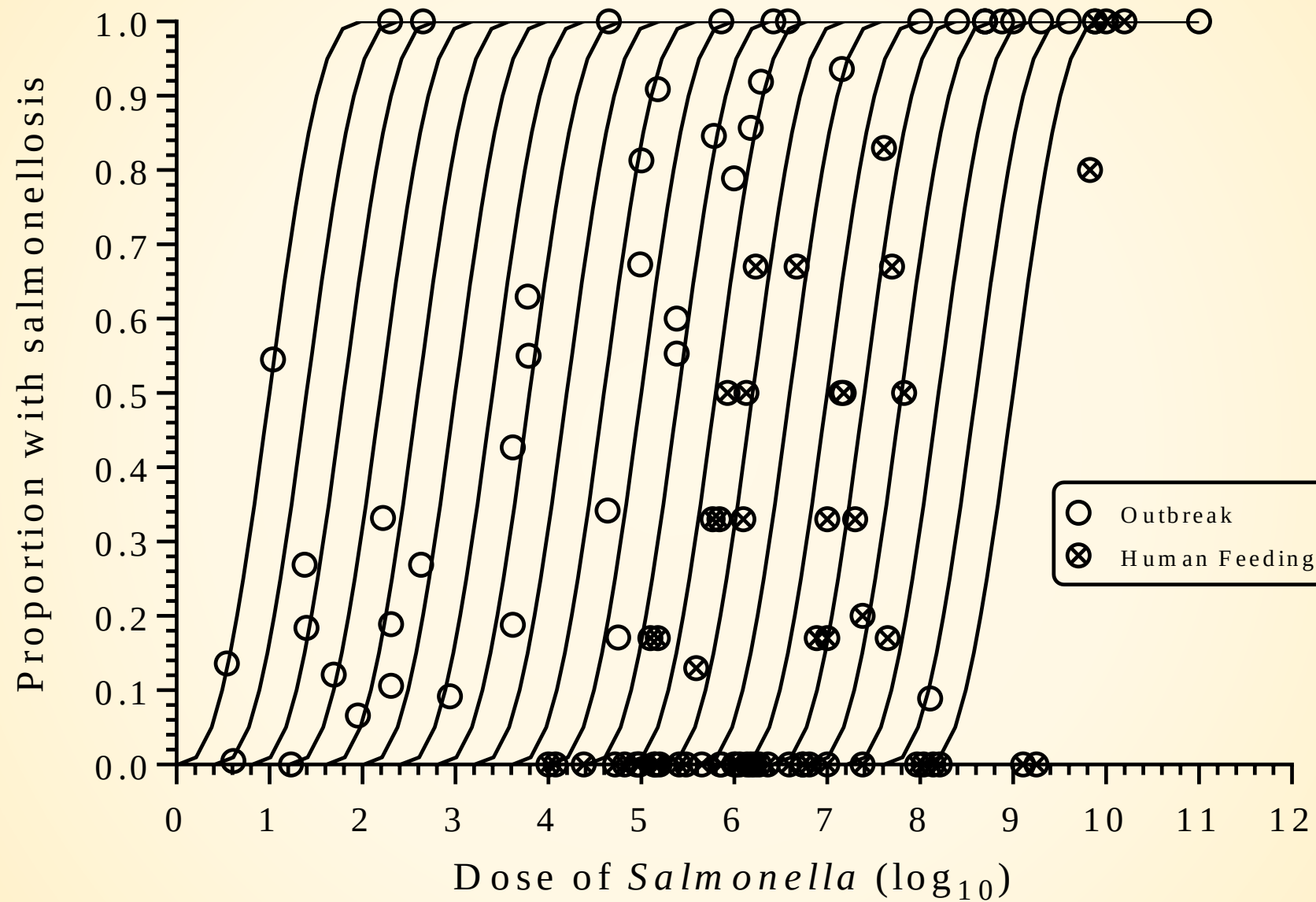
Purple = real data
 Red = scenario analysis
 Blue = formula
 Black = fixed

	J	K	L	M	N	O
14		lookup		Pert distribution (log ₁₀)		
15		value	Pert output	minimum	median	maximum
16		12.5	0.97	0.0	1.0	2.0
17		12.0	1.40	0.4	1.4	2.4
18		11.5	1.17	0.8	1.8	2.8
19		11.0	1.86	1.2	2.2	3.2
20		10.5	3.16	1.6	2.6	3.6
21		10.0	3.41	2.0	3.0	4.0
22		9.5	3.18	2.4	3.4	4.4
23		9.0	4.00	2.8	3.8	4.8
24		8.5	3.79	3.2	4.2	5.2
25	!	8.0	4.52	3.6	4.6	5.6
26		7.5	4.42	4.0	5.0	6.0
27		7.0	6.01	4.4	5.4	6.4
28		6.5	6.13	4.8	5.8	6.8
29		6.0	6.60	5.2	6.2	7.2
30		5.5	6.97	5.6	6.6	7.6
31		5.0	7.17	6.0	7.0	8.0
32		4.5	7.85	6.4	7.4	8.4
33		4.0	7.86	6.8	7.8	8.8
34		3.5	9.04	7.2	8.2	9.2
35		3.0	8.93	7.6	8.6	9.6
36		2.5	8.78	8.0	9.0	10.0

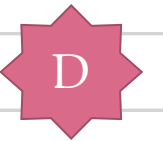


=RiskPert(minimum, median, maximum)





Node	Unit Operation	Pathogen Event	Consumer Event	Discrete	Pert	Salmonella	
0	Refrigeration	Growth/Spread	Proper Storage	0			
1	Meal Preparation	Contamination	Proper storage test results	0	0.02	0	!
			Improper storage test results	1	3.54	3,504	
						0	
2	Cooking	Death	Proper Cooking	0	-4.48	0	
3	Serving	Cross-contamination	Proper storage test results	0	0.03	0	!
			Improper storage test results	1	3.81	6,473	
			Improper handling	1		0	
4	Consumption	Salmonellosis	Dose			0	
			Illness Dose		2.50	316	
			Meal	high			
			Salmonella	high-high			
			Consumer	high			
			No Illness			0	



Monte Carlo Simulation

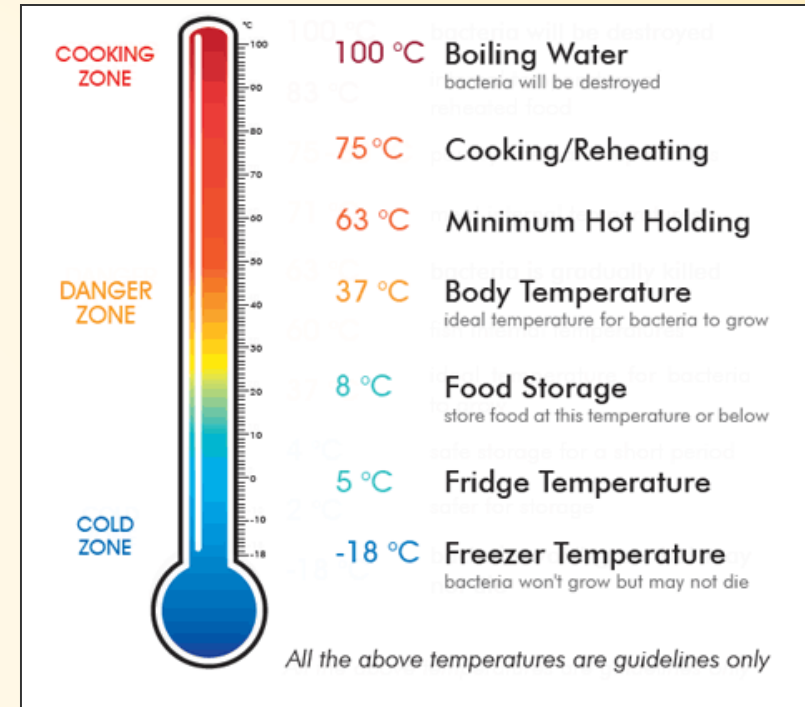
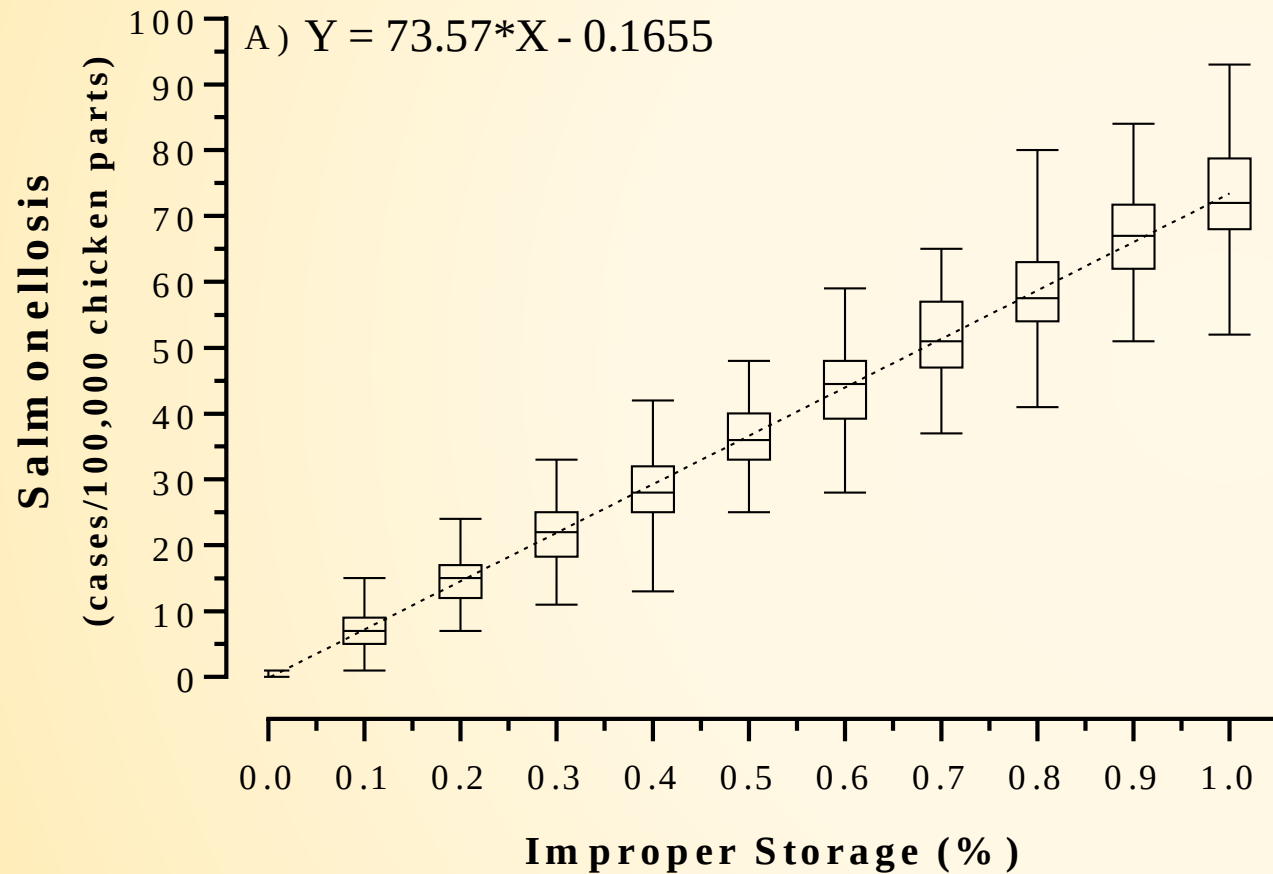
Scenario analysis

- Latin hypercube sampling
- Mersenne twister
- Iterations: 100,000
- Scenarios: 56
- Simulations: 100
- Random number generator seed: random selection
 - Variability and uncertainty due to the rare, random, variable, and uncertain nature of events in the risk pathway.



Refrigerated Storage (growth)

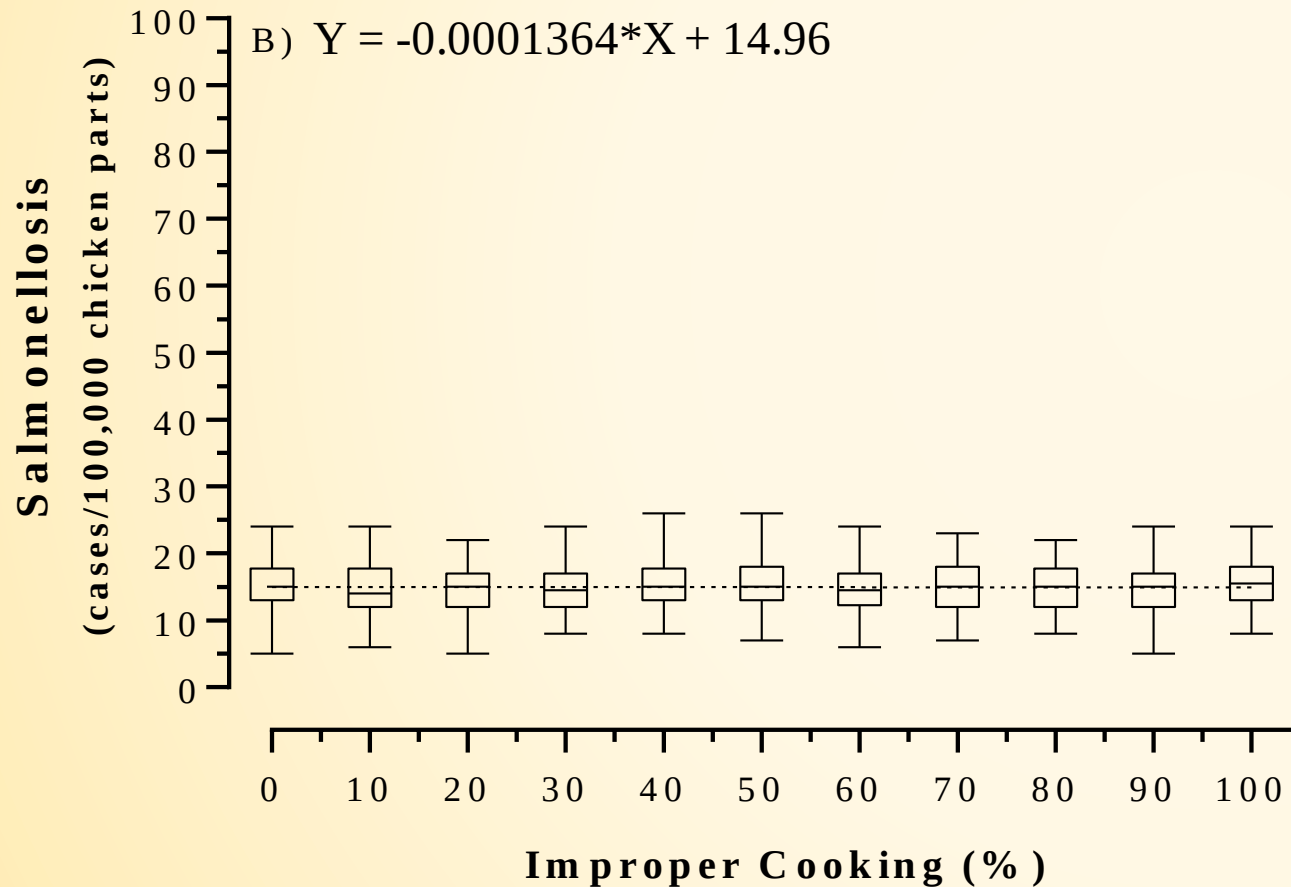
Temperature abuse



- Proper storage
 - 6 cases per 10^7 chicken parts
- Improper storage
 - linear increase ($P < 0.05$)

Cooking (death)

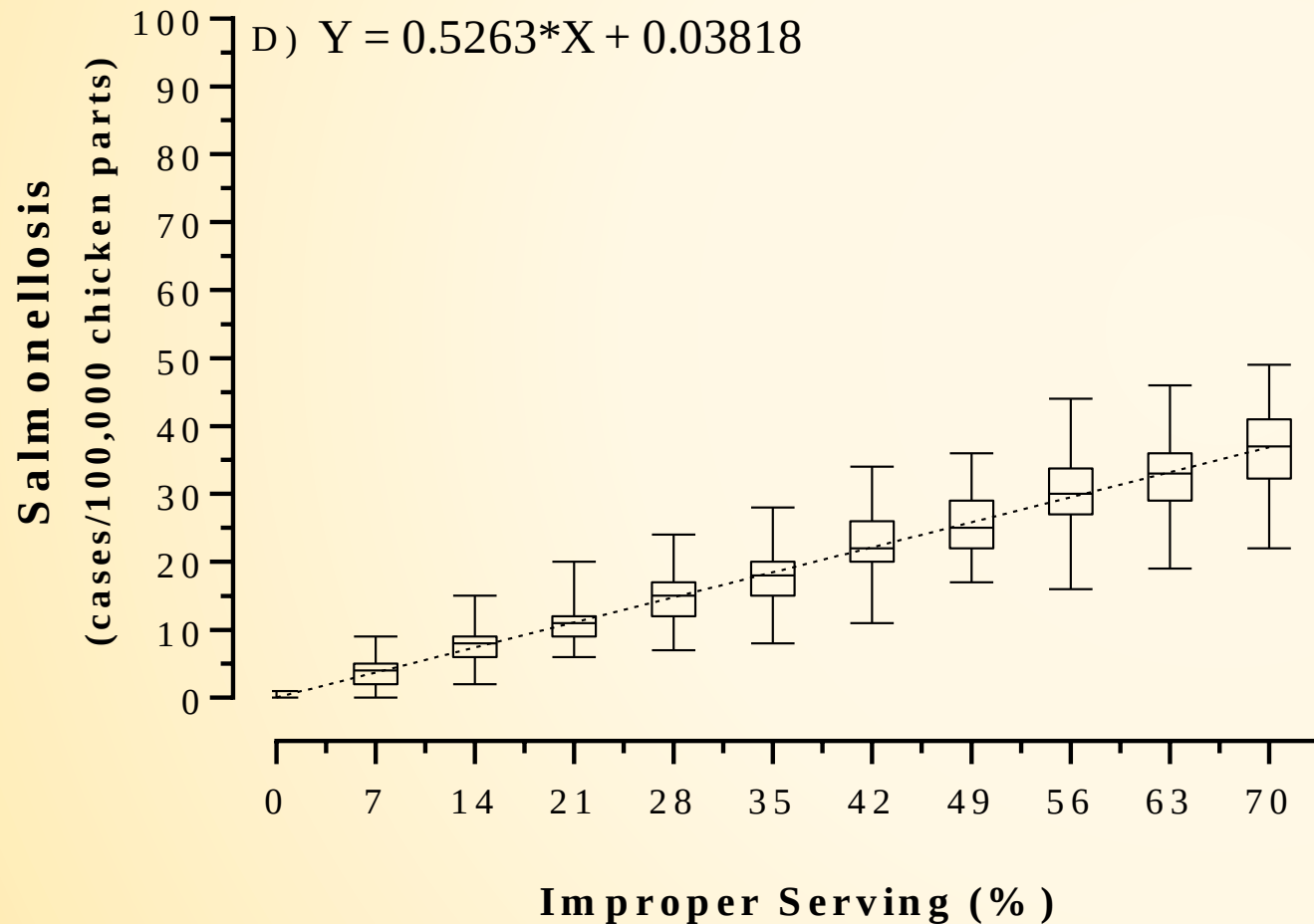
Undercooking



- Proper cooking
 - 15 cases per 10^5 chicken parts
- Improper cooking
 - linear increase ($P > 0.05$)

Serving (cross-contamination)

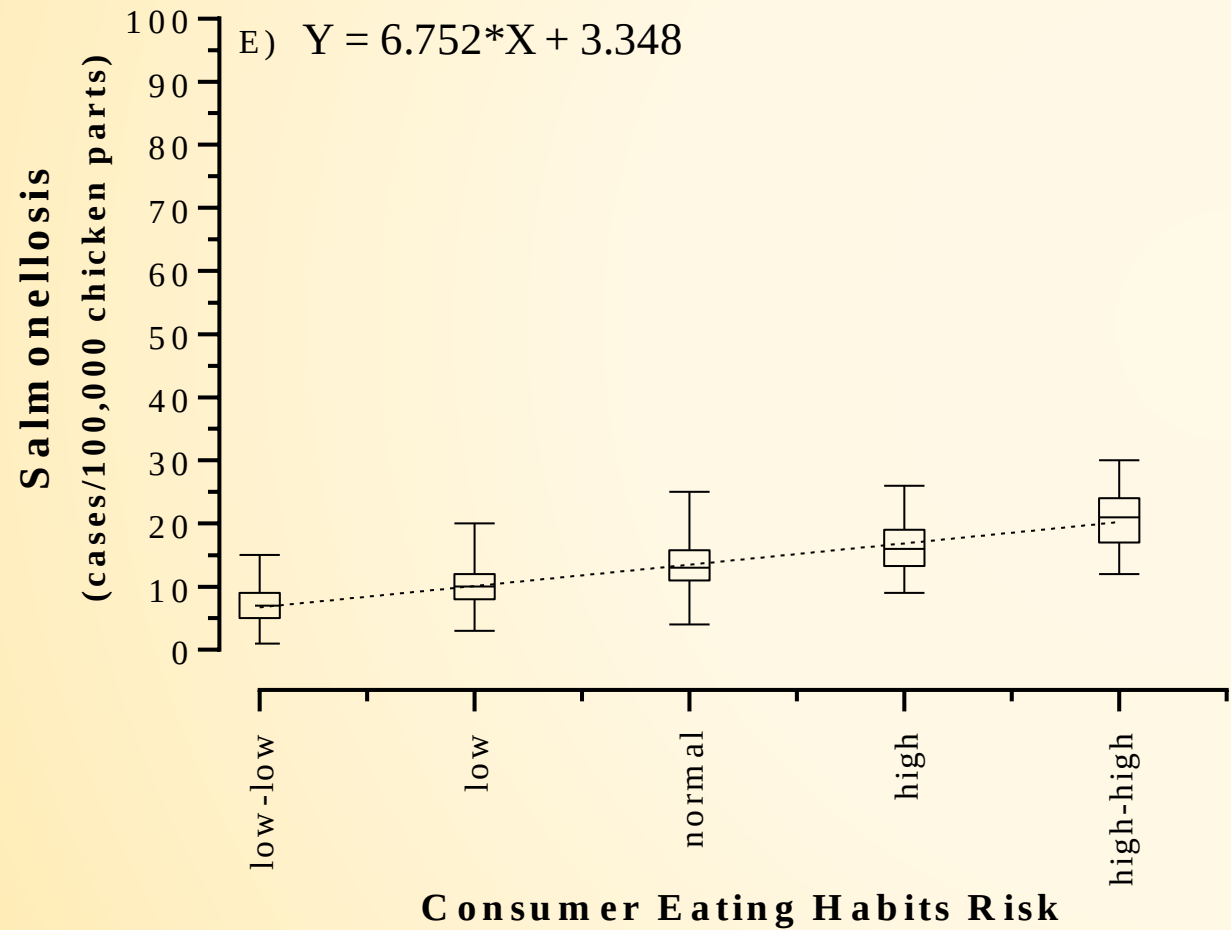
Unwashed utensils



- Proper serving
 - 2 cases per 10^7 chicken parts
- Improper serving
 - linear increase ($P < 0.05$)

Consumption (dose-response)

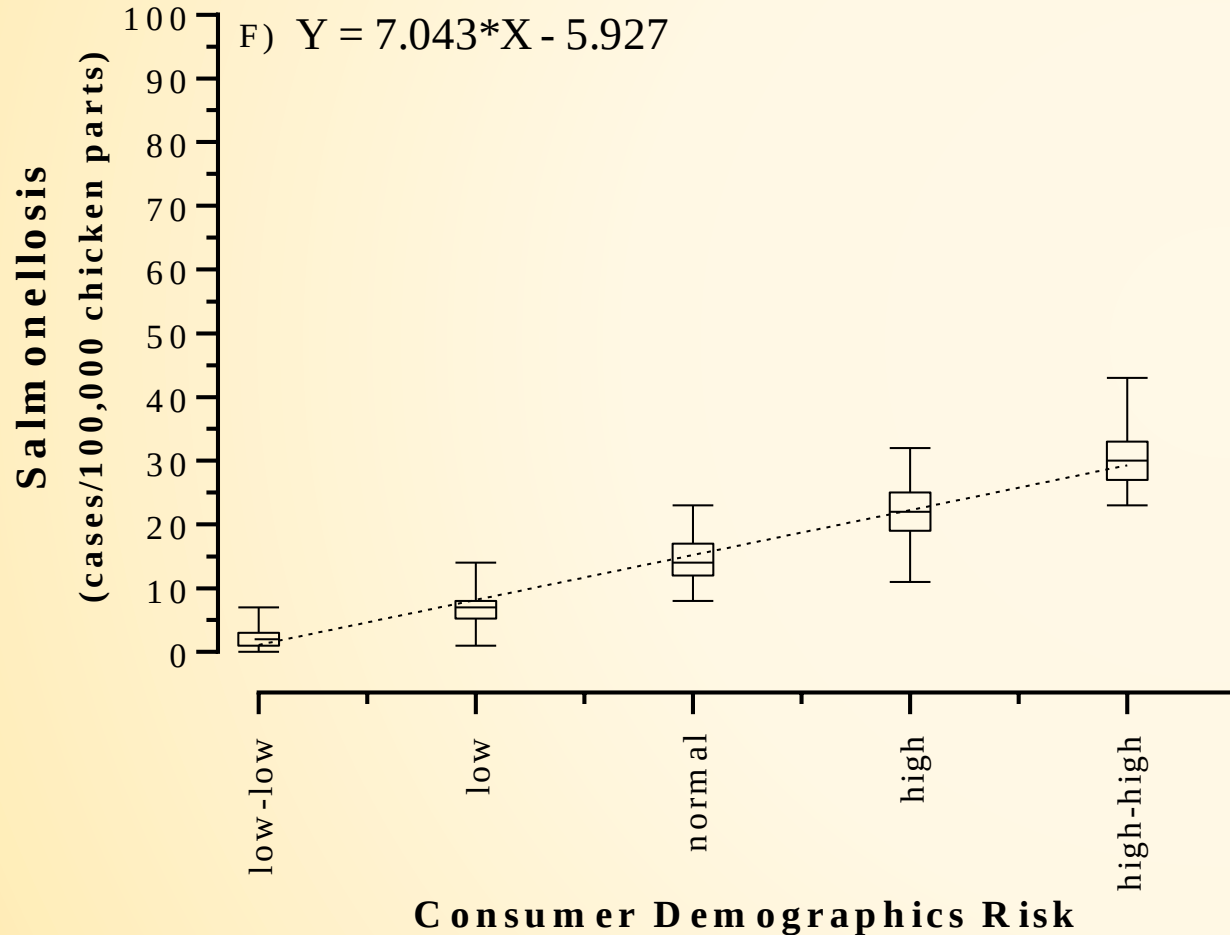
Less stomach acid



- Low-low risk meals
 - 7 cases per 10^5 chicken parts
- Higher risk meals
 - linear increase ($P < 0.05$)

Consumption (dose-response)

Host Resistance

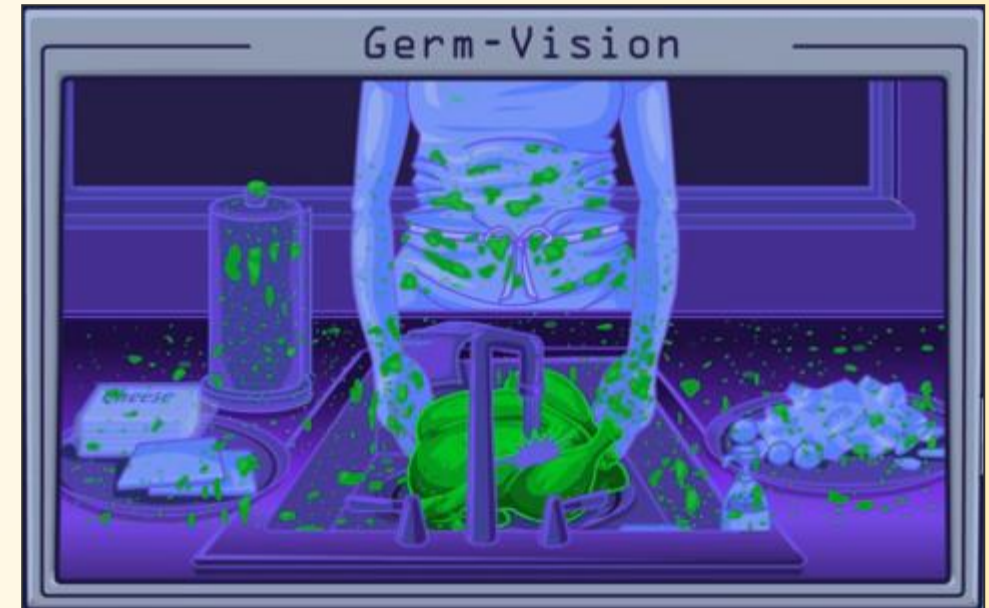


- Low-low risk consumer
 - 3 cases per 10^5 chicken parts
- Higher risk consumers
 - linear increase ($P < 0.05$)

Conclusion

Flow pack wrapper = risk to public health

- Improper storage
 - Increases prevalence and number of *Salmonella*
 - Increases risk of salmonellosis
- Risk factors
 - Temperature abuse
 - Cross-contamination
 - High risk meals, consumers, and *Salmonella*





Thank You!

Any Questions?