Salmonella in Poultry:
Surveillance and risk assessment to evaluate the public health impact of the presence of serotypes of concern and levels of contamination at production

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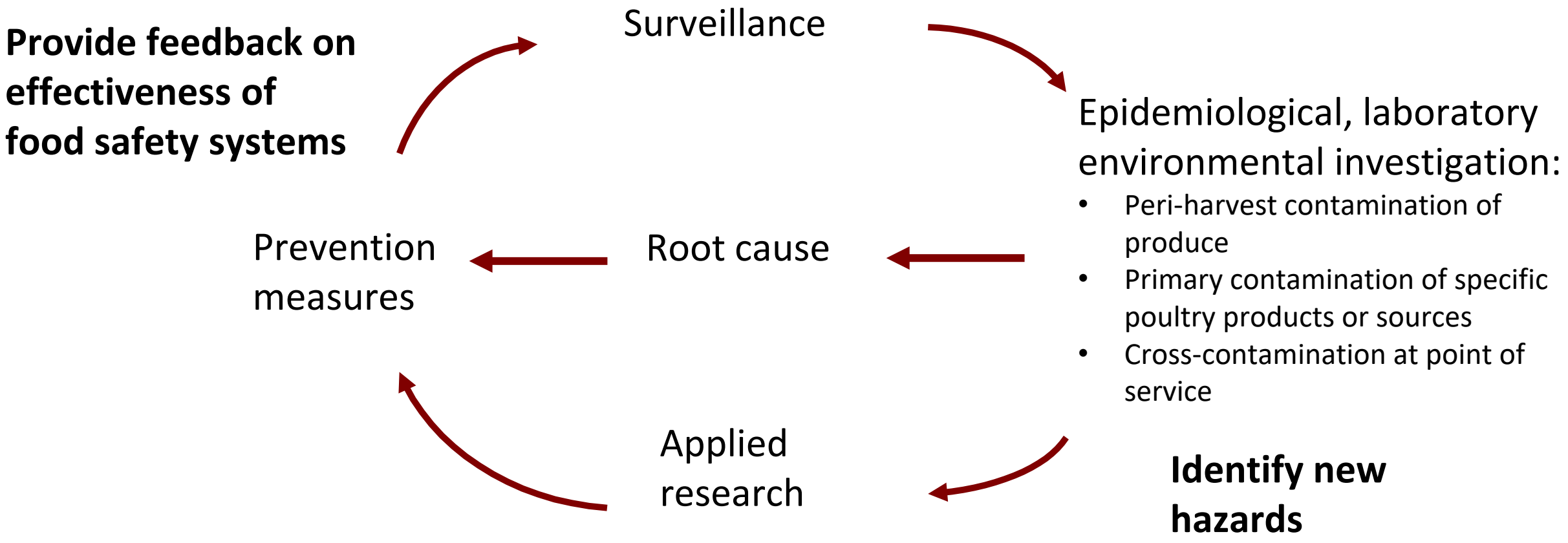
The Cycle of Public Health Prevention

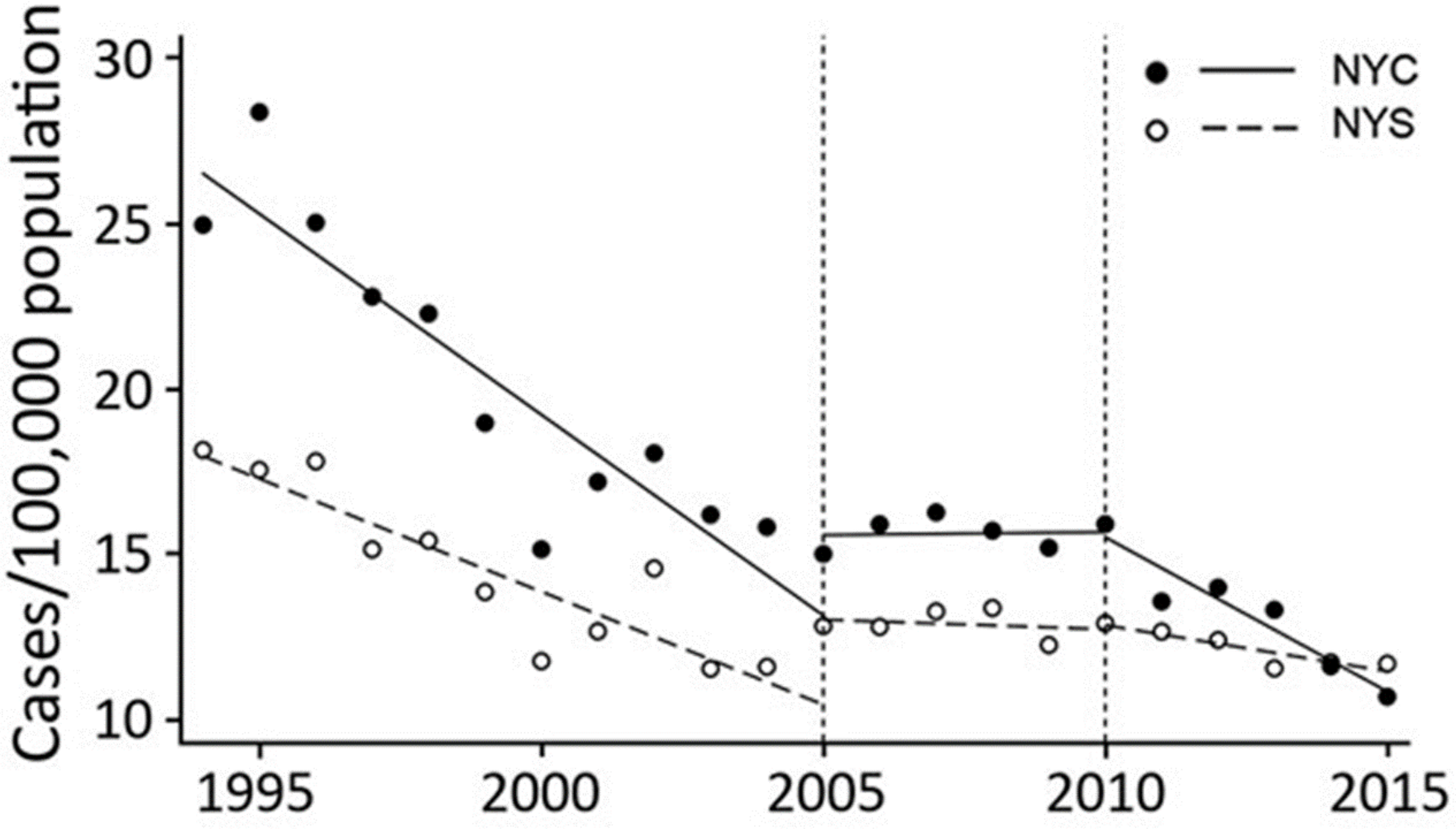
Humans are the ultimate bioassay for the food supply



Adapted from Rob Tauxe,CDC

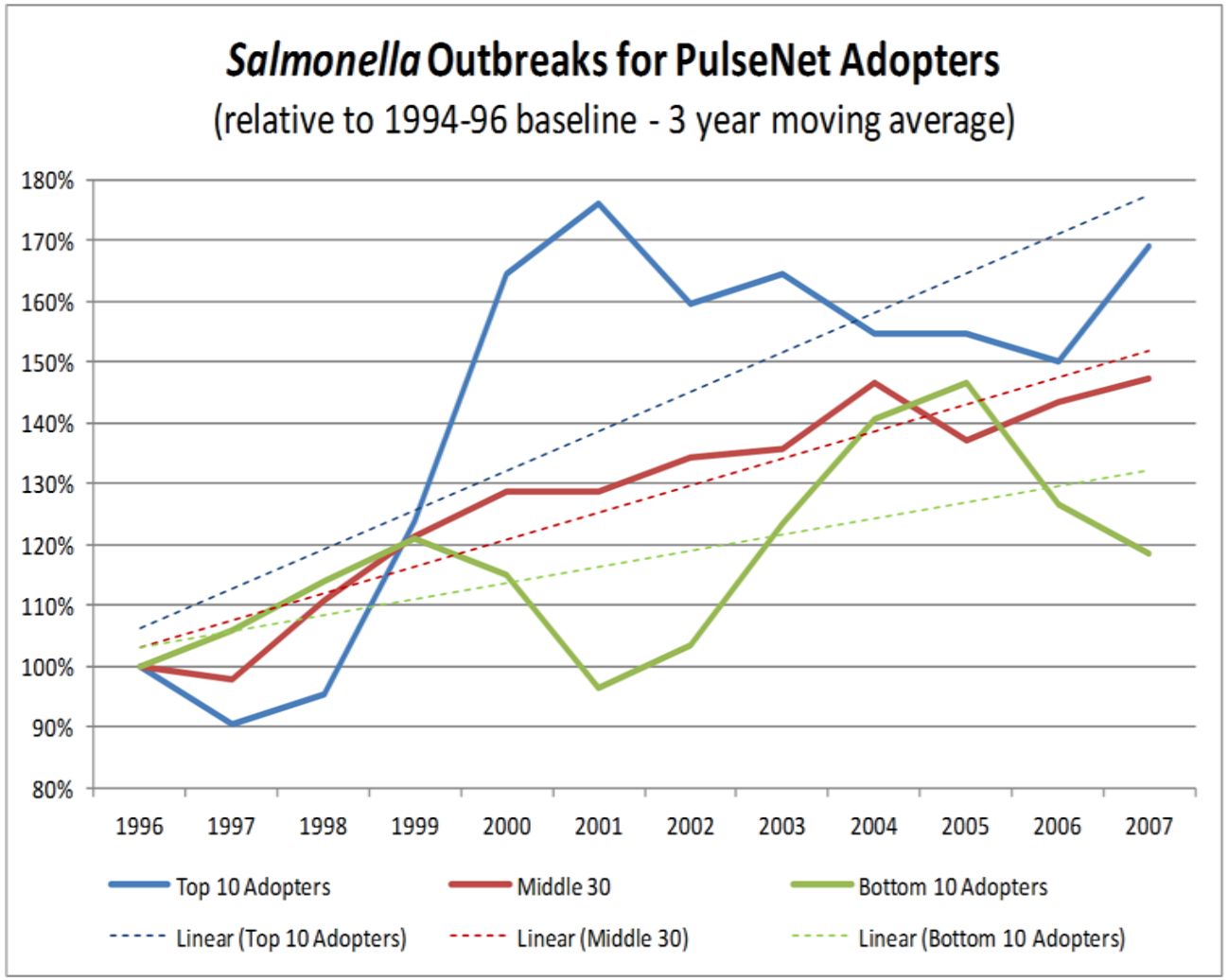
Interventions Should Lead to Better Control

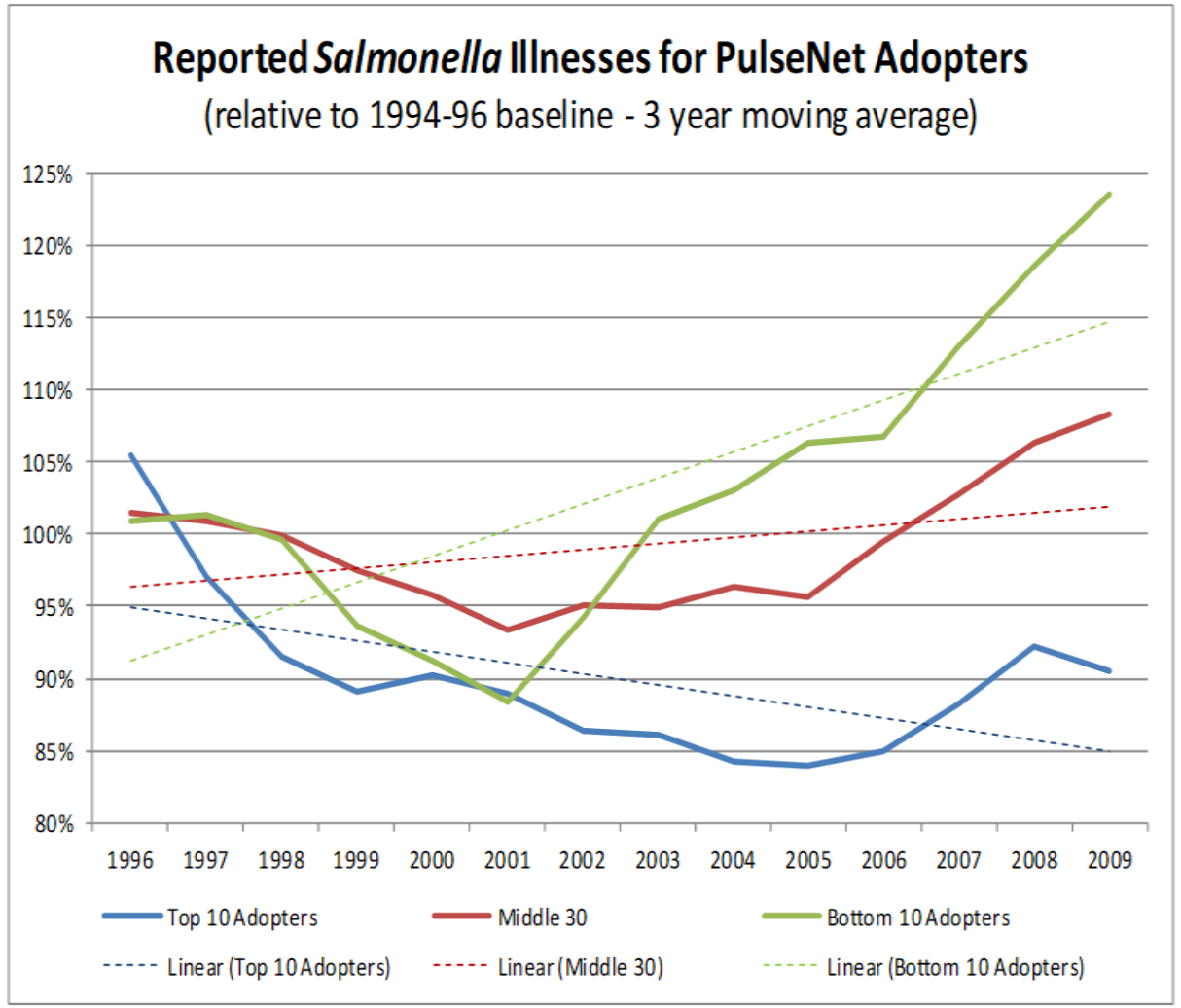
Restaurant Inspection Letter Grades and *Salmonella* Infections, New York, New York, USA



Firestone MJ, Hedberg CW. Emerg. Infect. Dis. 2018:24(12):2164-2168.

Validation that Surveillance Improves Prevention





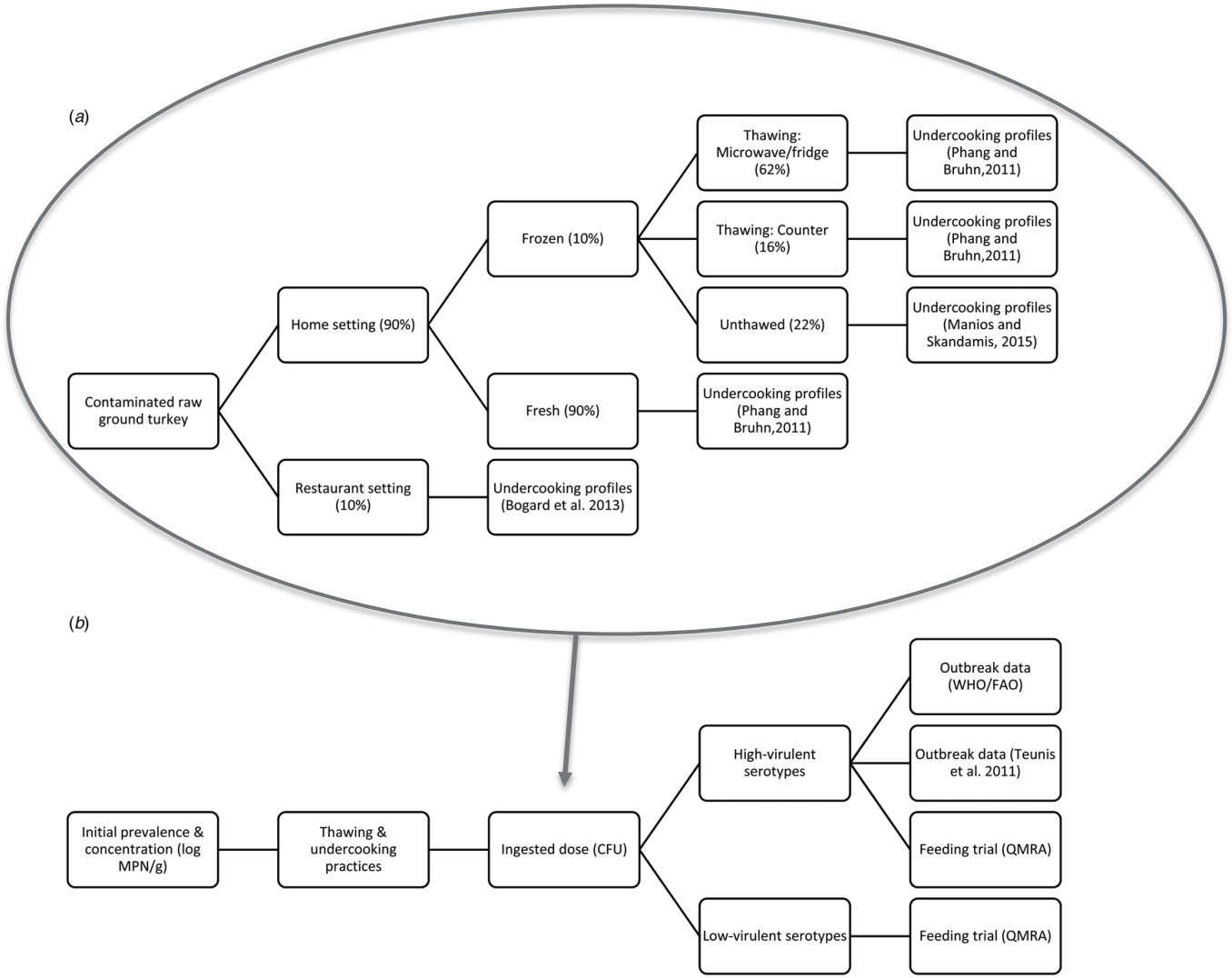
Scharff RL, Besser J, Sharp DJ, Jones TF, Peter GS, Hedberg CW. Am J Prev Med. 2016 May;50(5 Suppl 1):S66-S73.

Prioritization of Chicken Meat Processing Interventions on the Basis of Reducing the *Salmonella* Residual Relative Risk

- Quantitative microbial risk assessment studies on *Salmonella* have reflected that **the most impactful input parameter on reducing the number of illnesses is the ingested dose** (CFU) that is intimately related to the final pathogen concentration.
- Future research **studies focused on collecting data about the impact of current and novel food safety interventions on *Salmonella* levels** under real or closely simulated processing conditions would greatly **improve the accuracy of the predictions by simulation models.**

González RJ, Sampedro F, Feirtag JM, Sánchez-Plata MX, Hedberg CW. J Food Prot. 2019 Sep;82(9):1575-1582.

Risk Assessment Model: *Salmonella* in Ground Turkey



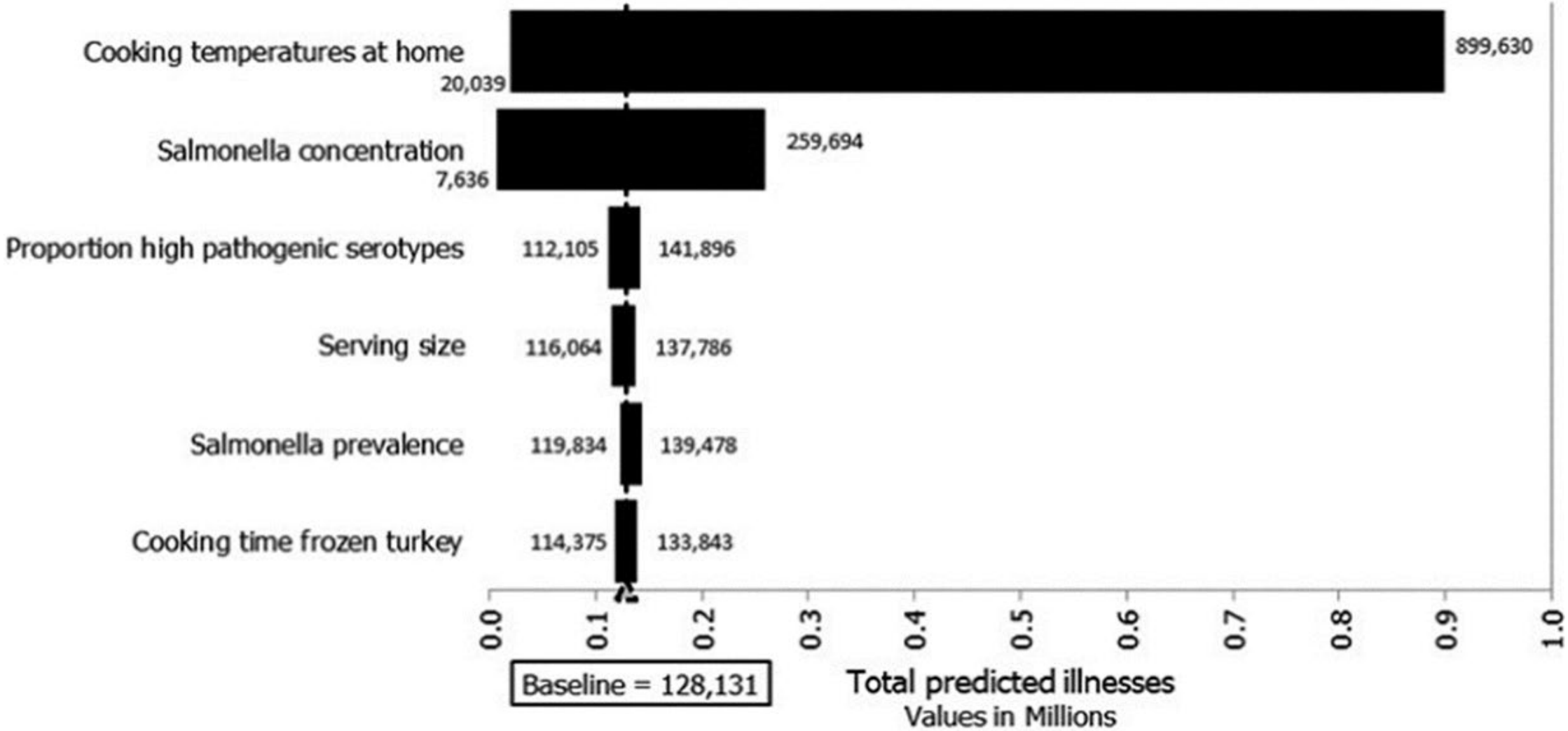
Input variable	Value	Source
National *Salmonella* prevalence	11.9%	Average proportion (2010–2016) FSIS (FOIA request)
Concentration levels	Normal (0.16, 1.00) log MPN/g	FSIS (2010–2016) FOIA request
Proportion of *Salmonella* high- and low-virulent serotypes[a]	37% (High) 63% (low)	Average proportion (2010–2016) FSIS (FOIA request)
Proportion of *Salmonella* cells in ground turkey centre point	Pert (0.1,0.16,0.2)	[9]

Revised Inputs

- Salmonella prevalence: 14.0%
- Proportion of highly virulent serotypes: 47%

Sampedro F, Wells S, Bender J, Hedberg C. Epidemiology and Infection, 147, E69. doi:10.1017/S095026881800328X

Risk Assessment Model: *Salmonella* in Ground Turkey



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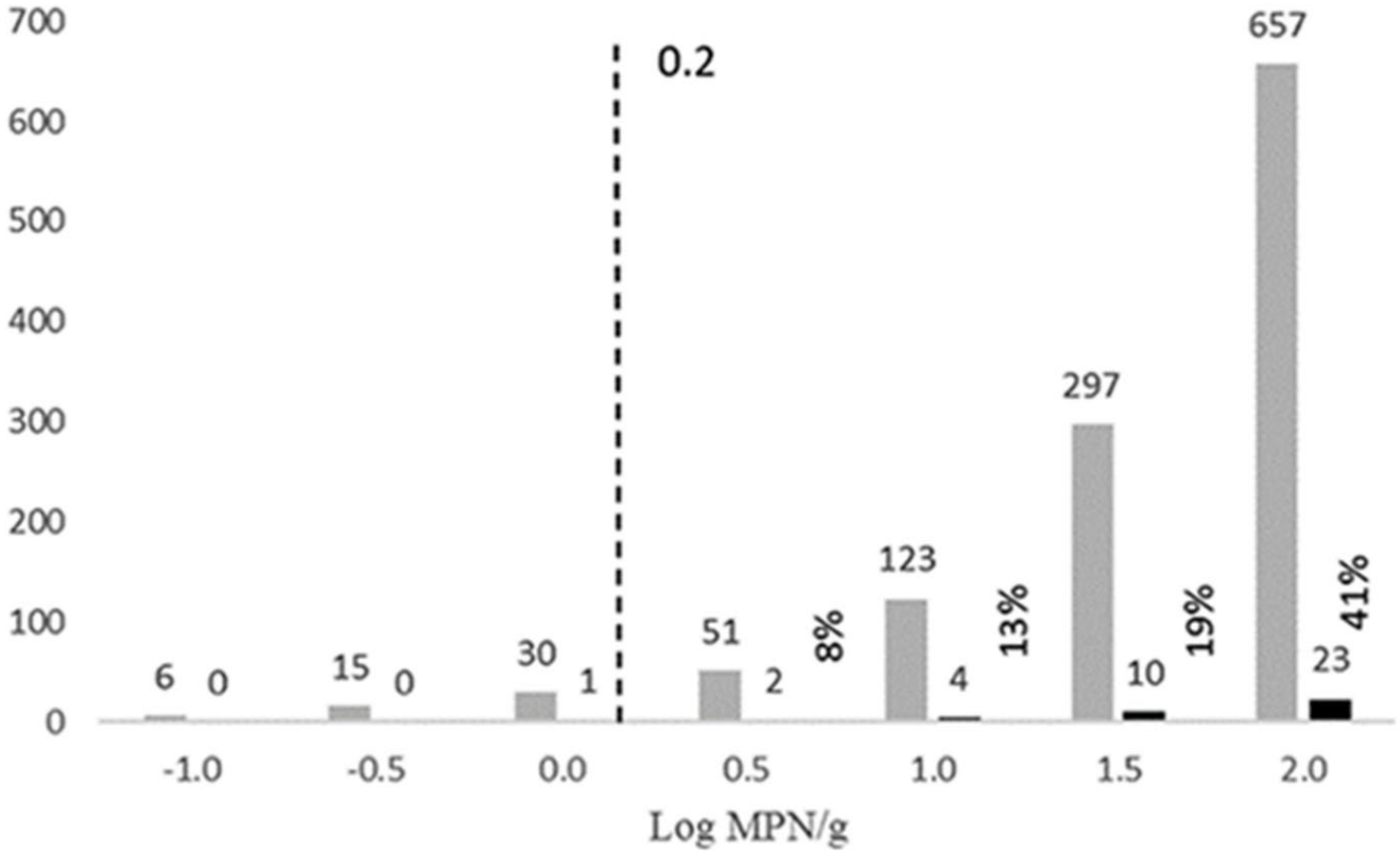
Risk Assessment Model: *Salmonella* in Ground Turkey

Effect of Mitigation Measures	Number of Illnesses	% Reduction in Illnesses
	Mean value (95%CI)	
Baseline estimate	23,073 (0-105,189)	NA
Remove high-virulence serotypes	3,228 (0-12,980)	96.9
Remove highly contaminated lots (>1 MPN/g)	1,328 (0-6,586)	94.2
Remove contaminated lots (>1 MPN/ 25g)	65 (0-262)	99.7



Illnesses associated with individual 2,000 lb. lots, % likelihood of detecting a cluster.

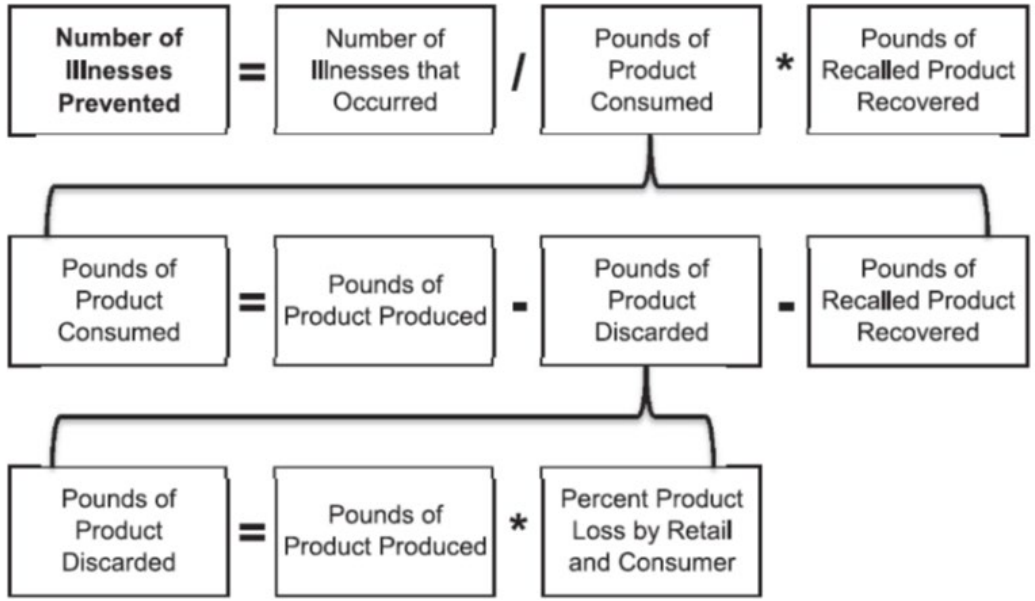
Sampedro F, Wells S, Bender J, Hedberg C. Epidemiology and Infection, 147, E69. doi:10.1017/S095026881800328X

TABLE 1. *Summary of salmonellosis outbreaks associated with frozen, microwaveable, breaded, stuffed chicken products in Minnesota, 1998 to 2006*

Yr(s)	Serotype	No. of cases	Median age in yr (range)	% male	Duration of outbreak (mo)
1998–1999	Typhimurium	33	17 (1–78)	48	5
2005	Heidelberg	4	30 (18–81)	100	3
2005–2006	Enteritidis	27	31 (5–85)	63	11
2006	Typhimurium	3	18 (16–25)	100	2

Smith KE, Medus C, Meyer SD, Boxrud DJ, Leano F, Hedberg CW, Elfering K, Braymen C, Bender JB, Danila RN.. J Food Prot. 2008 Oct;71(10):2153-60.

Assessment of Meat and Poultry Product Recalls Due to *Salmonella* Contamination: Product Recovery and Illness Prevention



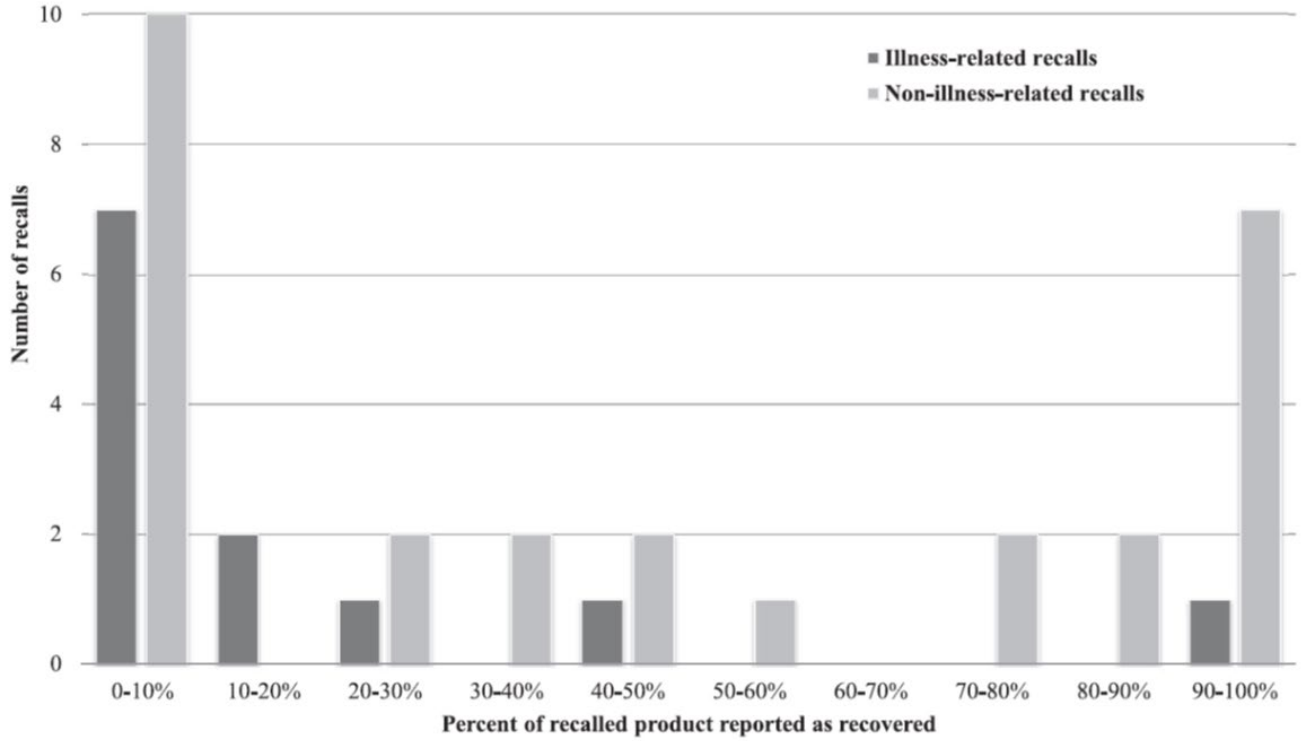


FIGURE 2. *Percentage of recalled product recovered by the number of recalls due to* Salmonella, *2000 to 2012.*

- States that reported more outbreaks were more likely to be part of illness-associated recalls.

Seys SA, Sampedro F, Hedberg CW. J Food Prot. 2017 Aug;80(8):1288-1292.

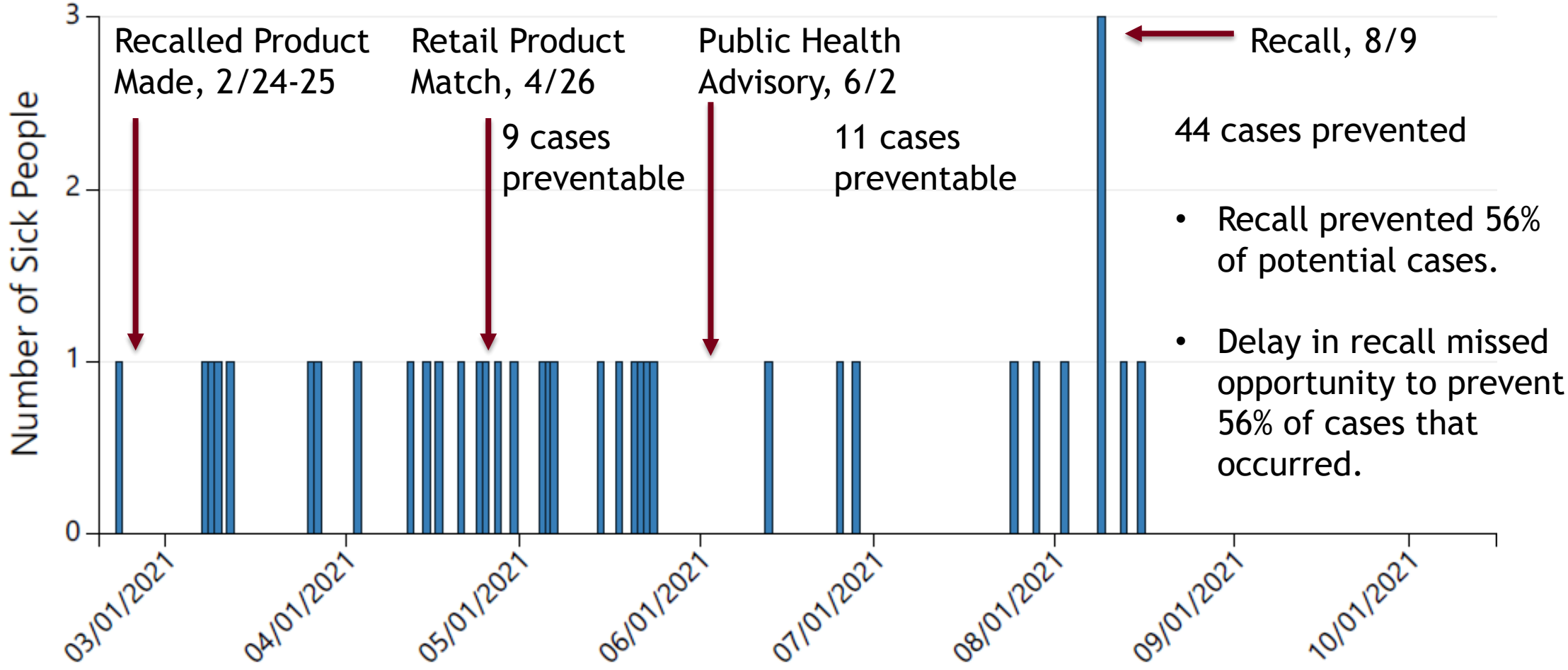
Estimated Number of *Salmonella* Cases Prevented by Recall of Implicated Frozen Raw Breaded Chicken Products, 2014-2021

Year	Agent	No. Cases (MN)	Lbs. Recalled	Lbs. Recovered	Illness Rate (per 100,000 lbs.)	No. Cases Prevented (Adjusted *)
2014	SE	9 (8)	28,980	1,234	43.2	<1 (16)
2015	SE	15 (8)	58,000 1,707,494	0	34.0 1.2	0
2015	SE	6 (6)	1,978,680	554,412	0.6	3 (100)
2021	SE	36 (4)	59,251	24,806	178.0	44 (1,294)

*Adjusted for underdiagnosis and underreporting.

Data from MDH, CDC, FSIS

Salmonella Enteritidis Associated with Frozen Raw Breaded Chicken Products, Epidemic Curve and Event Timeline, 2021



Data from MDH, CDC, FSIS

Lessons Learned from Outbreaks Associated with Frozen Raw Breaded Chicken Products

- Outbreaks are associated with serovars of concern, rather than full range of *Salmonella* detected in products.
  - *S*. Enteritidis, *S*. Typhimurium, *S*. Heidelberg
- Outbreak durations persist over several months, even when associated with 1 -2 days' production.
- Routine use of WGS for human illness surveillance will improve detection of outbreaks and give more accurate picture of size and geographic spread of outbreak.
- **Episodic nature of outbreaks suggests that contamination of specific lots with high levels of serovars of concern cause outbreaks associated with products that are frequently mishandled.**
- Product recalls can prevent illnesses-dependent on speed and effectiveness of investigation.