RUTGERS

New Jersey Agricultural Experiment Station

Using Modeling and Risk Assessment in Managing *Salmonella* Risk in Peanut Butter

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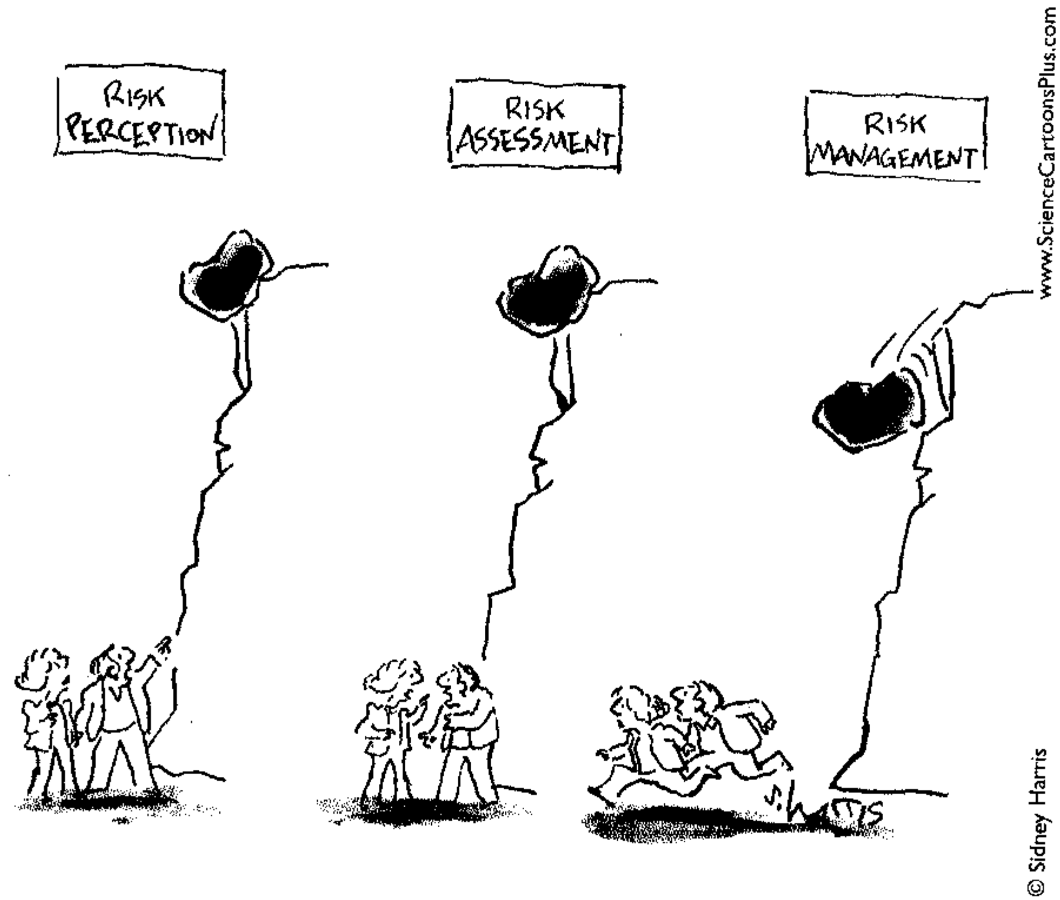
What is risk analysis?



General steps in the risk assessment

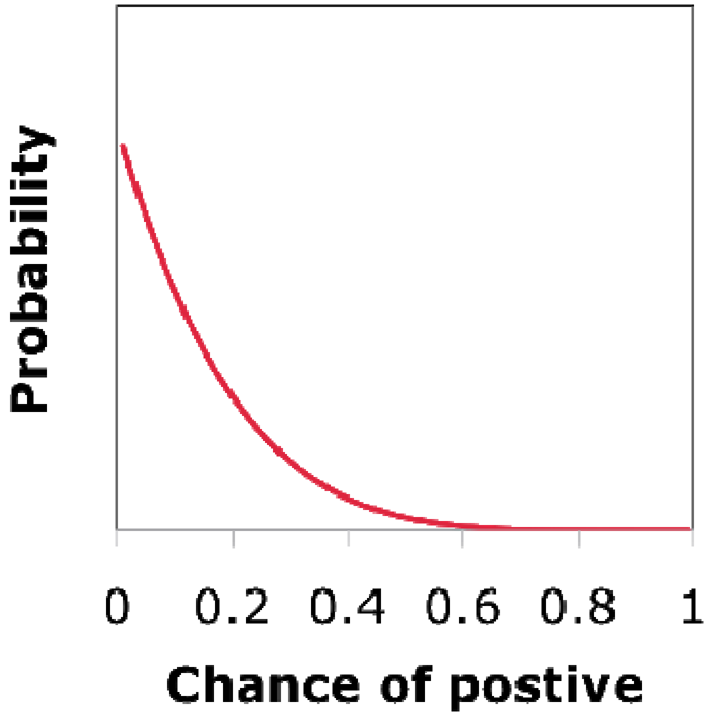
- Hazard Identification
  - What microbe, food(s) and people are involved?
- Exposure Analysis
  - What is the chance of exposure?
  - How many cells?
- Dose-Response Analysis
  - What is the human health effect of the exposure?
- Risk Characterization
  - Complete picture of the assessed risk

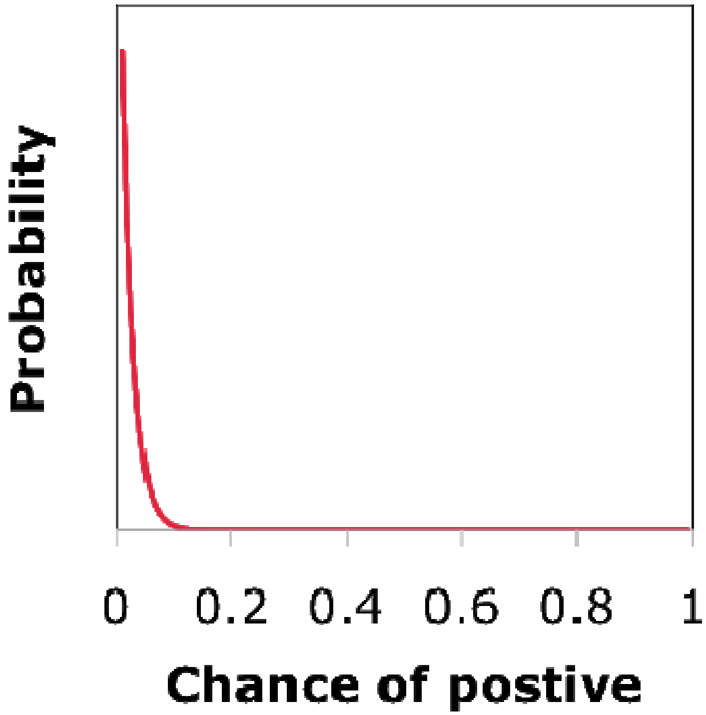
Peanut product risk assessment

Formulation details	What is the serving size? How much of ingredient X per serving? How much peanut butter in ingredient X?
Effect of testing	Probability of a Salmonella positive, given tests
Salmonella concentrations	Assumed Salmonella cells per gram Grams per serving Cells per serving Log cell per serving initial Log reduction Log cell per serving, final Cell per serving, final
Human illness	Probability of illness – Dose response Is this person sick?

What use is sampling?

- Zero of 5 positive
- Zero of 50 positive





Non-linear thermal process

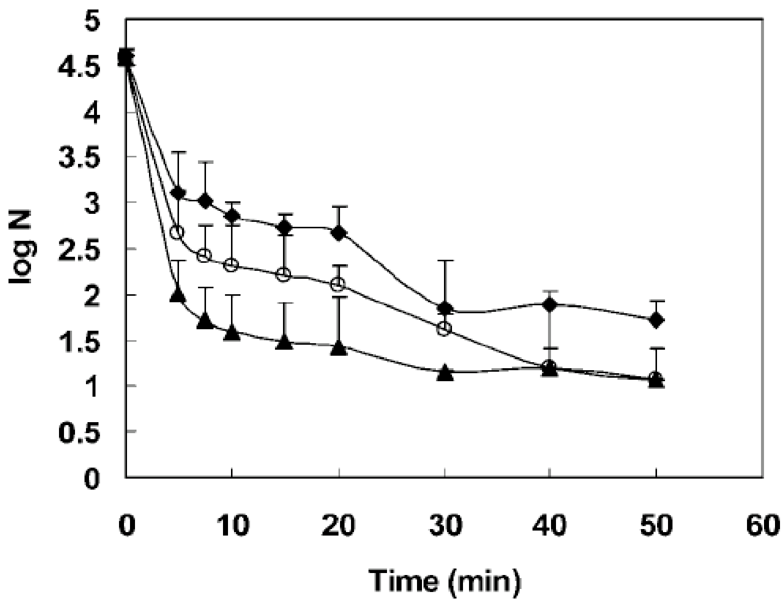
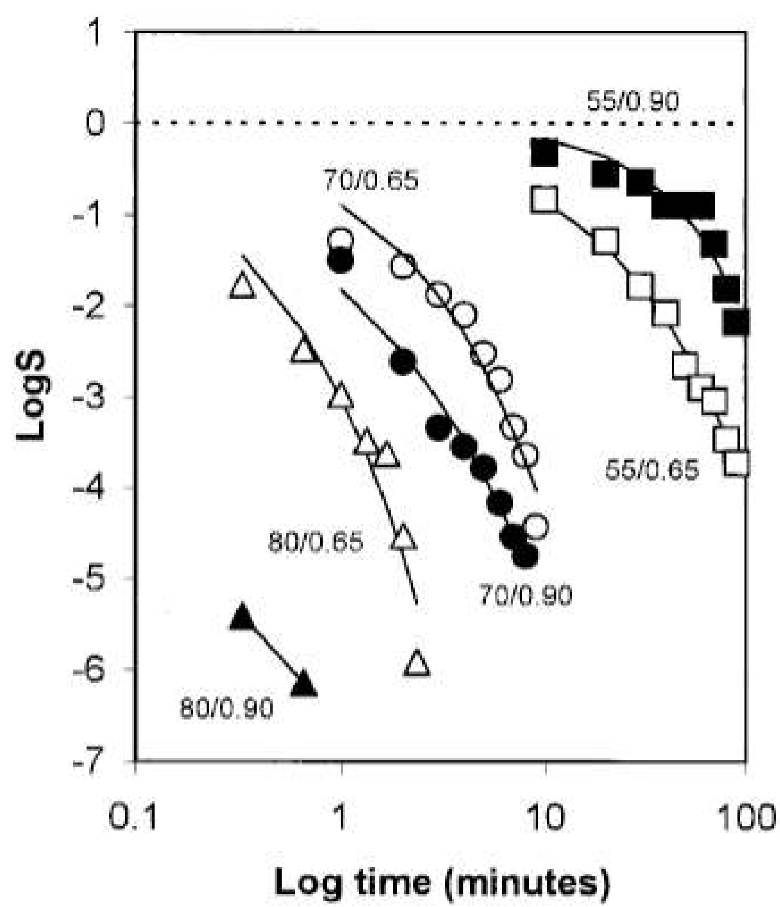


FIGURE 2. *Inactivation of low initial concentrations of* Salmonella *Agona,* Salmonella *Enteritidis, and* Salmonella *Typhimurium in peanut butter. Bacteria (approximately 5 × 10⁴ CFU/g) were introduced into preheated 25-g samples of peanut butter, and the number of surviving cells was determined from plate counts. Values are the log CFU per gram of sample. Bacteria were treated in peanut butter at 70°C (◆), 80°C (○), or 90°C (▲). The standard error of the mean for the results from the three serovars is shown.*

- ~~Log N = -D*t~~
- Log N = $-b*t^n$
- Sachar and Yaron (JFP, 2006)

Thermal process, Mattick et al, Kinetics



- Model system: Tryptic soy broth with added glucose, fructose and sucrose
- Temp conversions
  - 55 C = 131 F
  - 70 C = 158 F
  - 80 C = 176 F
- Note “flip” between 55 and 70

- Mattick, et al. AEM, 2001

Mattick et al, strain to strain variability

TABLE 4. Values for n in the equation $\text{LogS} = -b \times t^n$, when used to describe inactivation curves for *Salmonella* serovars exposed to high temperature and low a_w[a]

Serovar and/or strain	Value for n at heat challenge temp and water activity (rvp)								
	60°C			65°C			72°C		
	0.65	0.80	0.90	0.65	0.80	0.90	0.65	0.80	0.90
Typhimurium DT104 strain 30	0.55	0.72	1.30	0.82	0.73	0.79	0.76	0.85	0.63
Typhimurium DT104 strain 16	0.91	0.68	1.42	1.01	0.95	0.88	0.49	0.72	0.42
Enteritidis PT4 strain E	0.37	0.56	0.82	0.48	0.83	1.12	0.62	0.59	0.45
Napoli	0.85	0.87	1.44	1.19	0.76	1.05	1.07	1.01	0.44
Agona	0.68	0.46	0.59	0.60	0.72	0.51	0.90	0.64	0.33
Java	0.60	0.67	0.56	0.51	0.66	0.52	0.90	0.68	0.45
Senftenberg 775W	0.47	0.63	0.54	0.43	0.68	0.65	0.53	0.74	0.46

[a] If $n = 1$, then the inactivation is a straight line (when plotted as LogS versus t); when $n < 1$, then tailing is observed; when $n > 1$, the curve has a shoulder.

TABLE 5. Values for b in the equation $\text{LogS} = -b \times t^n$, when used to describe inactivation curves for *Salmonella* serovars exposed to high temperature and low a_w

Serovar and/or strain	Value for b at heat challenge temp and water activity (rvp)								
	60°C			65°C			72°C		
	0.65	0.80	0.90	0.65	0.80	0.90	0.65	0.80	0.90
Typhimurium DT104 strain 30	0.38	0.19	0.02	0.36	0.39	0.45	1.26	1.80	3.17
Typhimurium DT104 strain 16	0.09	0.23	0.01	0.19	0.23	0.29	0.17	0.10	0.54
Enteritidis PT4 strain E	0.99	0.41	0.13	1.24	0.33	0.14	0.16	0.21	0.52
Napoli	0.15	0.10	0.01	0.15	0.55	0.22	0.01	0.02	0.44
Agona	0.32	0.70	0.40	0.95	0.58	1.18	0.03	0.20	0.95
Java	0.42	0.23	0.45	1.20	0.55	1.04	0.02	0.14	0.47
Senftenberg 775W	0.68	0.32	0.52	1.46	0.54	0.78	0.27	0.11	0.52

Mattick et al – model validation

TABLE 7. Survival of serovar Typhimurium DT104 in sugar solutions and in low a_w foods at 55 to 74°C, expressed as the time to obtain a 3-log_{10} decrease in cell concentration

Food	Challenge temp (°C)	Death rate predicted in sugar solution			Death rate observed in foods		
		a_w	pH	Time to obtain a 3-log decrease (min)	a_w	pH	Time to obtain a 3-log decrease (min)
Pecorino cheese	55	0.87	6.5	143	0.87	5.7	10
	65			9.5			0.7
	74			1.1			0.8
Coconut cake	55	0.86	6.5	67[a]	0.86	6.2	111[a]
	65			9.5			18
	74			1.2			0.7
Pepperoni sausage	55	0.84	6.5	123	0.84	5.2	13
	65			9.6			1
	74			1.3			0.7
Strawberry jam	55	0.82	6.5	114	0.82	3.0	15
	65			9.7			3
	74			1.4			0.3
Dried apricots	55	0.64	6.5	206	0.64	4.0	44
	65			12			6
	74			2.5			1
Peanut butter	55	0.50[b]	6.5	13,679[a]	0.50[b]	6.1	98[a]
	65			5.6[a]			24[a]
	74			1.7[a]			6[a]

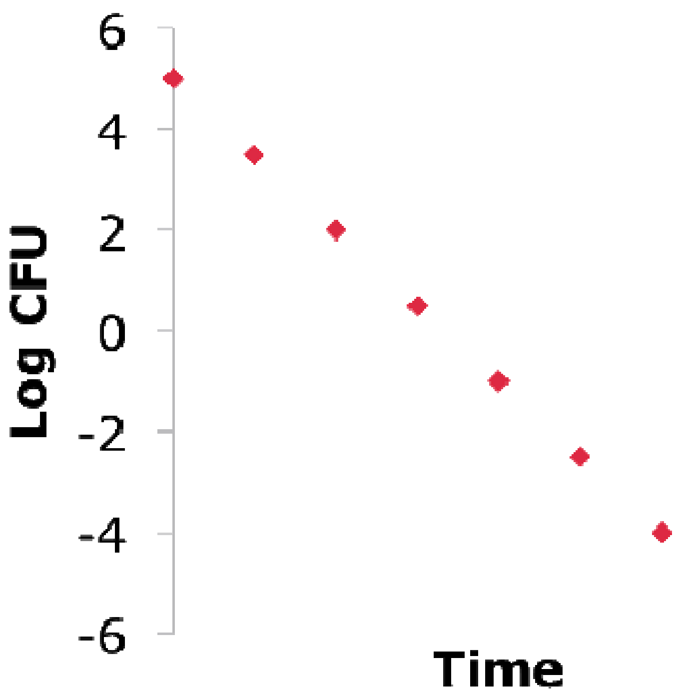
[a] Where the fall in bacterial concentration was less than 3 log_{10}, the time to decrease the population by 1.5 log_{10} is given.
[b] Prediction for a food with an a_w well outside the range of the model.

Math of log reductions

- Are you microbiologically numerate?
- Assume
  - There are 100 containers of food
  - Each container has exactly 10 pathogens
  - Each container is given a 1 log reduction
  - How many pathogens expected per container?

- Assume
  - Same situation, except that now each container is given a 2 log reduction
  - How many pathogens expected per container?
  - Hint: The answer is not zero!

Math of log reductions

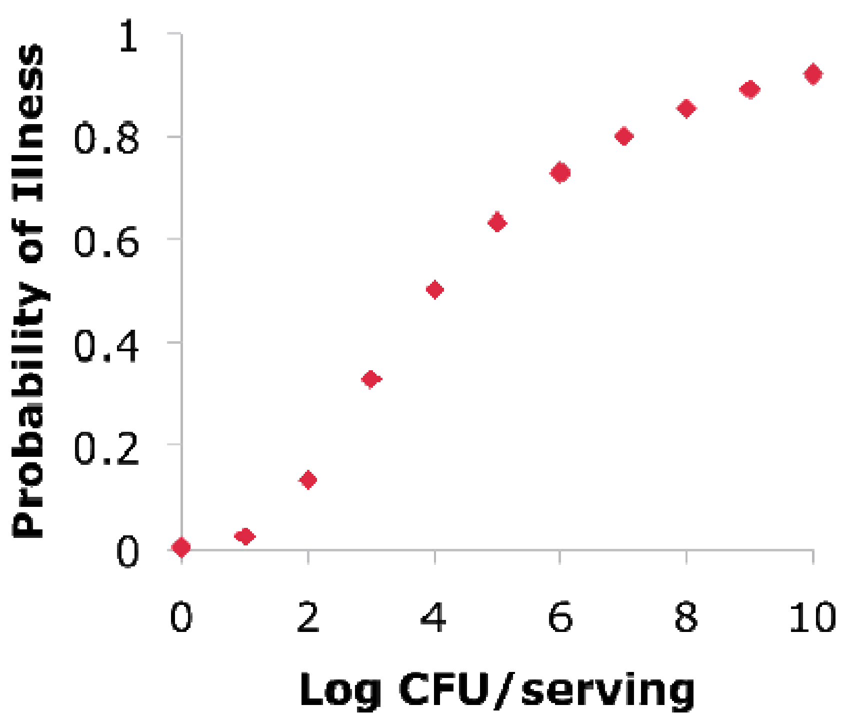


- 10 pathogens = 1 log CFU
- 1 pathogen = 0 log CFU
- ? Pathogen = -1 log CFU

- 1/10 of a pathogen?

- 1 in 10 containers have 1 cell

Dose response

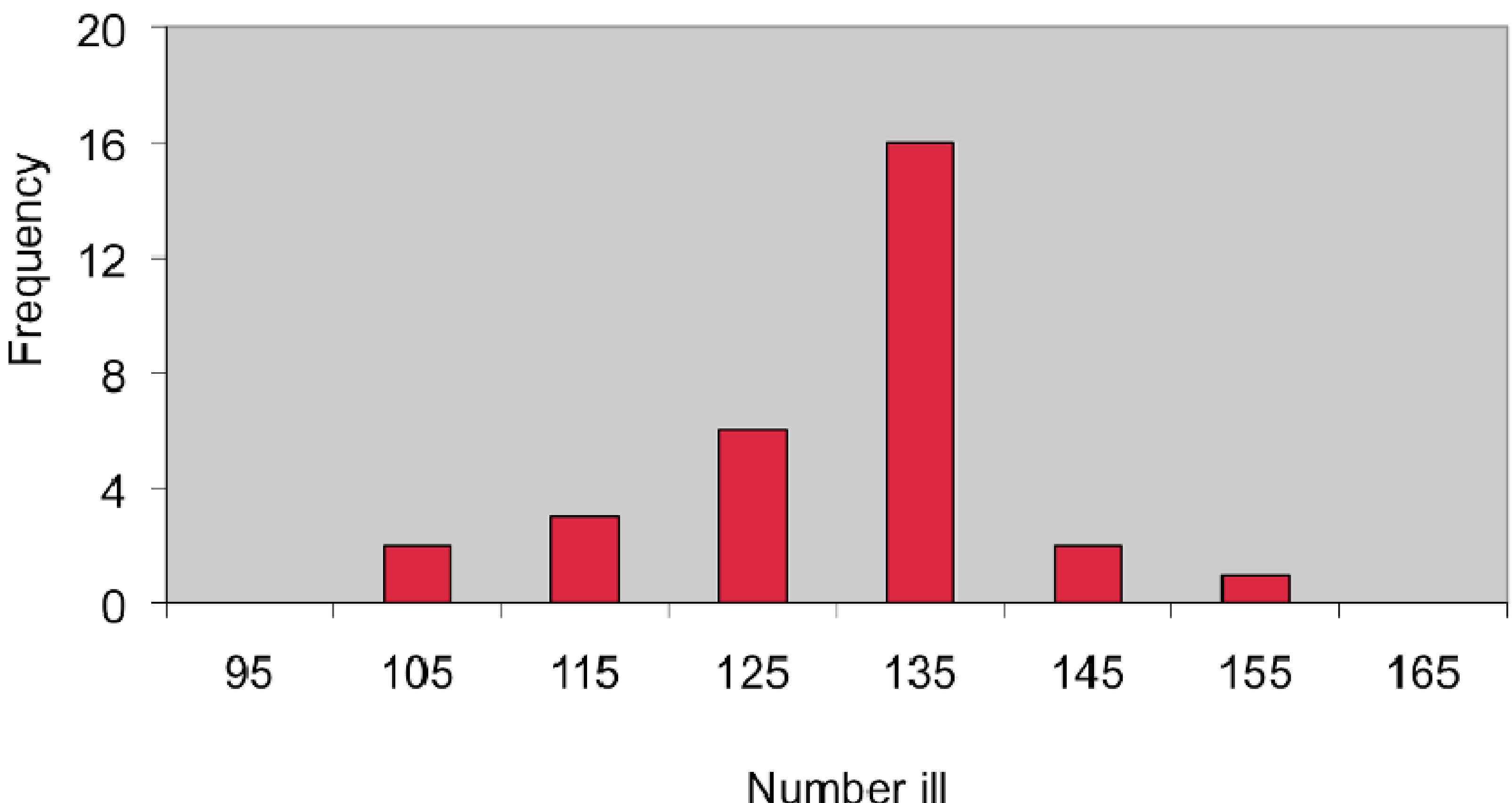


- There is no such concept as the “infectious dose”
- One cell can make you sick
- 1 cell = 0.02% prob of illness, 1/392 people
- DR model
  - FAO/WHO 2002. Risk assessments of Salmonella in eggs and broiler chickens.

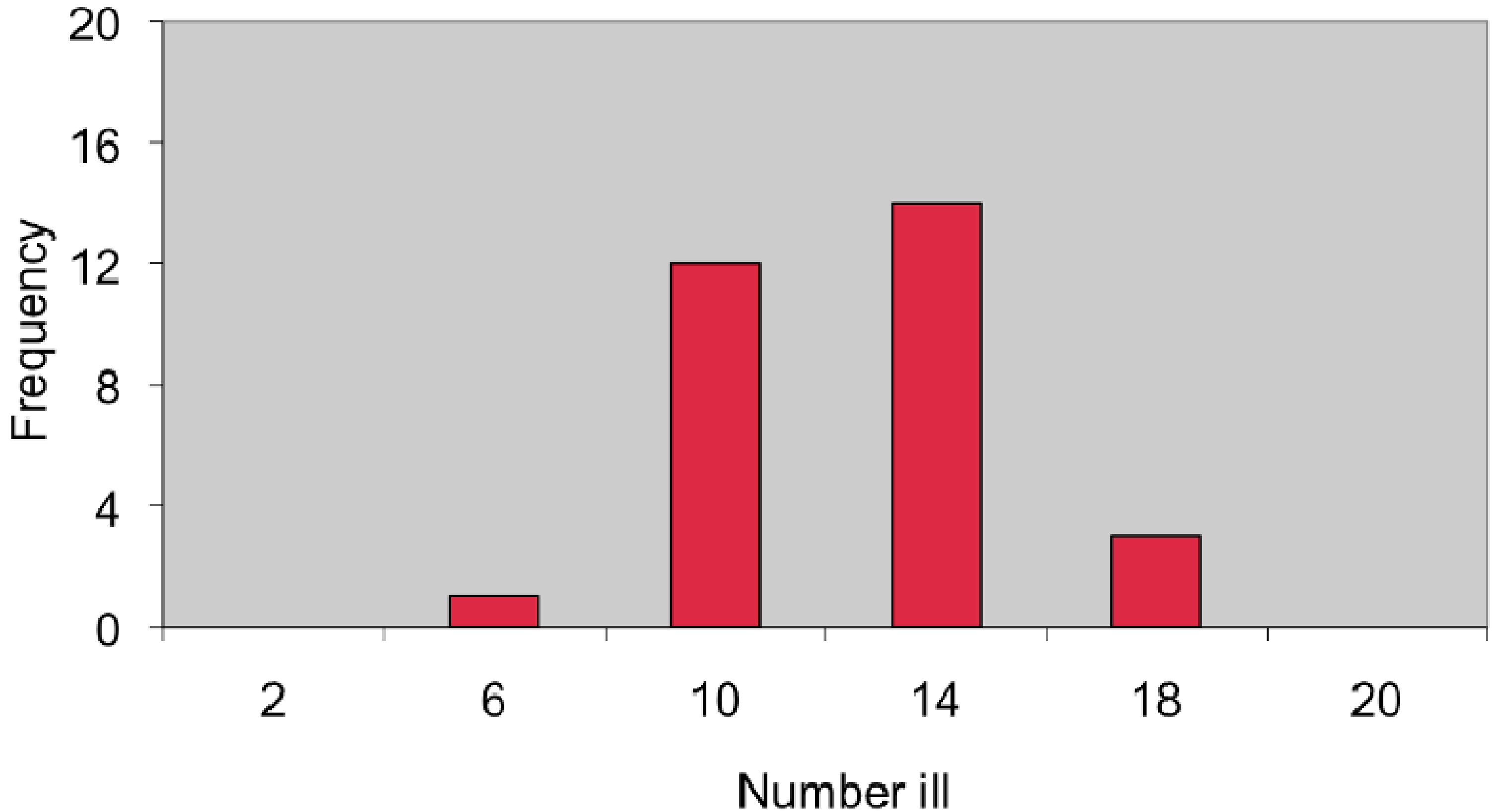
Scenario assumptions

- The peanut butter is contaminated at 1.5 cells/g
- One serving contains 3.6 grams of peanut butter
- One hundred and fifty tests of peanut butter, all negative
- One and a half million servings
- Log reduction assumed to vary uniformly from 0.86 to 1.49 Log CFU
- Dose response model from FAO/WHO RA for *Salmonella* in eggs and broiler chickens
- Simulated 1.5 million servings, 30 times

Results: assuming no log reduction



Results: assuming ~0.9-1.5 log reduction



Summary

- There is no such thing as zero risk
- Negative test results can be used to help estimate risks
- Data on prevalence and concentration would be very helpful
- Non-linear activation models are helpful
- Even a slight log reduction can have a positive effect, especially where doses are low
- A large number of servings, contaminated sporadically, at a very low level can produce an outbreak