Gordon C. Ashton Memorial Lecture

Systems and Risk Modelling for Food Safety Decision Making

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Risk

Probability: High
Severity: Serious

- Risk is a function of both the probability and impact of an event
- Dependent on who is assessing the risk

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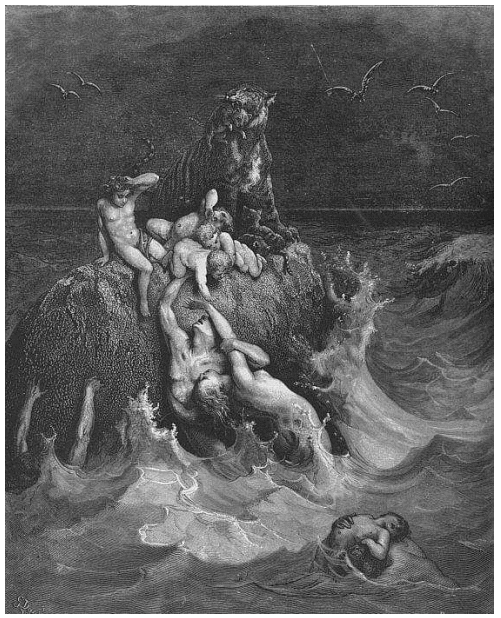
History

- The mastery of risk has been suggested as the step man took in moving into modern times

"Understanding that the future is more than fate and the whim of the gods"

Bernstein, 1996



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History

Took someone who threw a lot of dice

to finally begin understanding probability and risk

Girolamo Cardano (1501–1576), Mathematician & Physician

Sum	Probability
2	1/36
3	2/36
4	3/36
5	4/36
6	5/36
7	6/36
8	5/36
9	4/36
10	3/36
11	2/36
12	1/36

- one of first clinical descriptions of Typhoid Fever
  - "Liber de ludo aleae" written in the 1560s
    - first systematic treatment of probability, as well as a section on effective cheating methods
    - Probability of rolling various dice combinations

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History

- Blaise Pascal (1623–1662) and Pierre de Fermat (1601-1665)
- Established the foundations of Probability
- Determined the ability to forecast uncertain future outcomes

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History

- 1700's
  - Mathematicians devising tables of life expectancies
  - English government financing itself through sale of life annuities
- 1750's
  - Marine insurance flourishing as a business

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History

- 1750 - 1770
  - Smallpox in France
  - To vaccinate or not ?
  - Daniel Bernoulli calculated risks of taking live vaccine vs. taking your chances
  - Odds
    - 1 in 7 dying of smallpox
    - 1 in 200 dying of vaccine
  - Pretty bad either way, better to take it

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Risk Modelling

- Why do we do risk modelling
  - Estimate the risk
    - Regulation
    - Acceptability
  - Gain an understanding of the system
    - Appropriate mitigation
    - Research direction

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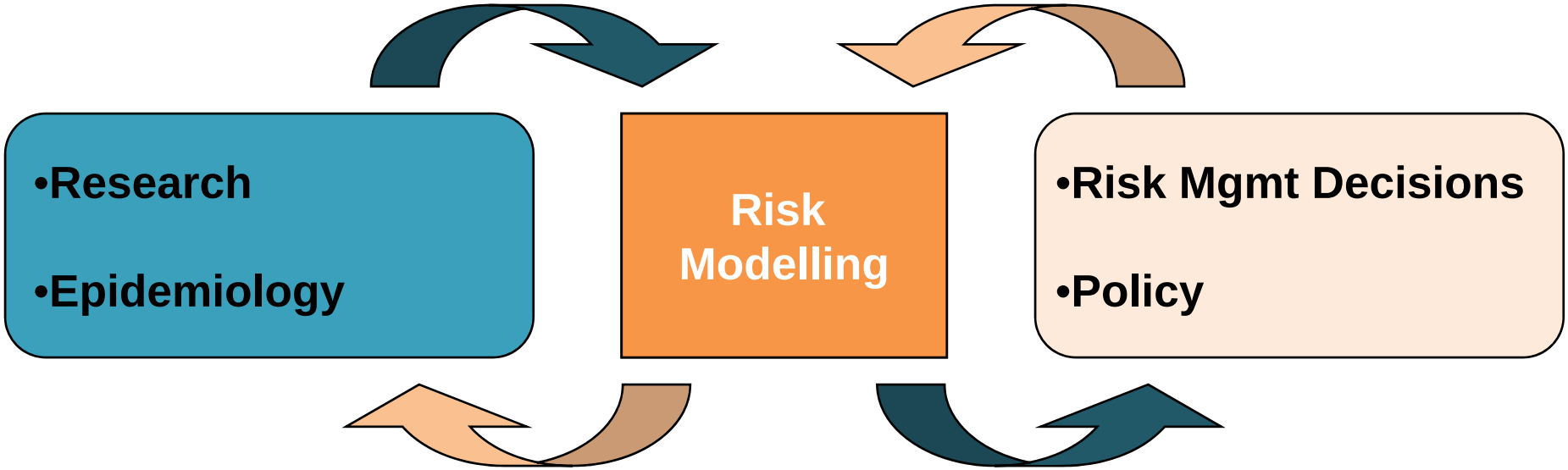
Risk Modelling



- Link: Research / Data and Decisions

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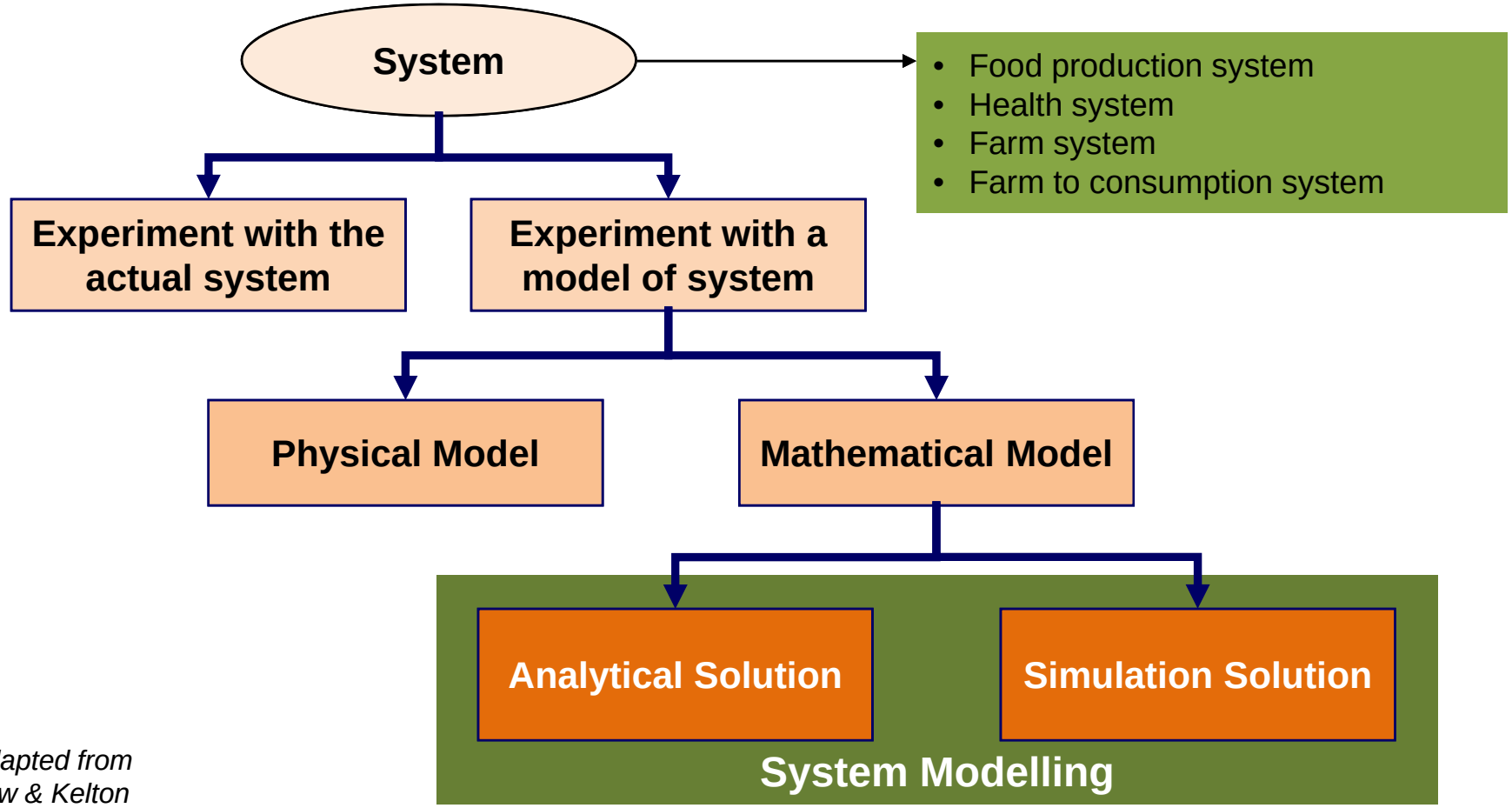
System risk modeling



Adapted from Law & Kelton

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Modeling Approaches

"All models are wrong, some are useful"

- Essence of why we model a system:
  - Not to create a perfect representation
  - To create a tool that will provide insight into the system

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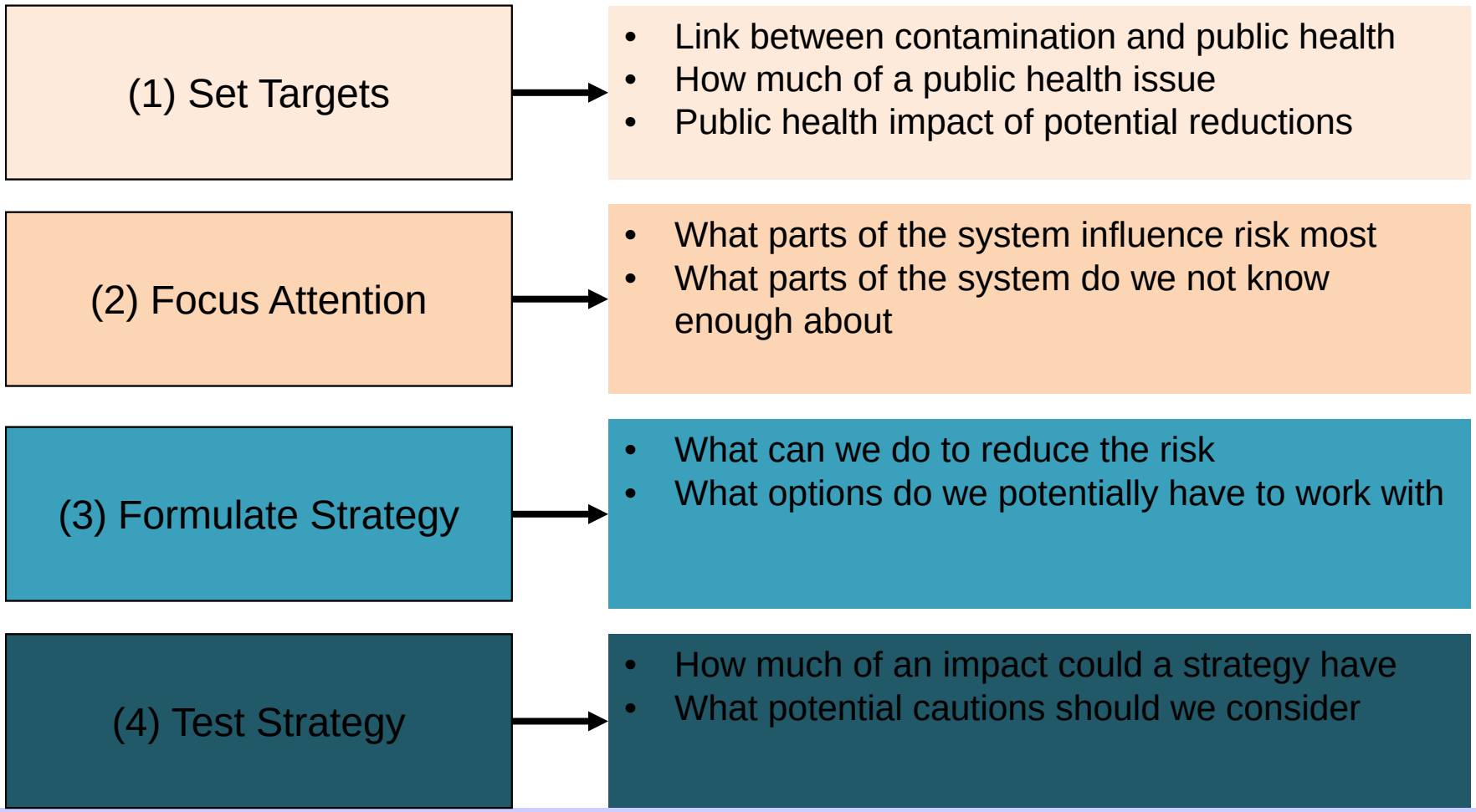
Risk Modelling
Contribution to Decision Making



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Risk Modelling
Contribution to Decision Making

(1) Set Targets

- Link between contamination and public health
- How much of a public health issue
- Public health impact of potential reductions

(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

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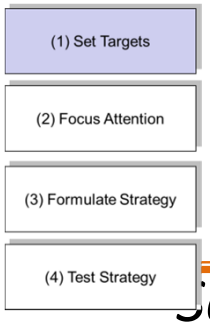

Decision Making(1)
Set Targets: Model Introduction

Salmonella & *Campylobacter* human health impact model

- Objective: Construct human health impact model
  - Translate pathogen prevalence levels and reductions to health impact
  - Translate pathogen prevalence levels and reductions to cost and savings

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(1) Set Targets

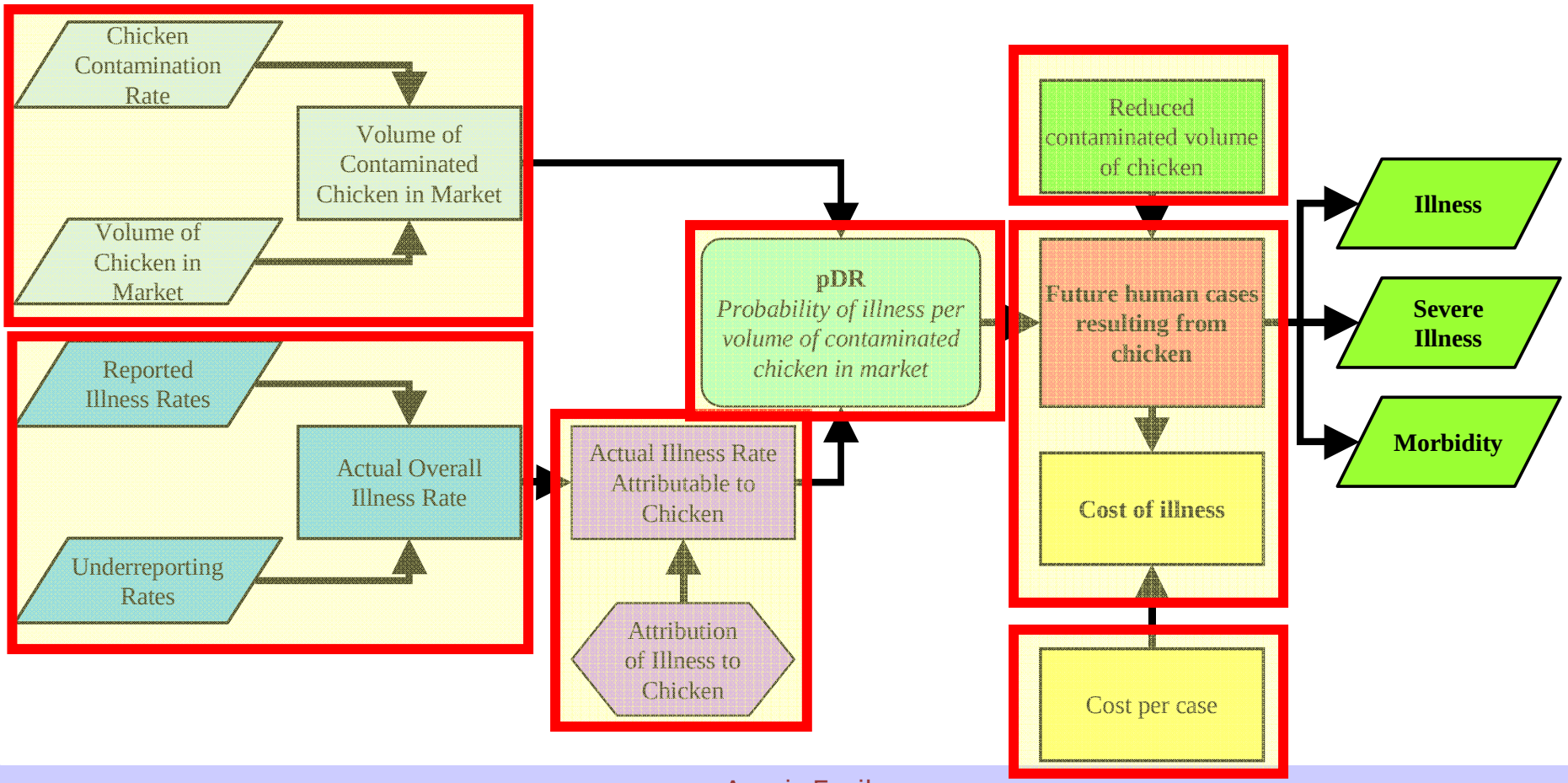
(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(1)

Set Targets: Model Overview



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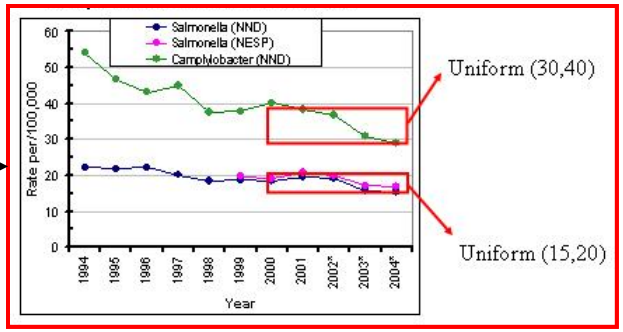
(1) Set Targets

(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

- Reported Illness Rates



- Underreporting Rates

– Unreported for every reported case (*Thomas et al. (2006)*
  - *Salmonella* : 13 – 37
  - *Campylobacter*: 24 - 50

- Contamination Rates

	Salmonella % (tested)			Campylobacter % (tested)		
	2002	2003	2004	2002	2003	2004
Retail - Chicken	n.t.	16 (346)	16 (676)	n.t.	51 (344)	47 (678)

Uniform (0.15,0.20) Uniform (0.45,0.55)

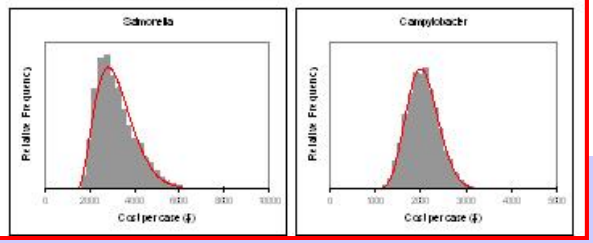
- Chicken in Market
- Canadian Population

– Domestic consumption, subtracting imported chicken products (CFC 2004)
  - Range: 800 – 890 million kg

– Canadian Population (SC 2004)
  - Approx 31,000,000

- Cost per Case

Includes: lost days of work; physician visits; hospitalization; death; and chronic sequelae
– Salmonella: $3650 / Case
– Campylobacter: $2400 / Case
» Derived from OMAF (2005)



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(1) Set Targets

(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(1)

Set Targets: Model Objective

- Primary purpose of model
  - Explore impact of reduction in contamination rates to:
    - Public health outcomes
    - Cost savings
  - Outcomes are a function of attribution

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(1) Set Targets

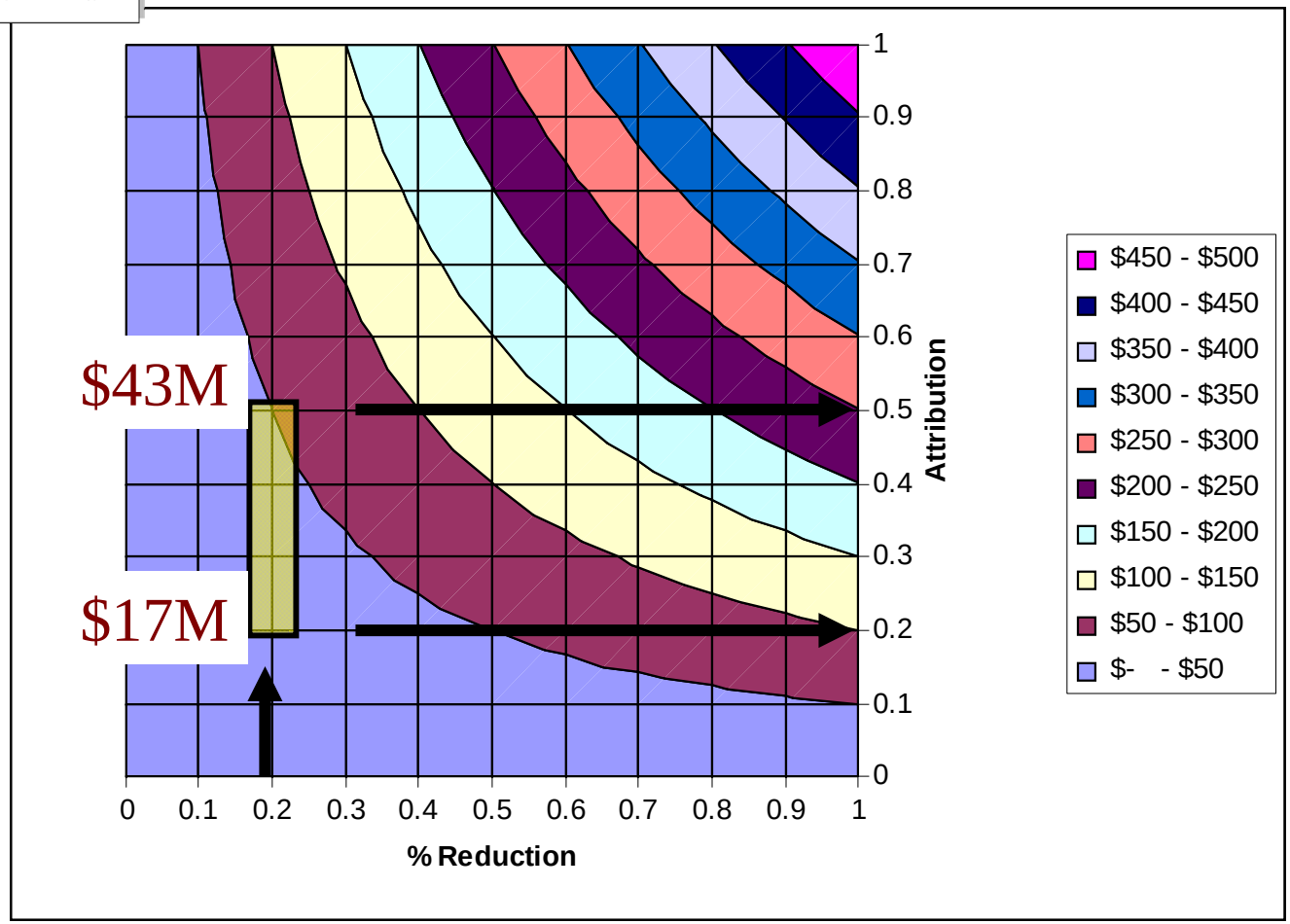
(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(1)

Set Targets: *Salmonella* Cost Contour



Target of 20% reduction

Attribution 0.2 - 0.5

Expected to produce mean cost savings of $17M to $43M

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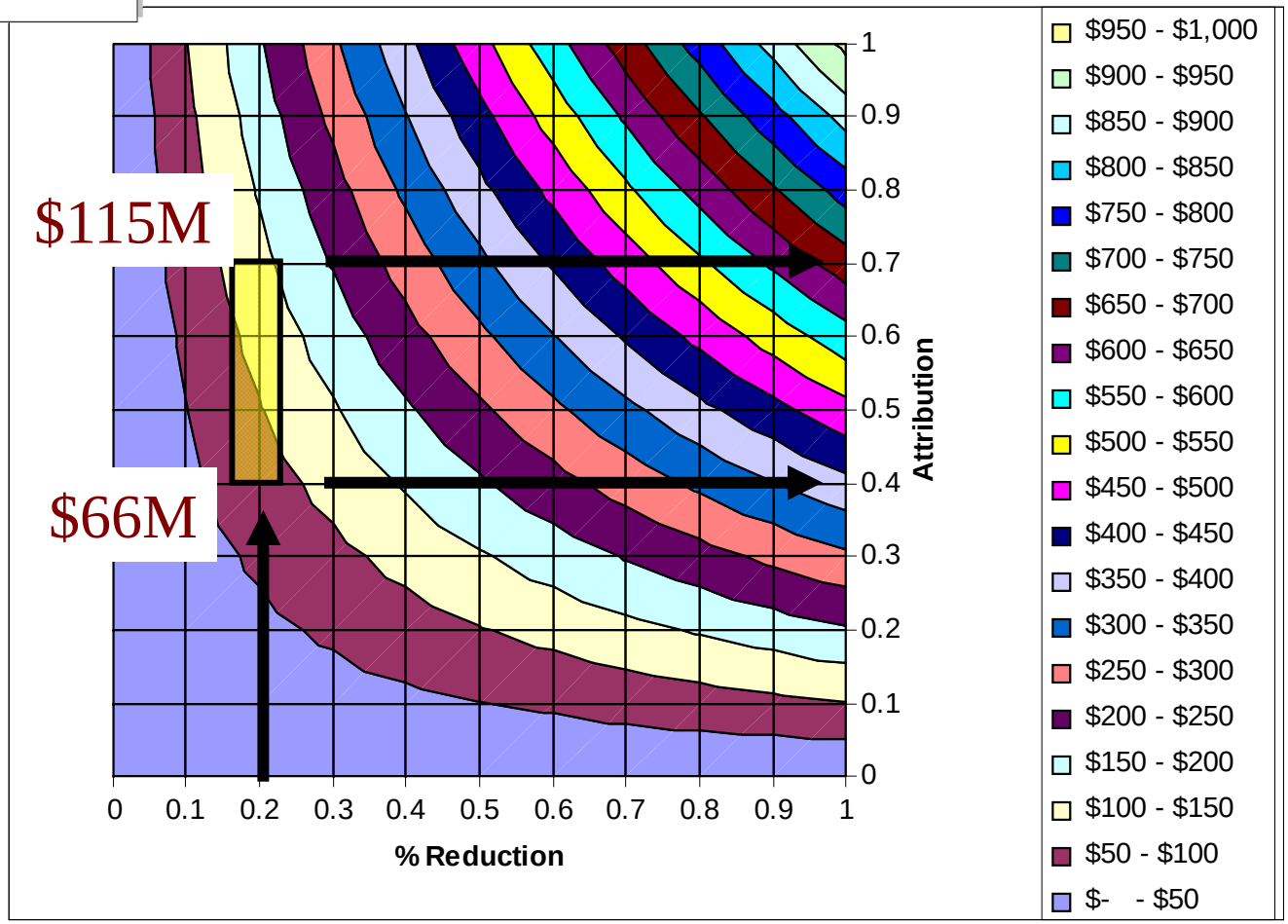
(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(1)

Set Targets: *Campylobacter* Cost Contour



Target of 20% reduction

Attribution 0.4 - 0.7

Expected to produce mean cost savings of $66M to $115M

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Risk Modelling Contribution to Decision Making

(1) Set Targets

(2) Focus Attention

- What parts of the system influence risk most
- What parts of the system do we not know enough about

(3) Formulate Strategy

(4) Test Strategy

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(1) Set Targets

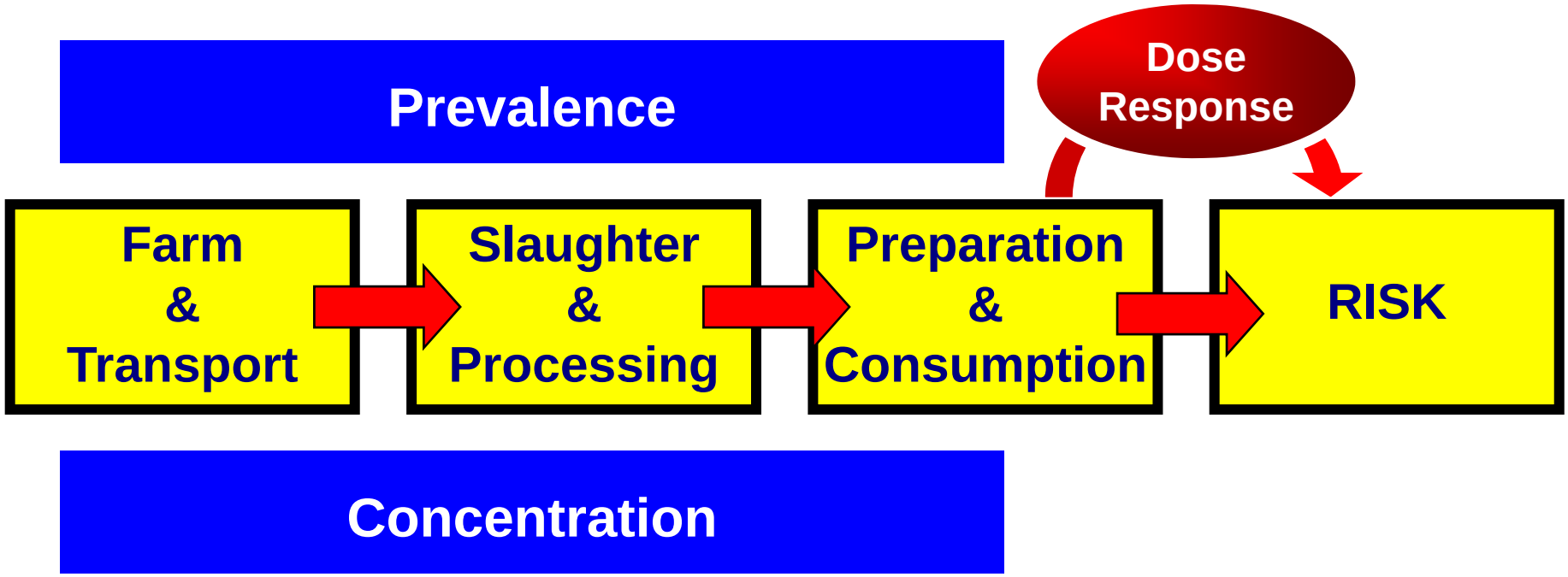
(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(2)

Focus Attention: *C.jejuni* Process Model



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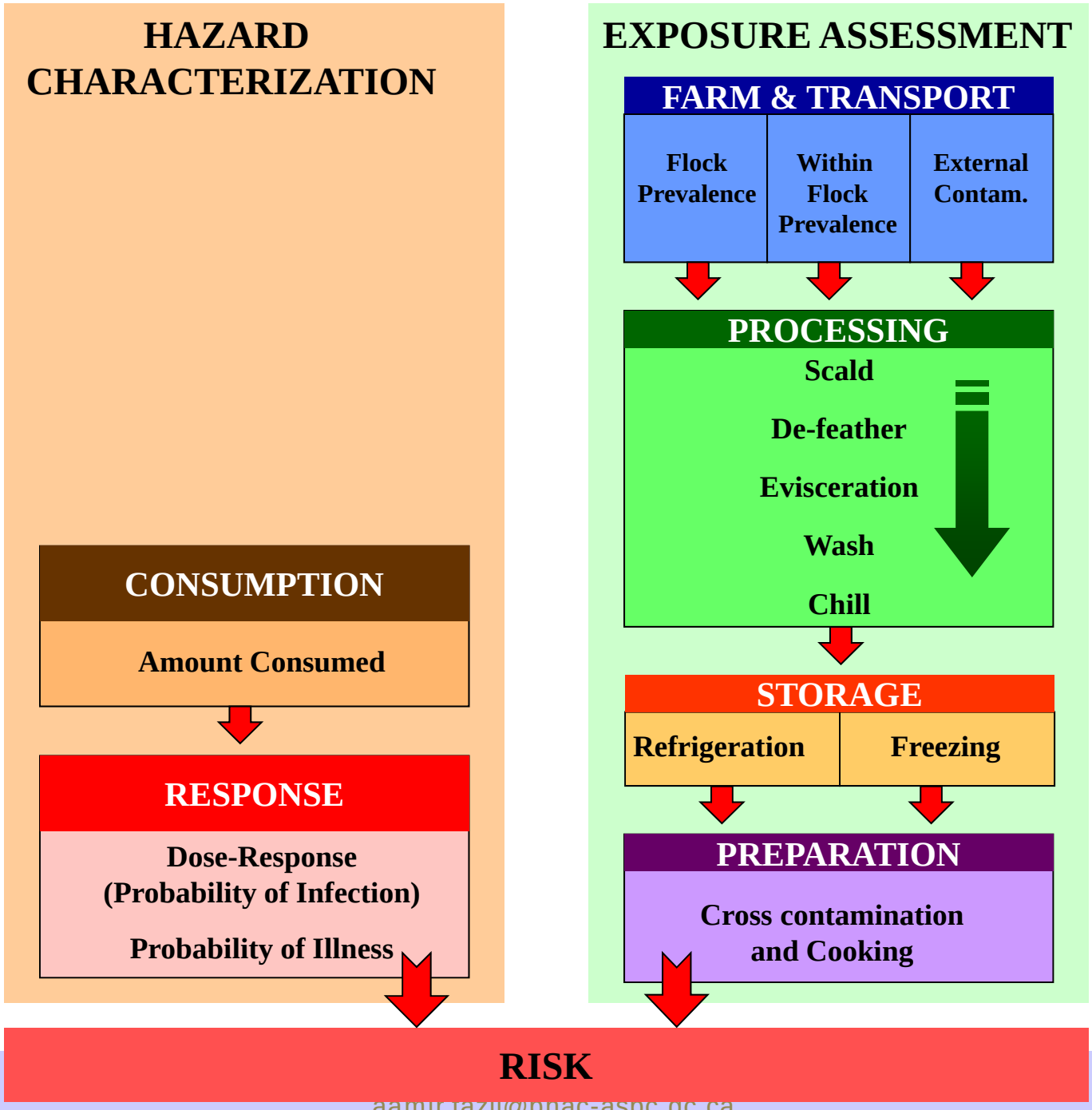

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(1) Set Targets

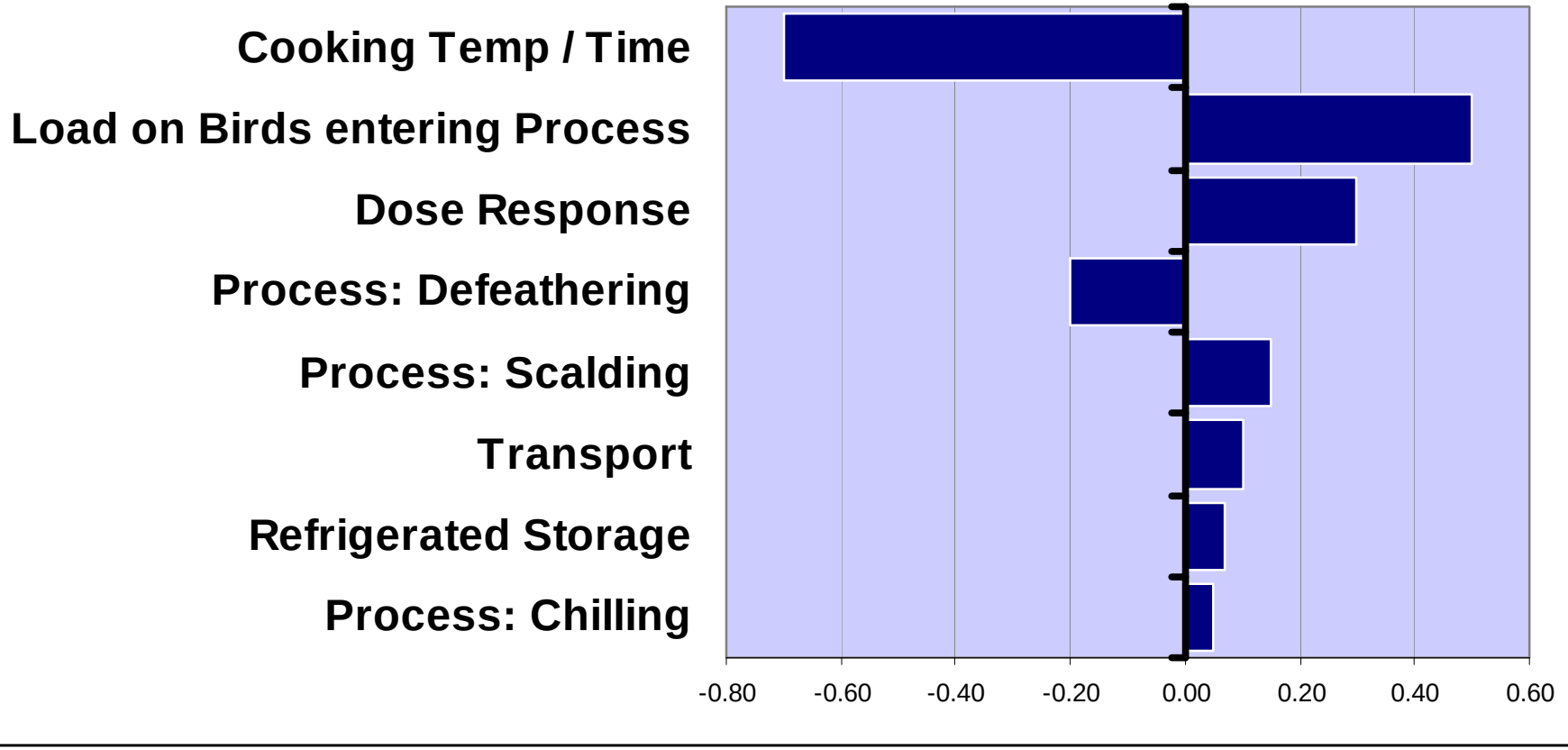
(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(2)

Focus Attention: Sensitivity Analysis



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(1) Set Targets

(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(2)

Focus Attention: Sensitivity Analysis

- Cooking Temp/Time
  - Difficult to control consumer practice
  - Education is an option, how effective?
  - Research into survival of *C.jejuni* in real world cooking scenarios
  - Research into consumer practices

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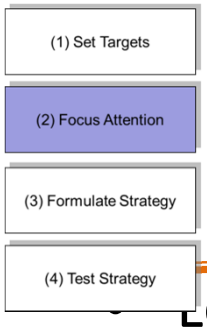

Decision Making(2)
Focus Attention: Sensitivity Analysis

Load on Birds Entering the Process

- Controls to reduce the load entering the process substantial impact on risk.
- Research into pathogenicity.
  - Example: should we be concerned with all strains?
- More data to quantify the conc. of pathogenic *C.jejuni* strains entering process.
- Research into ways to reduce contamination pre-processing

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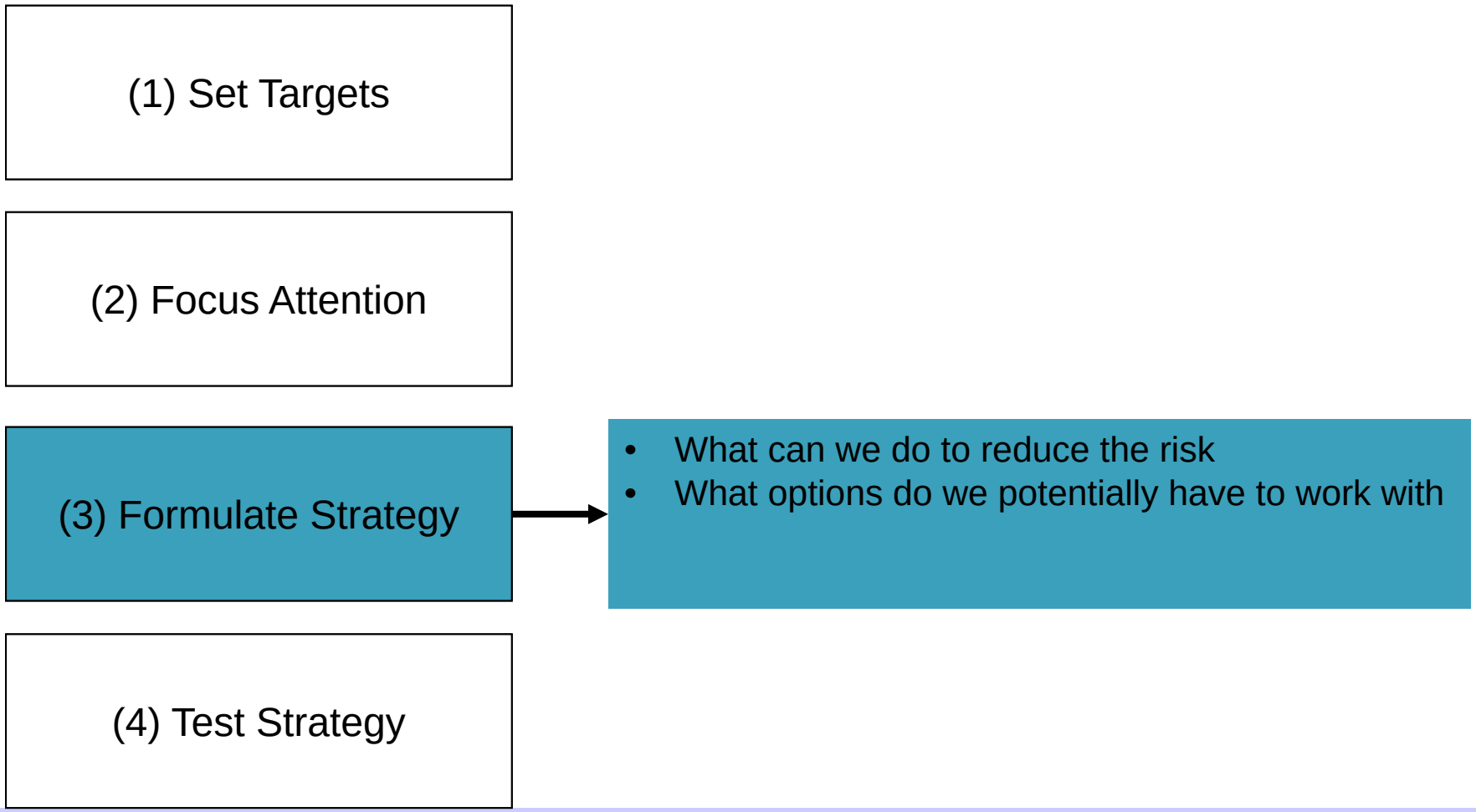
Risk Modelling Contribution to Decision Making



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(1) Set Targets

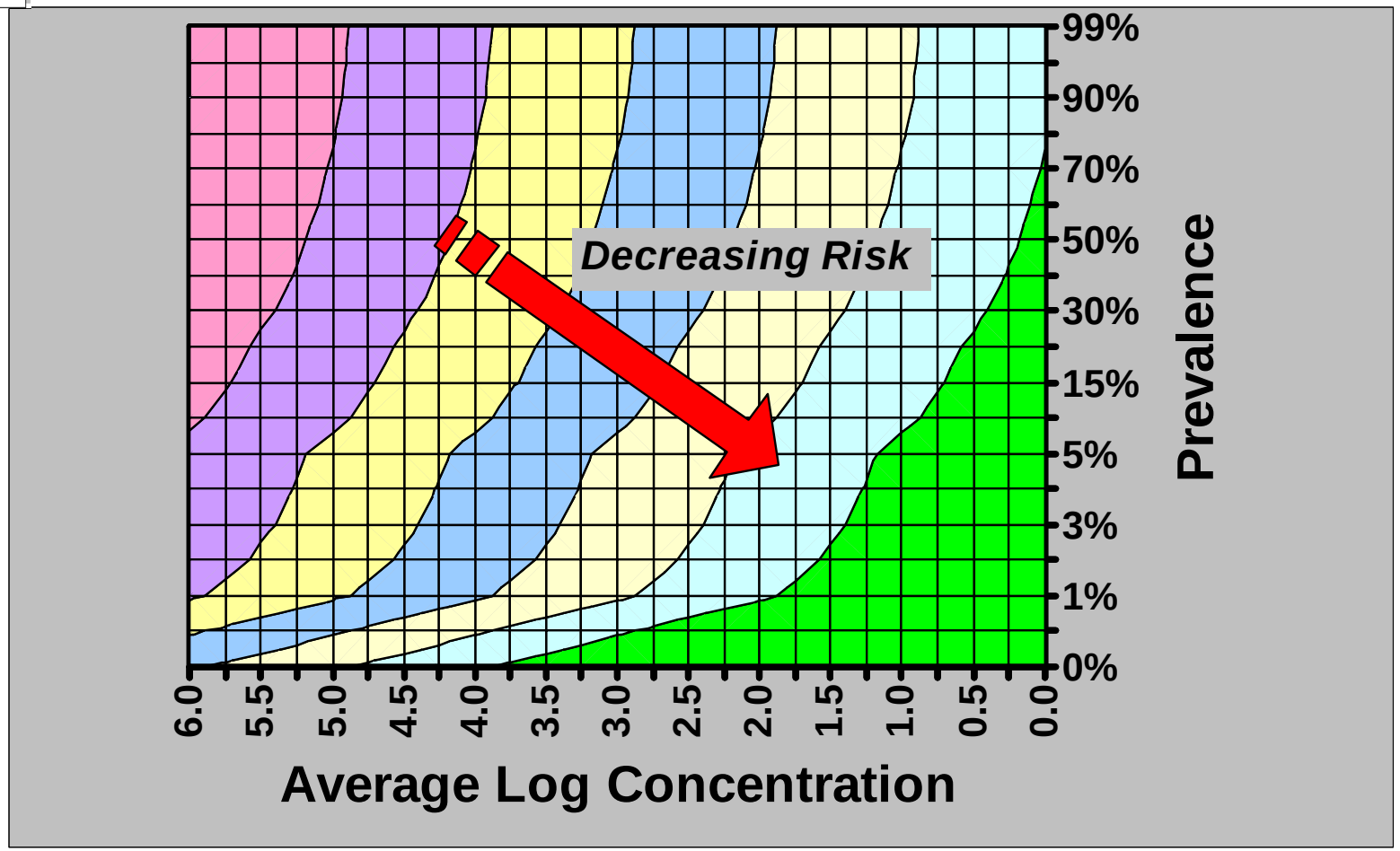
(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(3)

Formulate Strategy: Reduction Options



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(3) Formulate Strategy

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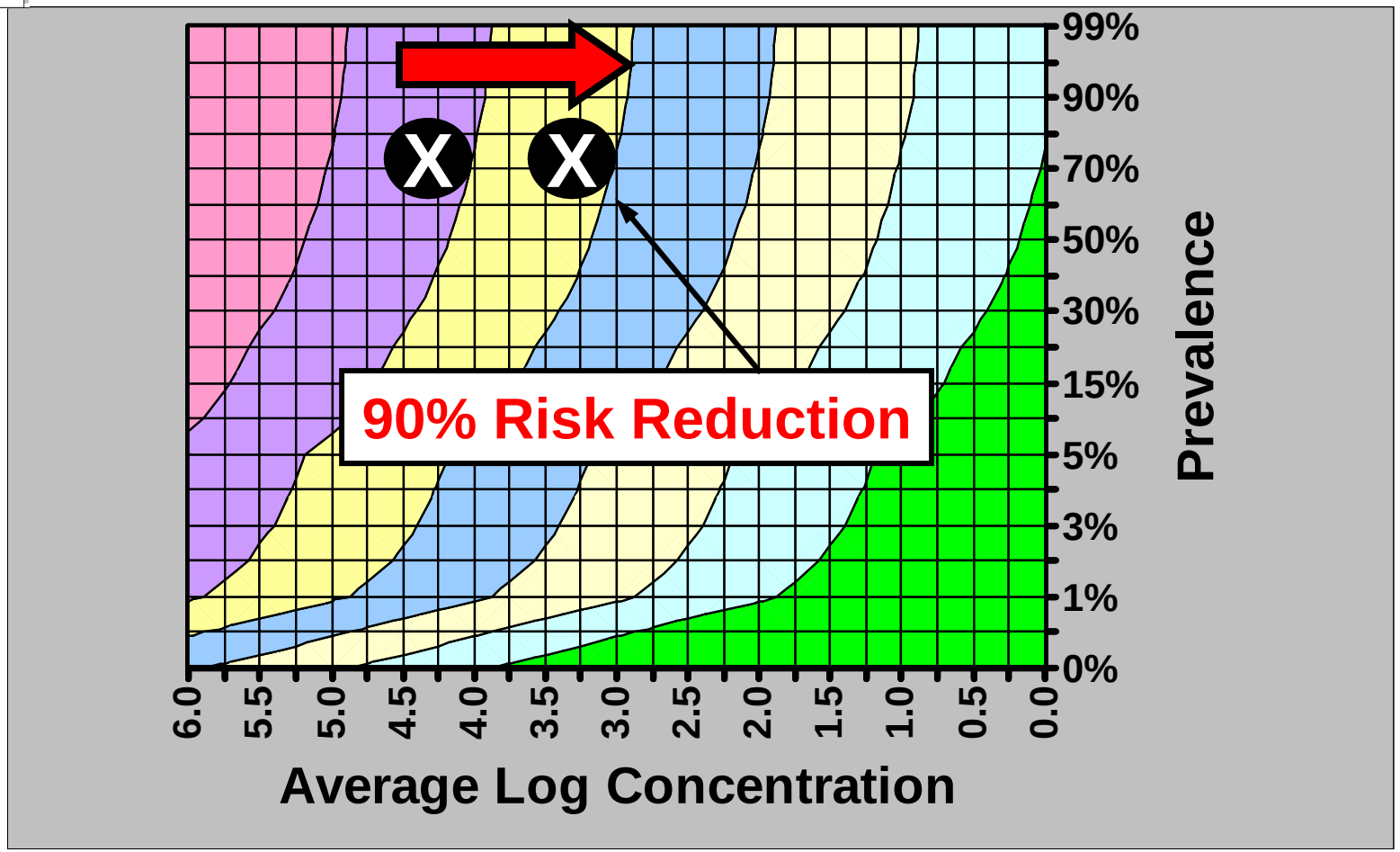
Decision Making(3)

Formulate Strategy: Reduction Options



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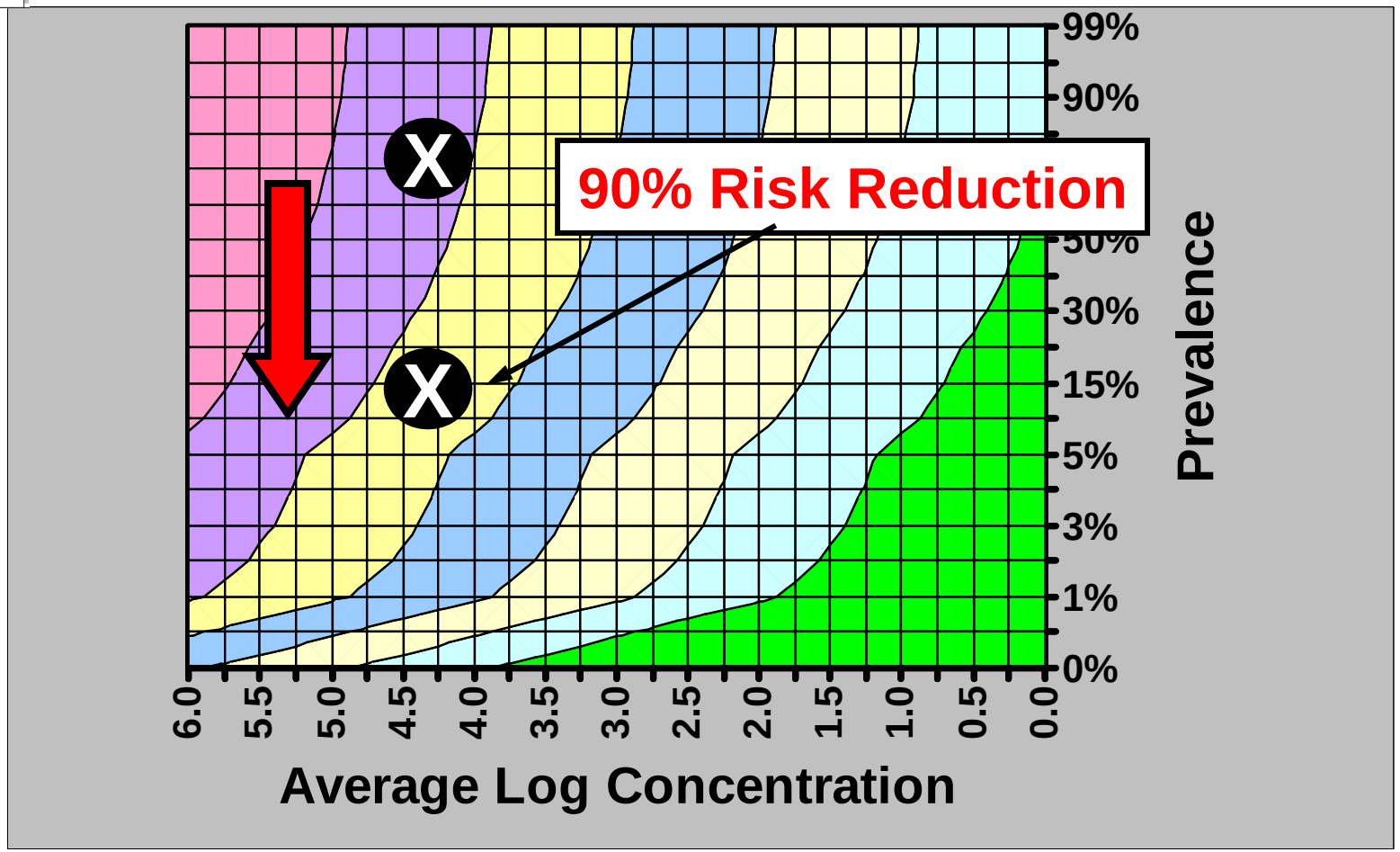
Decision Making(3)

Formulate Strategy: Reduction Options



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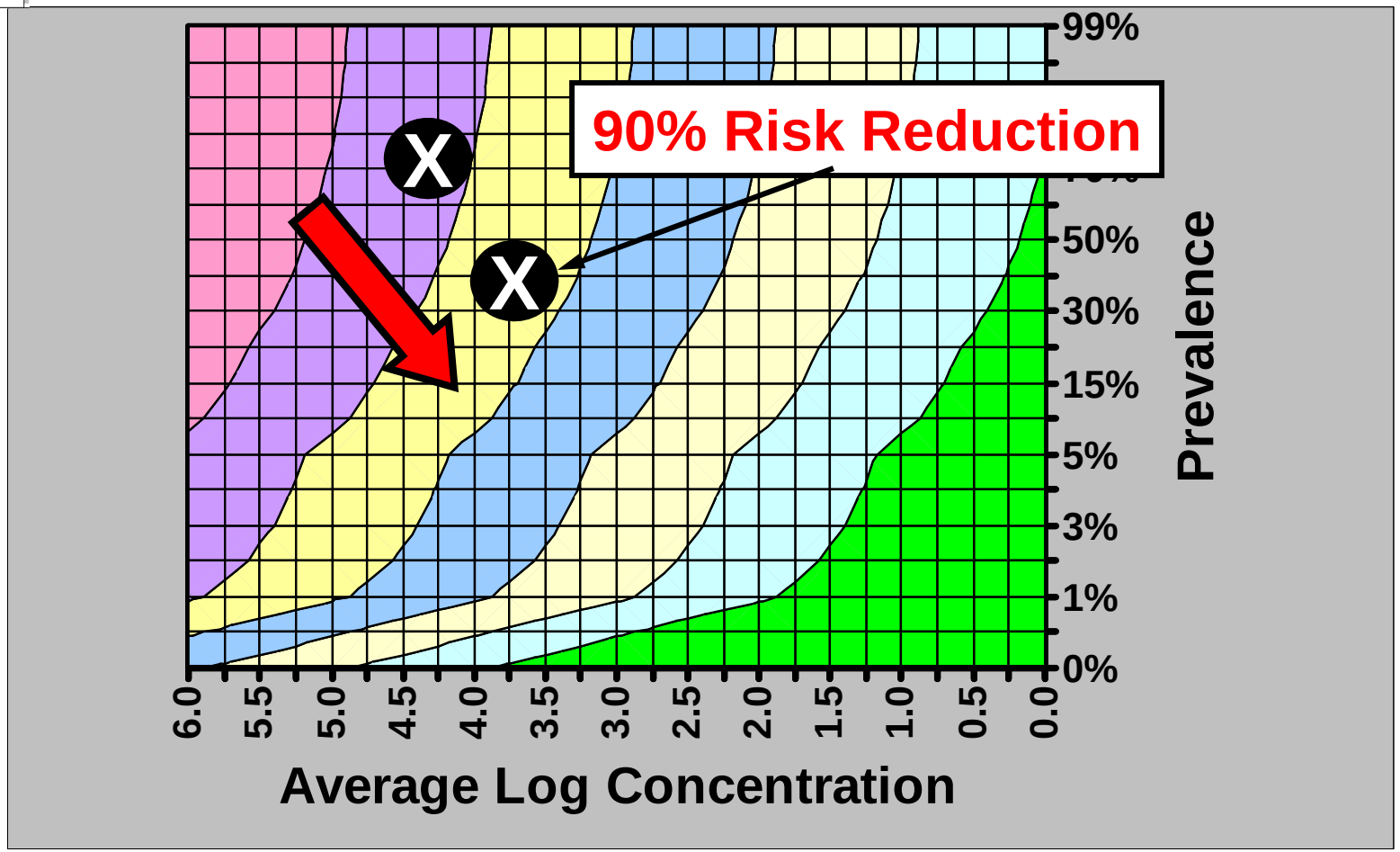
Decision Making(3)

Formulate Strategy: Reduction Options



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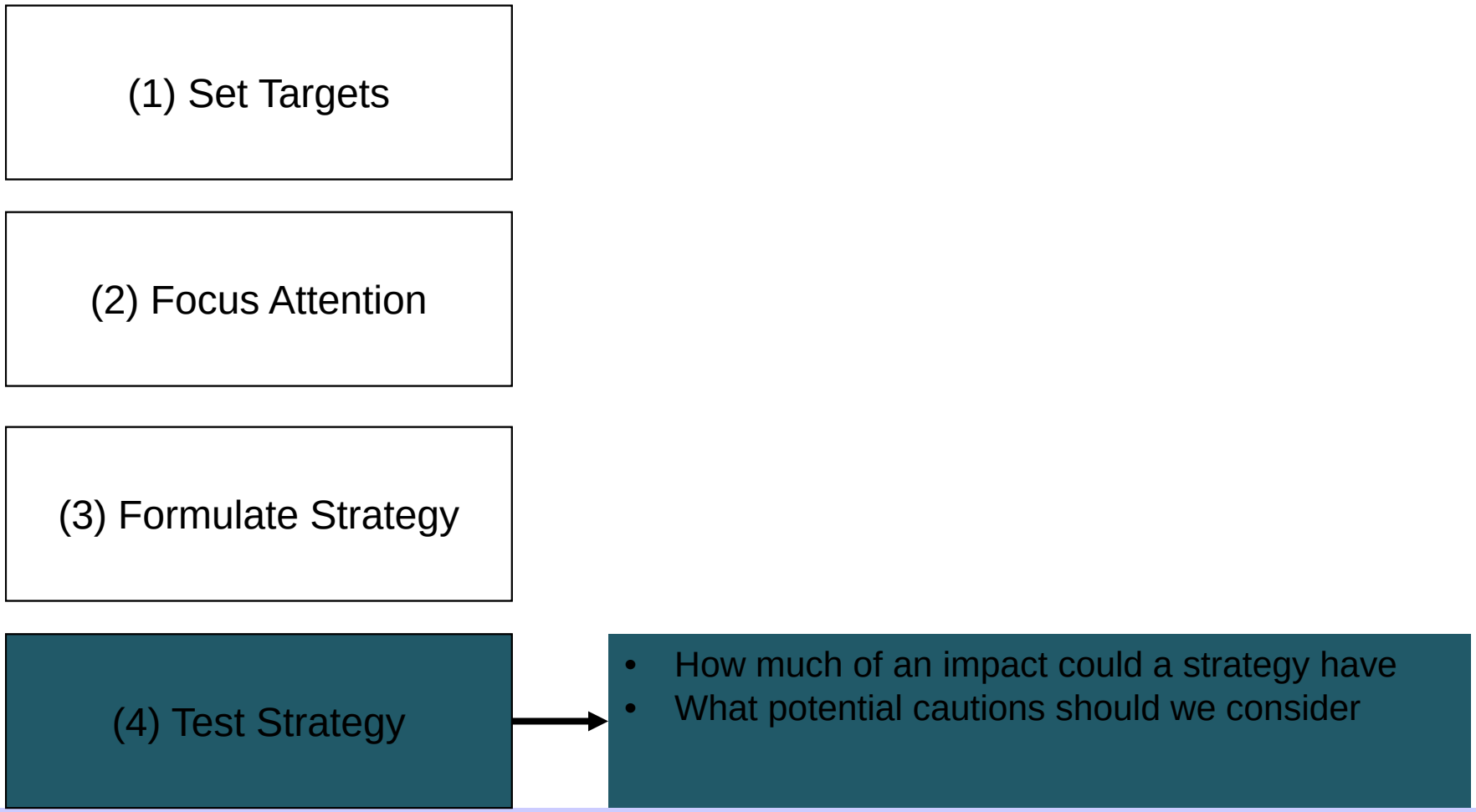
Risk Modelling Contribution to Decision Making



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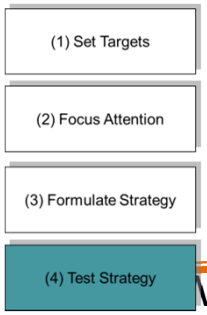

Decision Making(4)
Test Strategy: Model Scenario Analysis

What effect does changing the internal and surface contamination of chickens before and through processing have ?

- Four (4) alternative strategies investigated
  - **Strategy 1:** Reduction in surface contamination level after transport
  - **Strategy 2:** Reduction in levels contaminating carcasses at evisceration
  - **Strategy 3:** Reduction in surface contamination post evisceration
  - **Strategy 4:** Reduction in initial internal contamination levels (overall reduction in contamination entering the system)

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(1) Set Targets

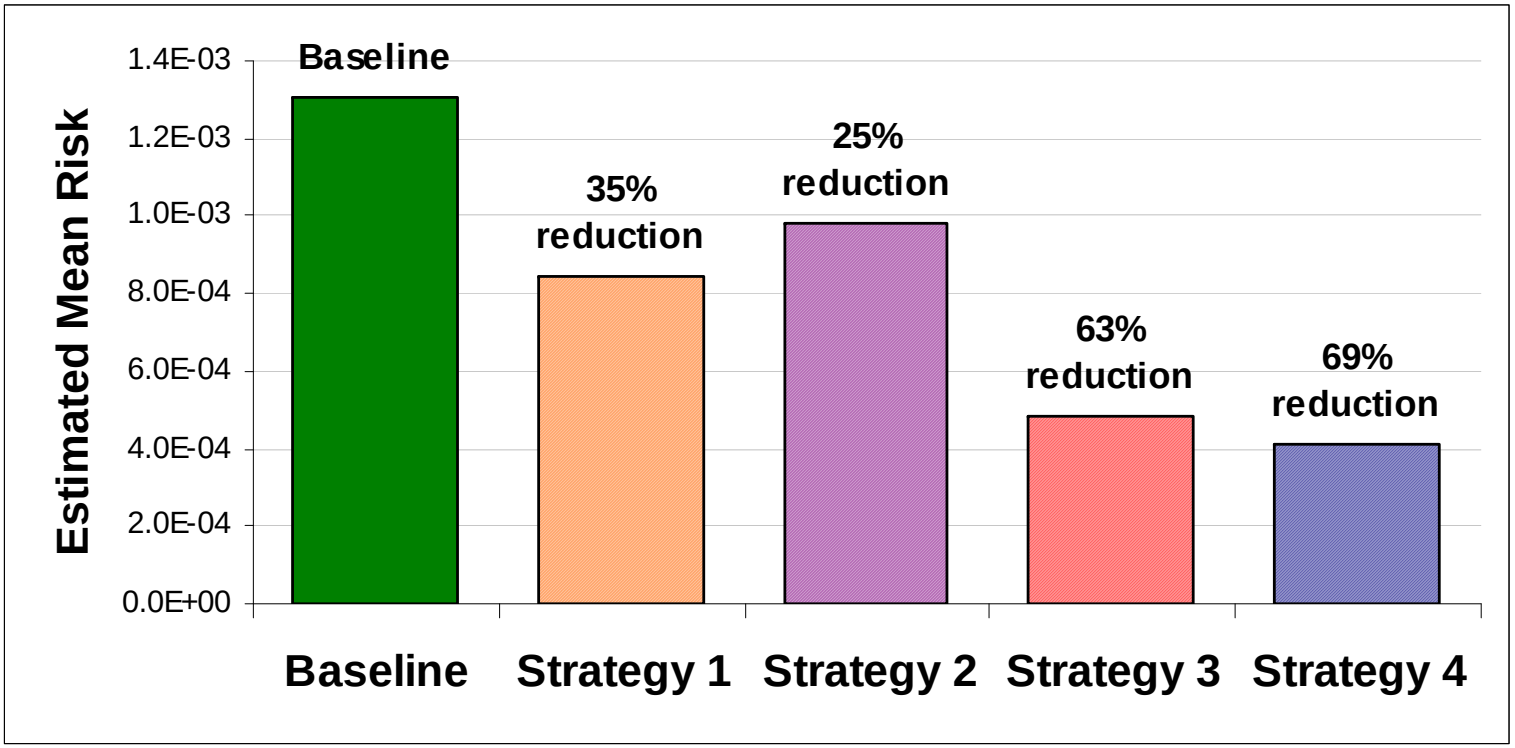
(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(4)

Test Strategy: Scenario Analysis Results



Strategy 1: Reduction in surface contamination post transport

Strategy 2: Reduction in amount of contamination deposited at evisceration

Strategy 3: Reduction in surface contamination post evisceration

Strategy 4: Reduction in overall internal colonization and contamination levels

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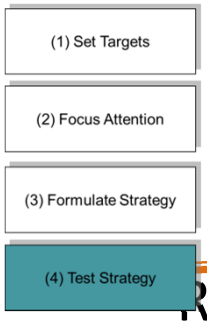

Decision Making(4)

Test Strategy: Scenario Analysis Results

- Reducing surface contamination after evisceration can have a significant impact on reducing the risk
  - Reductions of surface contamination prior to this get negated by additional contamination being deposited

- Targeting the internal colonization levels at the farm level has a significant effect on reducing the risk
  - Reducing the overall pool of contamination entering the system

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(1) Set Targets

(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(4)

Test Strategy: Potential complications

- Freezing chicken as a risk reduction strategy
- What is the difference in risk for refrigerated or fresh chicken compared to frozen chicken ?
- Assumptions
  - Refrigerated (0 to 9 days)
  - Frozen (1 day to 6 weeks)

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(1) Set Targets

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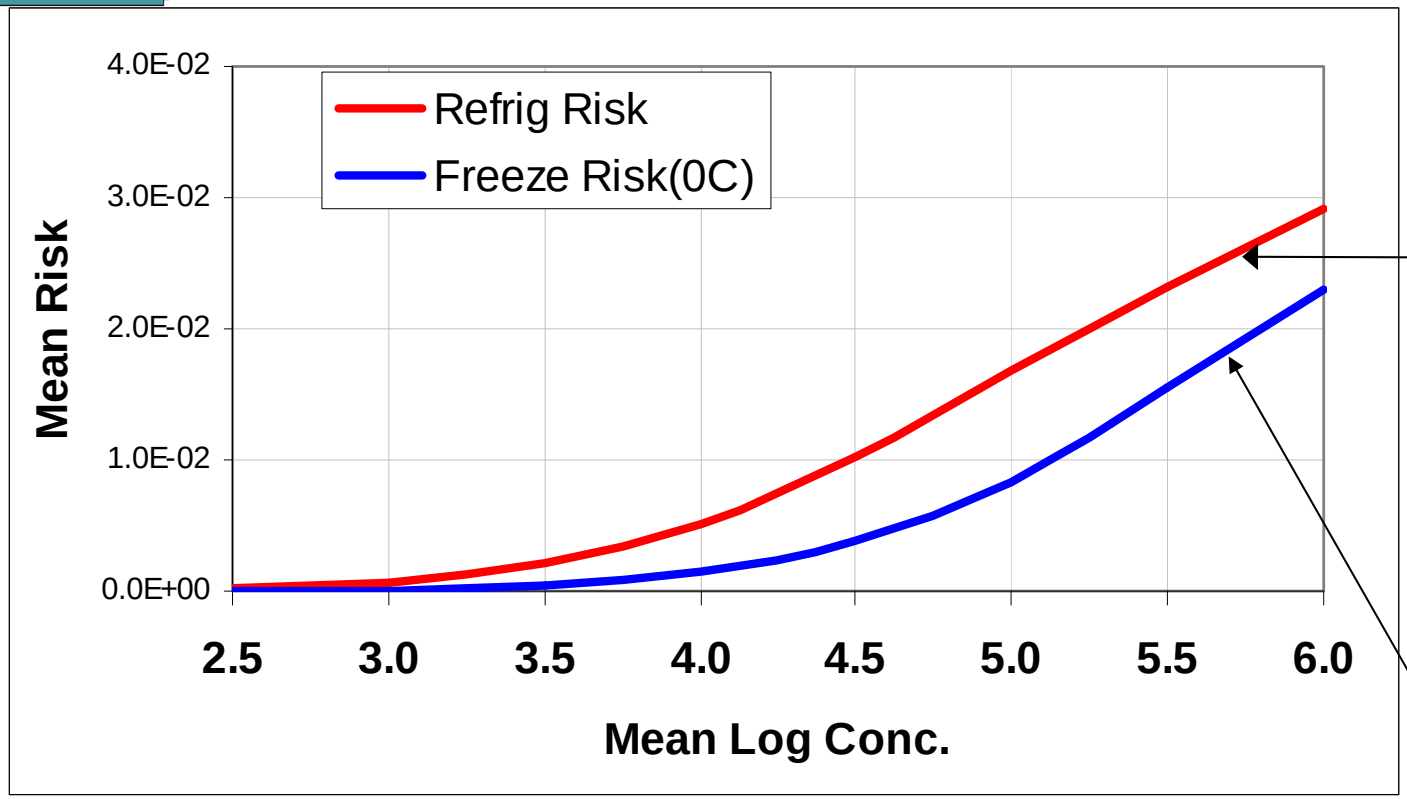
Decision Making(4)

Test Strategy: Potential complications



Risk for refrigerated chicken

Risk for frozen chicken

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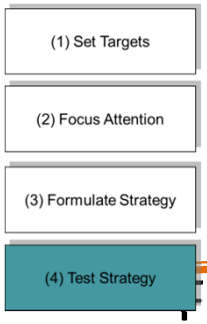

Decision Making(4)
Test Strategy: Potential complications

- Frozen chicken is estimated to result in lower risk
- However, these results can be complicated
  - Preparation practices could reverse the effect
  - Example: it is possible that cooking effectiveness could be diminished for frozen chicken compared to fresh chicken
    - Scenario A: Final cooking temperature, 2C cooler in cold spots for frozen chicken
    - Scenario B: Final cooking temperature, 5C cooler in cold spots for frozen chicken

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(1) Set Targets

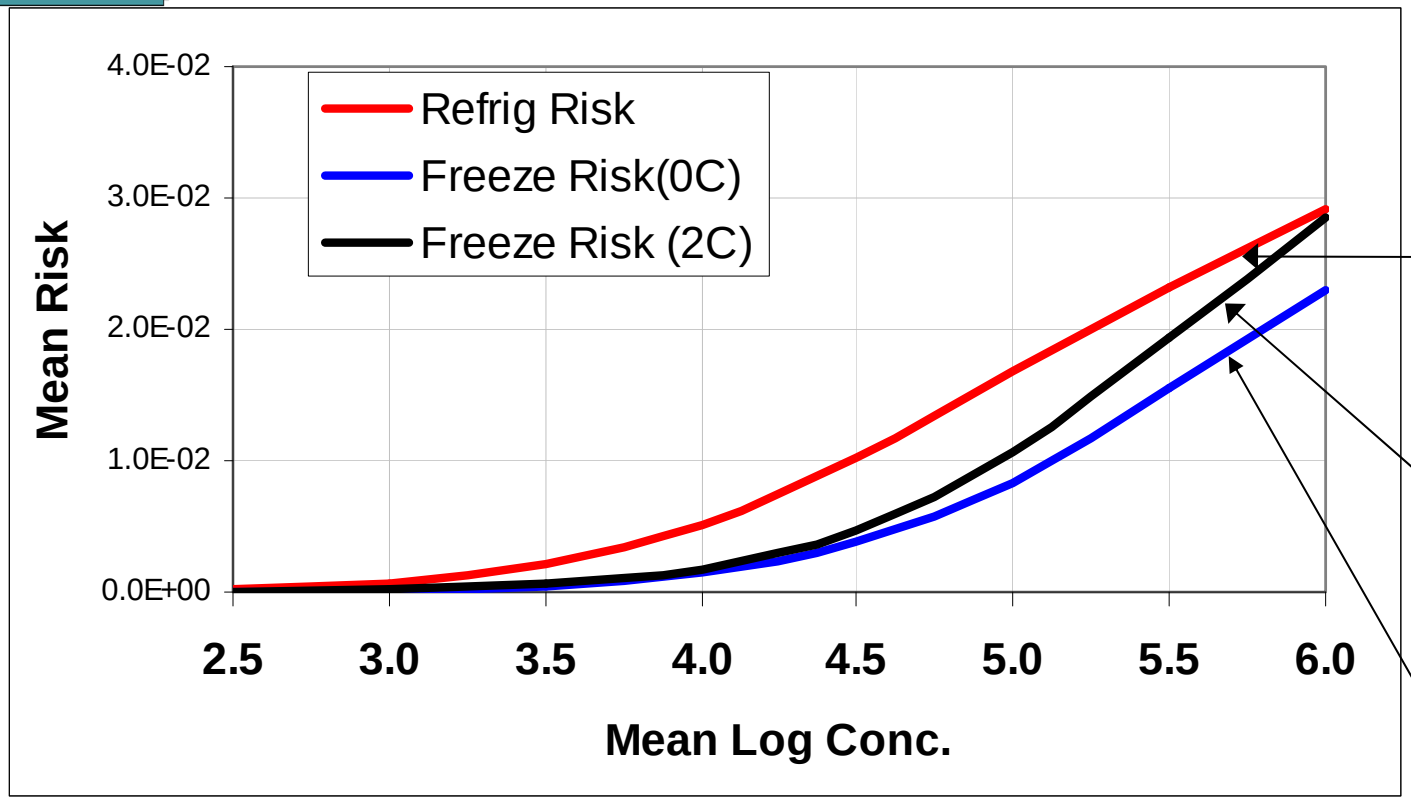
(2) Focus Attention

(3) Formulate Strategy

(4) Test Strategy

Decision Making(4)

Test Strategy: Potential complications



Risk for refrigerated chicken

Risk for frozen chicken with 2C cooler cooking

Risk for frozen chicken

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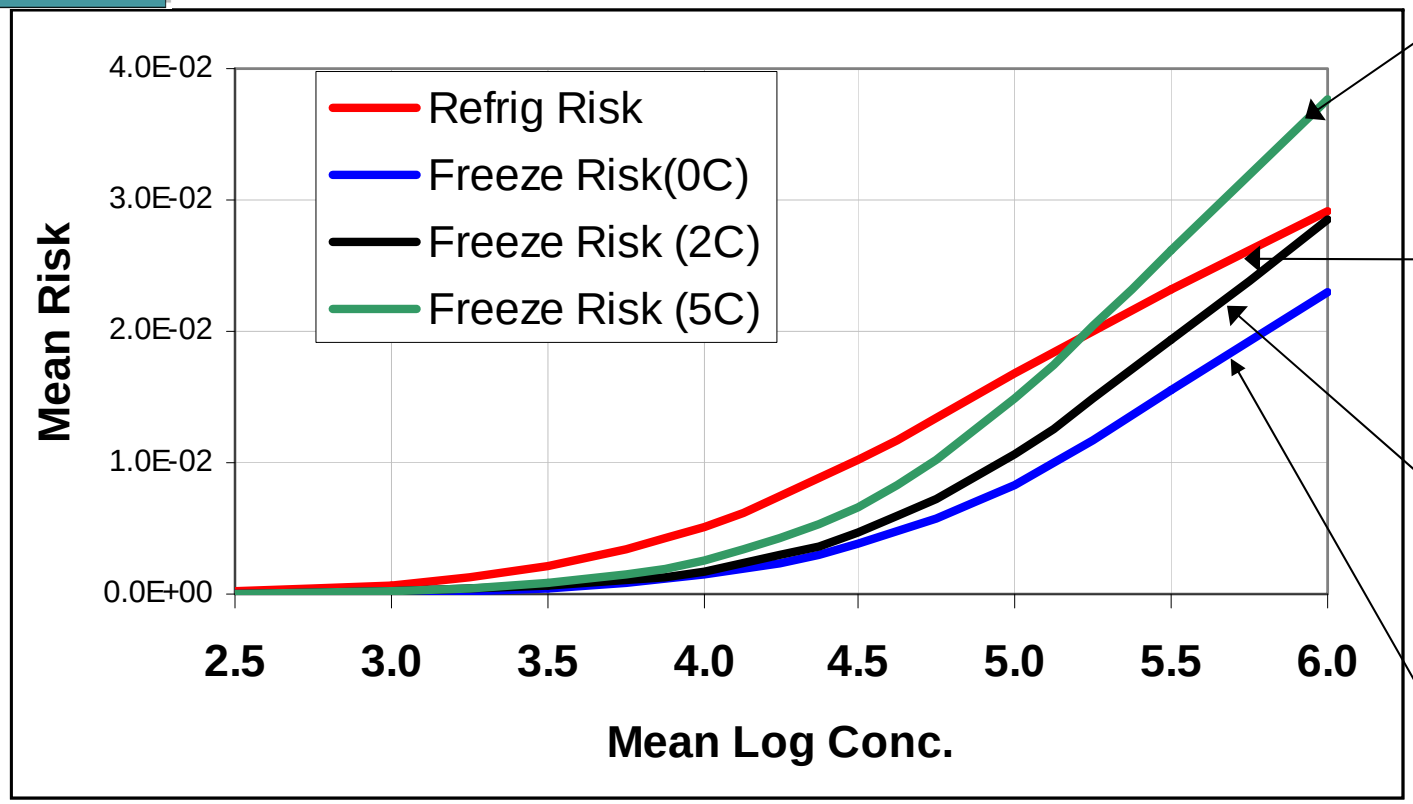
(4) Test Strategy

Decision Making(4)

Test Strategy: Potential complications



Risk for frozen chicken with 5C cooler cooking

Risk for refrigerated chicken

Risk for frozen chicken with 2C cooler cooking

Risk for frozen chicken

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Conclusions

- Risk Assessment / Modelling
  - Contributes to the understanding of the system
  - Helps identify critical factors that most significantly influence risk
    - Risk mitigation / control implications
    - Research direction implications
      - Discrimination between information that is unknown and relatively unimportant vs. unknown and important.
  - Provides guidance on expected impact of risk mitigation strategies

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Conclusions

- For good decision making, quantitative risk modelling is a good alternative
  - For complex systems
  - For difficult decisions
  - For transparent processes
  - To ensure appropriate allocation of resources

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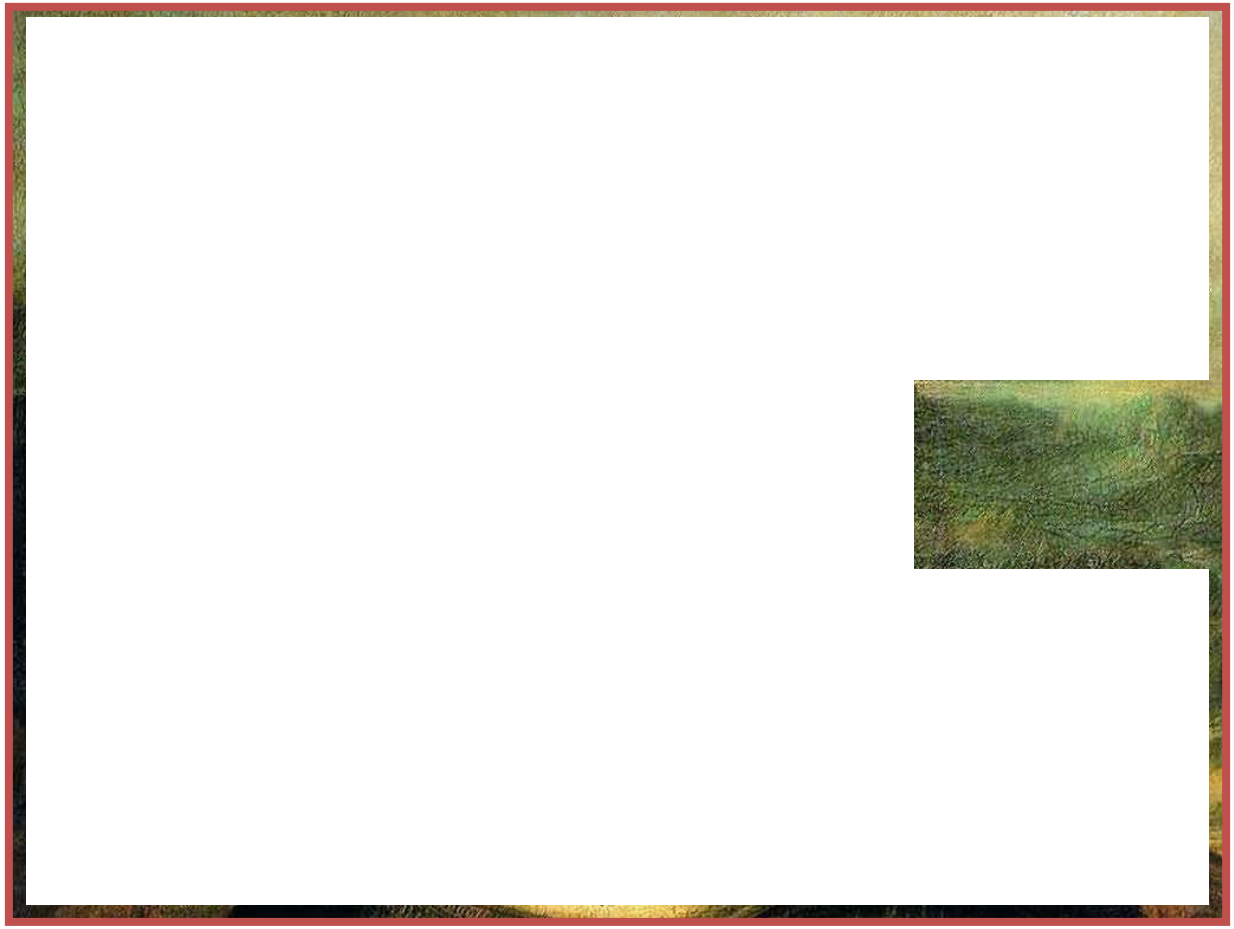
Lots of Detail in One Area



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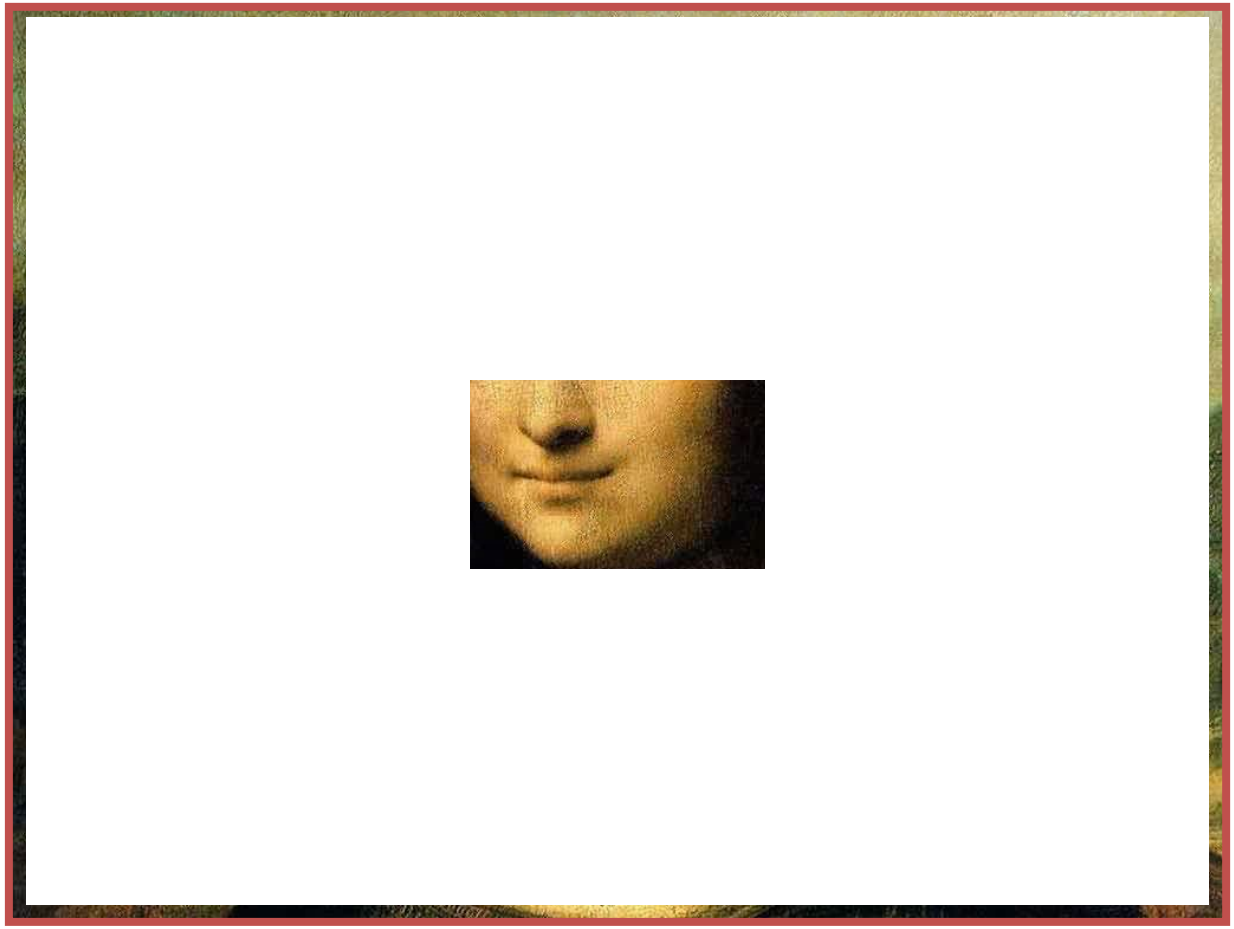
Lucky, capture the essence



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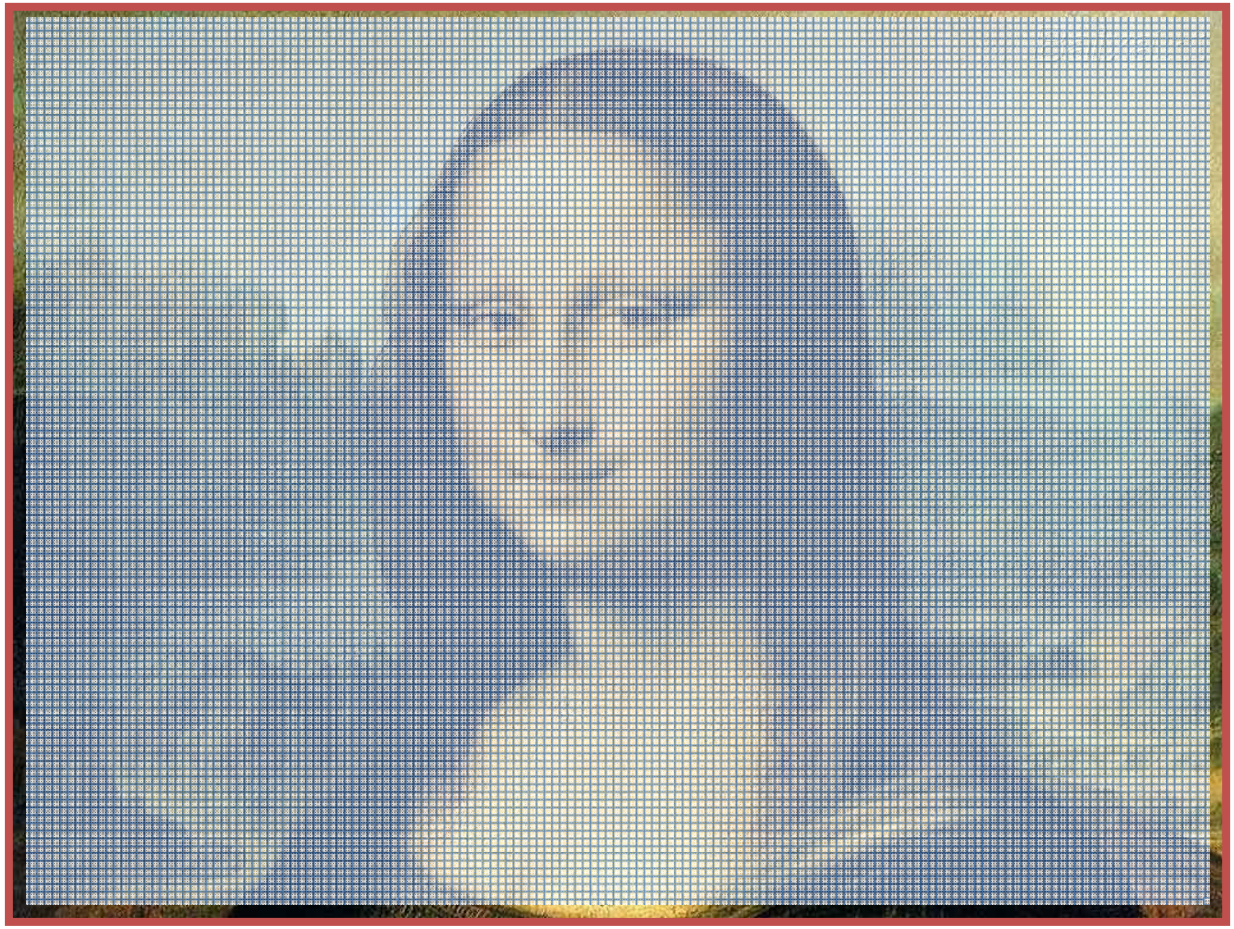
Understand the big picture



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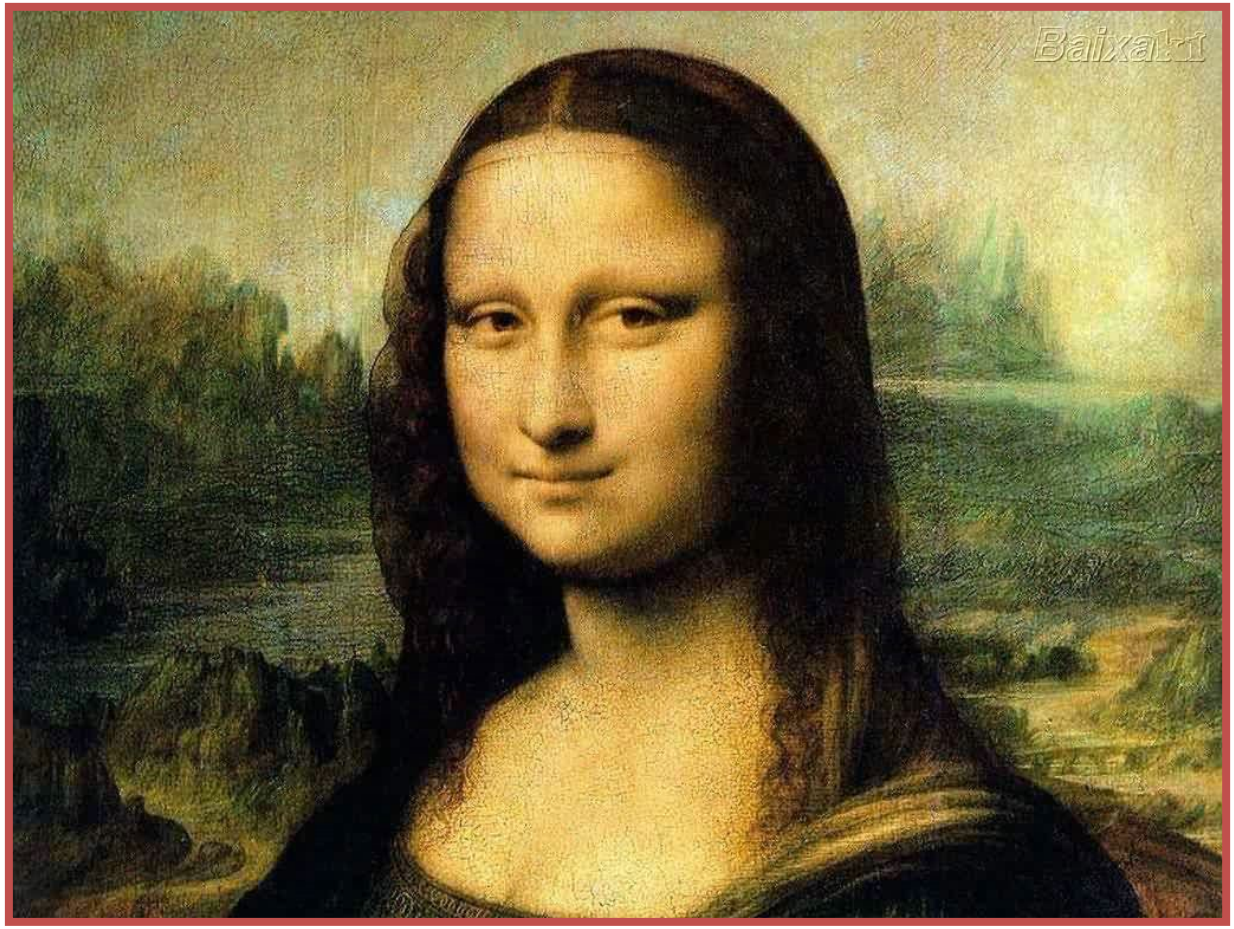
Thank You



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