A Decision-Support Tool for Food Safety Technology Investments

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INTRODUCTION

Foodborne pathogens are an ongoing concern for low-moisture food processors, causing outbreaks and recalls for numerous products[1, 2].

Recall, *Salmonella*
June 2024

Recall, *L. monocytogenes*
May 2024

Outbreak, *E. coli*
April 2024

These events are costly to the public health sector, consumers, and industry[3]. Current research on economic impacts are largely focused on public health and consumer costs, rather than company-specific costs that are important to business decision makers.

Furthermore, food safety investments do not elicit immediate financial returns for food producers, making investing in food safety technology a difficult business decision. Economic benefits associated with investing in food safety technology have never been quantified, and **risk reduction should = $ for producers.**

OBJECTIVES

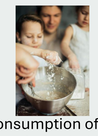
The objective of this study is to develop a **novel, proof-of-concept framework for economic valuation of food safety risk reduction**, and to demonstrate the framework using a case study of a 20-year example scenario, *E. coli* in raw flour, encompassing:

1. QMRA for illnesses due to raw flour consumption
2. Recall/outbreak costs incurred by firms
3. Food safety technology cost-benefit decision analysis

QMRA

Methods

- **Program used:** R version 4.4.1
- **Calculations:** Monte Carlo simulation with 10,000 iterations
- **Exposure scenario:**

Wheat contaminated (*E. coli*) in the field →  Potential vacuum steam treatment application →  Tempering with water → **Breaker** → **Sizing** → **Reduction** →  Consumer storage →  Consumption of raw flour during baking

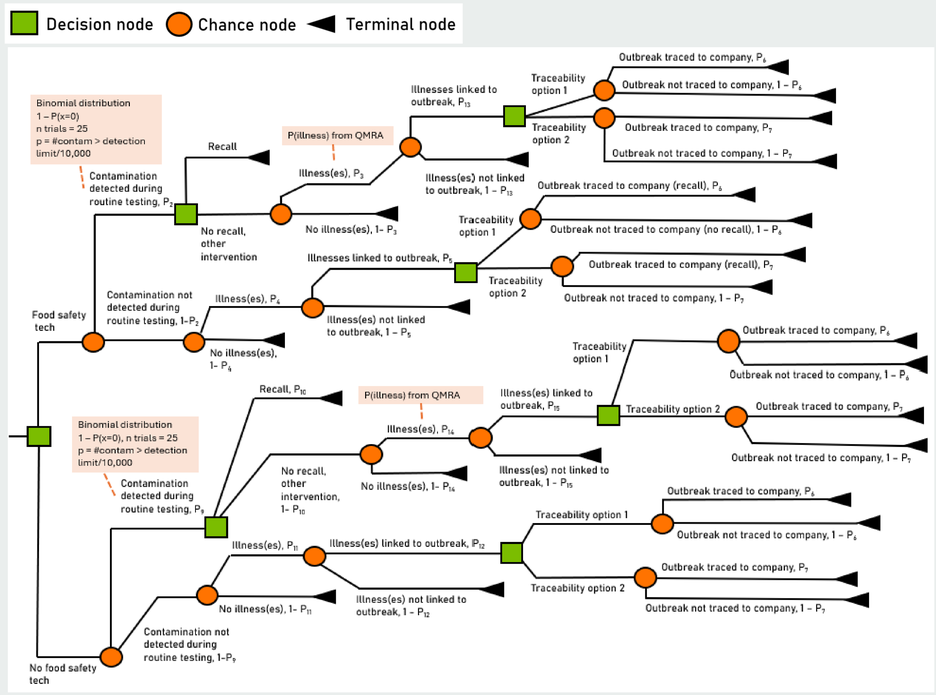
REFERENCES

1. US FDA. 2023. *Recalls, Market Withdrawals, & Safety Alerts*.
2. CDC. 2023. *List of Multistate Foodborne Outbreak Notices.*

ACKNOWLEDGEMENTS

This work is supported by the Agriculture and Food Research Initiative, Sustainable Agricultural Systems Program grant no. 2020-68012-31822 from the USDA National Institute of Food and Agriculture.

DECISION MODEL FRAMEWORK

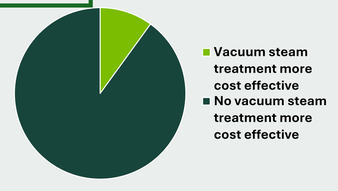


CASE STUDY RESULTS

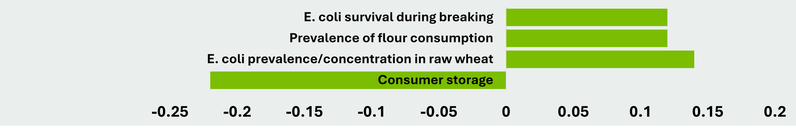
Cost-Benefit Analysis (total cost when investing or not investing in example kill step)

Intervention	Min	1st Quartile	Median	Mean	3rd Quartile	Max
Vacuum steam treatment	$7,600,000	$7,600,000	$7,600,000	$12,200,000	$7,600,000	1,600,000,000
No vacuum steam treatment	$10,600	$10,600	$10,600	$72,000,000	$10,600	1,550,000,000

- Mean differential ~ $60,000,000
- $60,000,000 ÷ 20 years = $3,000,000 yearly benefit
- Payback period for $5,000,000 technology ~ **1.7 years**
- **Food safety technology more cost-effective intervention in 10% of 10,000 iterations**



Spearman Rank Correlation Coefficients



CONCLUSIONS

- The framework can be used in a variety of scenarios to demonstrate the economic value in food safety risk reduction investments
- The specific case-study scenario illustrates that an investment in an example flour safety technology is on average the more cost-effective long-term decision
- This tool can improve decision making for food producers, equipment suppliers, and regulators

FUTURE WORK

- Verify framework with other, higher-value products
- Package tool for use by food safety decision makers
- Develop and test a user manual
- Account for other food safety technologies

MODEL INPUTS

Input Type	Application	Input	Unit	Distribution
Case-specific or user-input	QMRA	Flour milled per day	lb	Static
		Proportion flour milled used for consumer baking	-	Static
	Decision model	Amount product recalled	lb	Static
		Capital cost, food safety tech	$	Static
		Training cost, food safety tech	$	Static
		Sanitation cost, food safety tech	$	Static
		Utilities cost, food safety tech	$	Static
		Consumables cost, food safety tech	$	Static
		Retail value, recalled product	$/lb	Uniform
		Percent profit, recalled product	%	Uniform
		Amount product restocked	lb	Uniform
		Number stores selling product		Static
		Sales pre-recall	lb/year	Static
		Sales pre-recall, unrecalled product	lb/year	Static
		Capital cost, traceability system	$	Static
		Utilities cost, traceability system	$/year	Static
		Consumables cost, traceability system	$/year	Static
		Probability outbreak traced, traceability systems	-	Static
		Prevalence recall insurance	-	Static
		Plant downtime, recall	days	Uniform
		Plant downtime, no recall, other intervention	days	Uniform
		Utilities cost, no recall, other intervention	$/year	Static
		Consumables cost, no recall, other intervention	$/year	Static
		Detection limit, product testing	log CFU/g	Static
"Tunable" decision modeling	Decision model	Product restocking spillover rate	%	Uniform
		Product holding rate	%	Uniform
		Sales decrease post-recall	%	Uniform
		Sales decrease post-recall, unrecalled product	%	Uniform
		No illness recall factor	-	Uniform
		Probability illness linked to outbreak	-	Static
		Probability test detects contamination	-	Binomial
Literature or expert-based	QMRA	*E. coli* prevalence, raw wheat	log CFU/g	Beta
		E. coli concentration, raw wheat	log CFU/g	Uniform
		E. coli D-value, vacuum steam treatment 65°	min	Normal
		Duration vacuum steam treatment 65°	min	Static
		E. coli survival, water tempering	log CFU/g	Gamma
		E. coli survival, breaking	Transfer rate	Lognormal
		E. coli transfer, breaking, uncontaminated wheat	Transfer rate	Lognormal
		E. coli survival, sizing, contaminated wheat	Transfer rate	Lognormal
		E. coli transfer, sizing, uncontaminated wheat	Transfer rate	Lognormal
		E. coli survival, reduction, contaminated wheat	Transfer rate	Lognormal
		E. coli transfer, reduction, uncontaminated wheat	Transfer rate	Lognormal
		Consumer storage	days	Exponential
		E. coli survival, consumer storage, Weibull δ	-	Uniform
		E. coli survival, consumer storage, Weibull β	-	Uniform
		Beta-Poisson dose-response α	-	Static
		Beta-Poisson dose-response N50	-	Static
		Flour per baking recipe	g	Uniform
		Raw flour consumed	g	Uniform
	Decision model	Product destroy fee	$/lb	Static
		Product restocking fee	$/store	Uniform
		Product holding fee	$/lb	Static
		Litigation cost	$	Triangle
		Crisis management cost	$	Uniform
		Post-recall decreased sales duration	days	Uniform
		Post-recall decreased sales duration, unrecalled product	days	Uniform
		Recall insurance coverage	$	Uniform
		Recall insurance premium	$/year	Uniform

CONTACT ME

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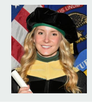

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