Why Sustainable Investment in Quality Tools Is a Smart Decision

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Working for #ZeroHunger

Objectives

- To demonstrate trade-off between higher quality diagnostics & vaccines and economic effect

- To open a debate and get feedback on usefulness of the models

- To refine the models as decision-support tools, and publish the results

- To find collaborators

Methods

Developed two simple economic models to better understand the benefits and costs of investing in high-quality diagnostics and vaccines:

1. For diagnostics, using the example of conducting surveillance in live bird markets;

2. For vaccines, a decision-tree model comparing four varying qualities under uncertainty
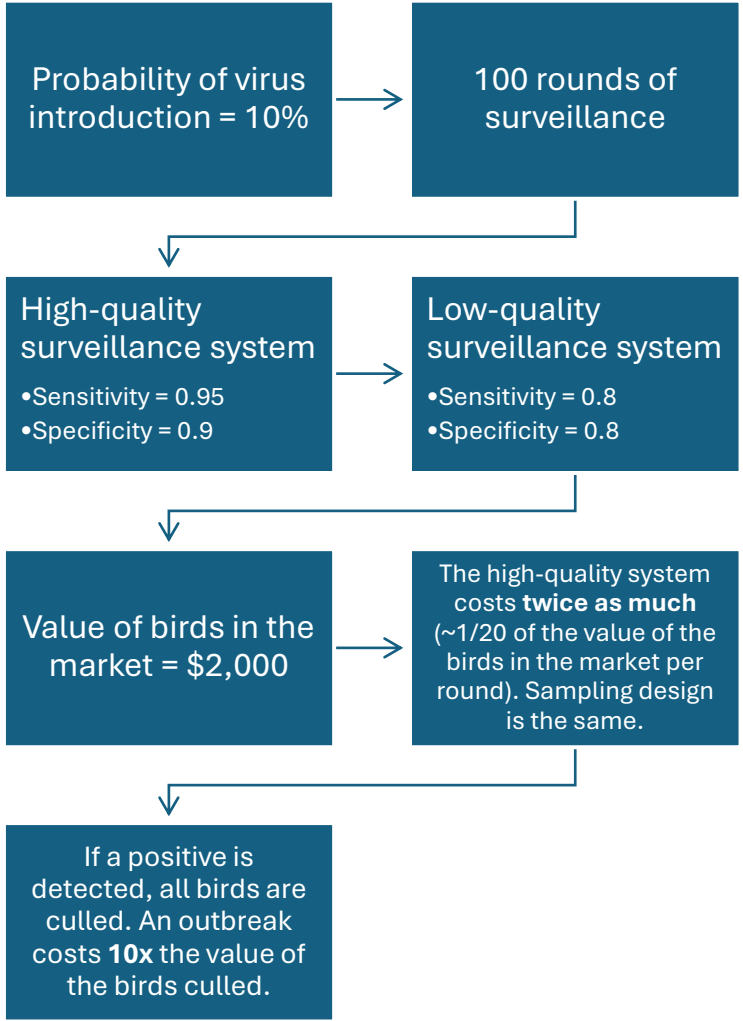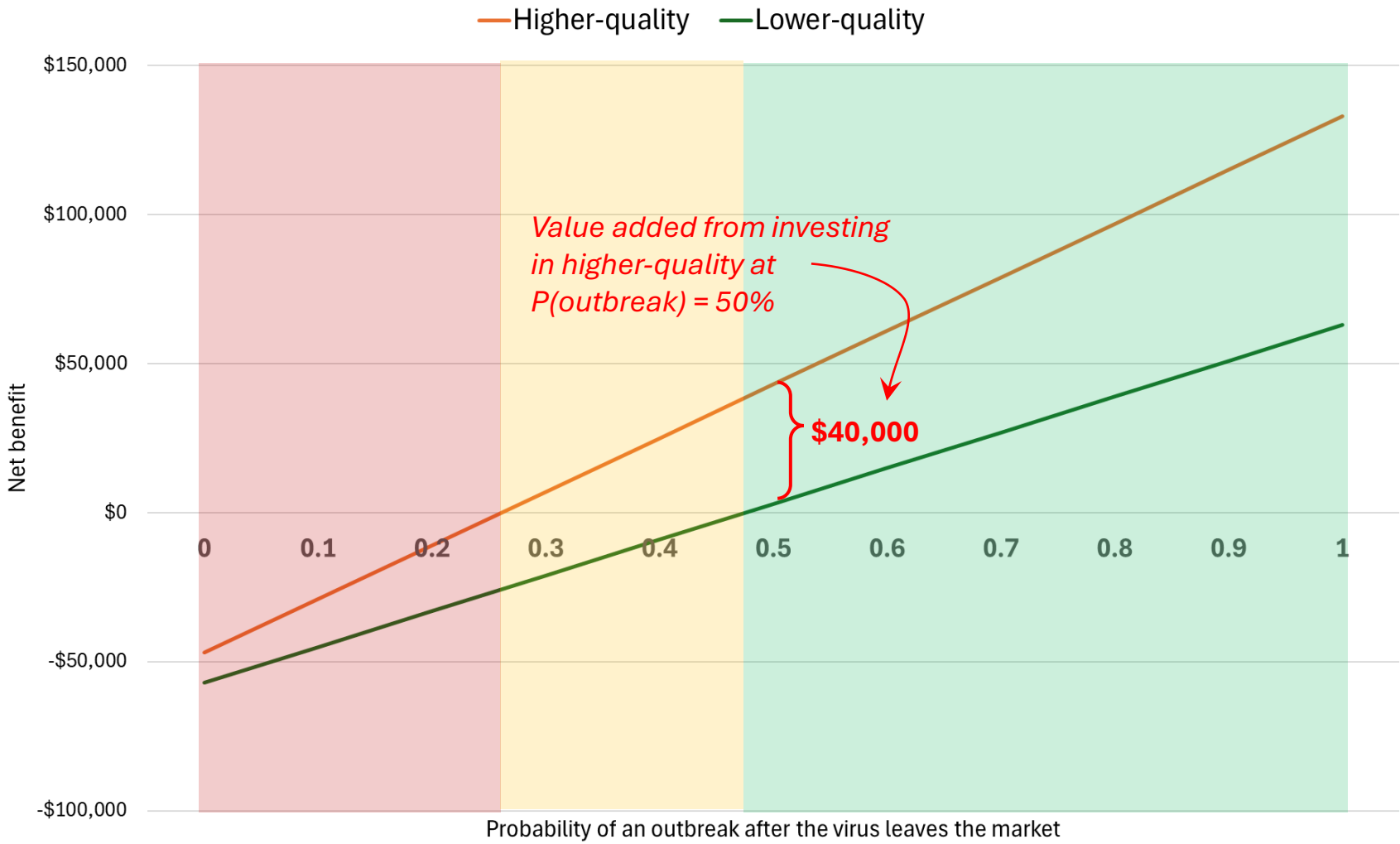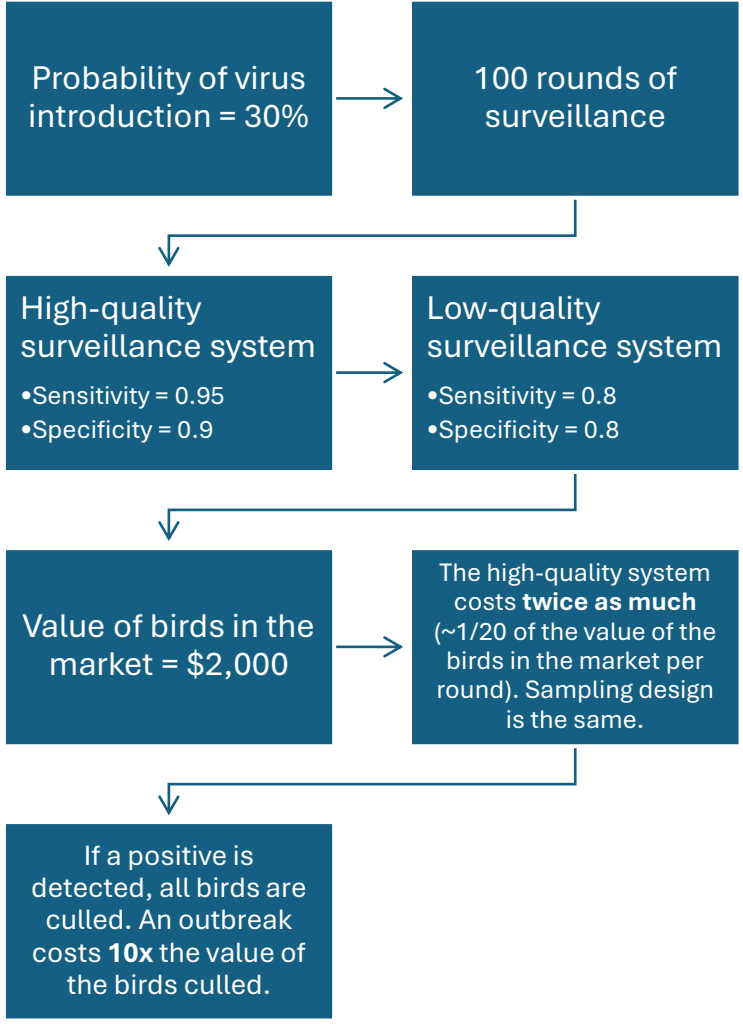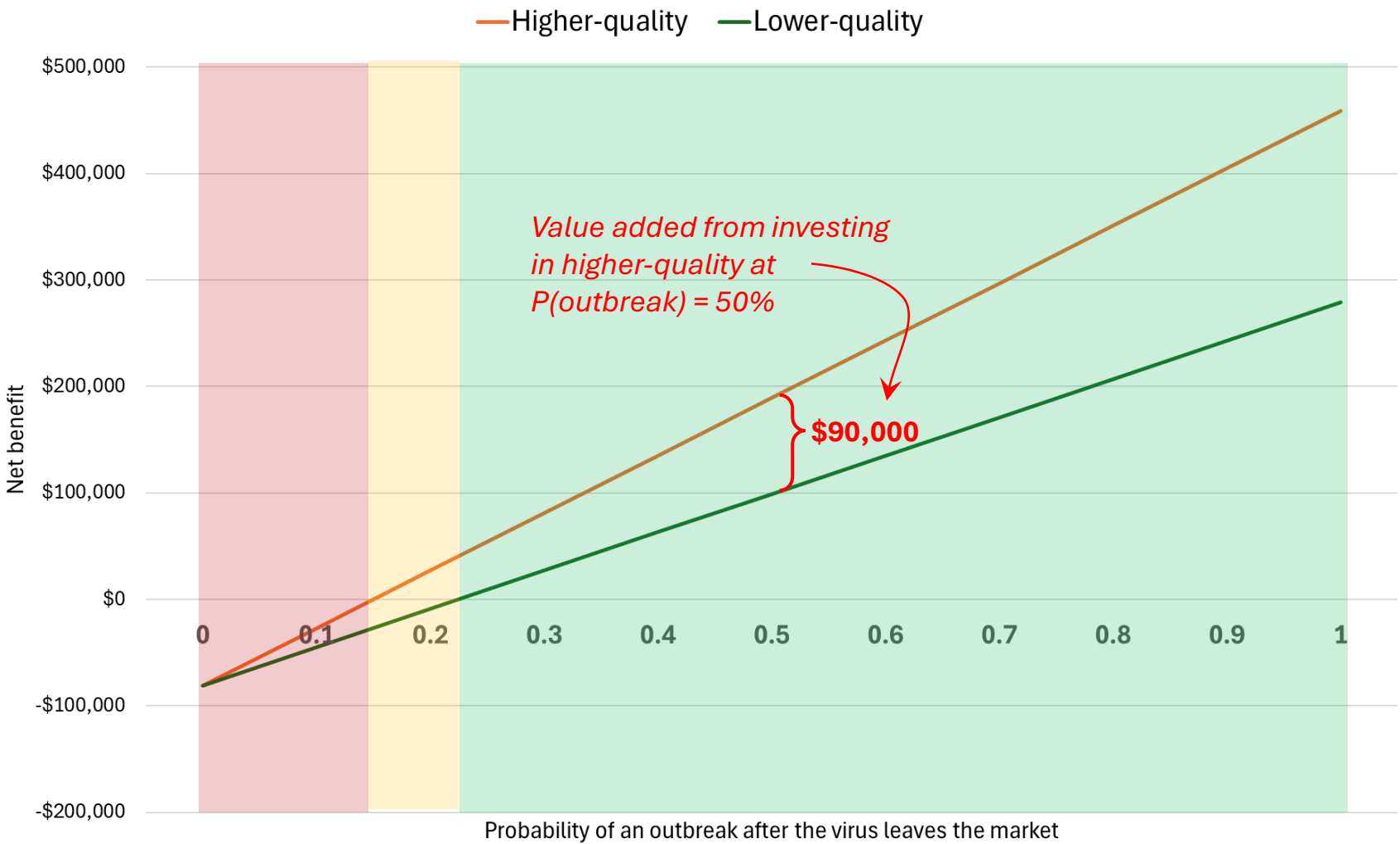
Deterministic model: surveillance in live bird markets

Benefit-Cost analysis of surveillance in LBM

Benefit-Cost analysis of surveillance in LBM

— Higher-quality — Lower-quality

Value added from investing in higher-quality at P(outbreak) = 50%

$90,000

Net benefit

Probability of an outbreak after the virus leaves the market

Probability of virus introduction = 30% → 100 rounds of surveillance

High-quality surveillance system
• Sensitivity = 0.95
• Specificity = 0.9
→
Low-quality surveillance system
• Sensitivity = 0.8
• Specificity = 0.8

Value of birds in the market = $2,000
→
The high-quality system costs **twice as much** (~1/20 of the value of the birds in the market per round). Sampling design is the same.

If a positive is detected, all birds are culled. An outbreak costs **10x** the value of the birds culled.

Benefit-Cost analysis of surveillance in LBM

— Higher-quality — Lower-quality

Value added from investing in higher-quality at P(outbreak) = 50%

$310,000

Net benefit

Probability of an outbreak after the virus leaves the market

Probability of virus introduction = 10%

100 rounds of surveillance

High-quality surveillance system
- Sensitivity = 0.95
- Specificity = 0.9

Low-quality surveillance system
- Sensitivity = 0.8
- Specificity = 0.8

Value of birds in the market = $2,000

The high-quality system costs **twice as much** (~1/20 of the value of the birds in the market per round). Sampling design is the same.

If a positive is detected, all birds are culled. An outbreak costs **100x** the value of the birds culled.

Key observations

As the cost of an outbreak increases:

- o the benefits of investing in surveillance increase too
- o the gap between the two technologies increases at a higher rate

As the cost of outbreaks increases, paying for high-quality diagnostics becomes more profitable

Next steps to improve the model

- Use real world data on cost and quality of diagnostics and impact of outbreaks (OutCosT-Poultry)
  - Include sensitivity and specificity values of tests available in the market
  - Expand the analysis to include the socioeconomic impacts of outbreaks (livelihoods, food security, public health) using real data
- Link with an Epi model to disentangle the impact of the diagnostic test from the impact of the surveillance strategy (sampling, frequency, etc.)
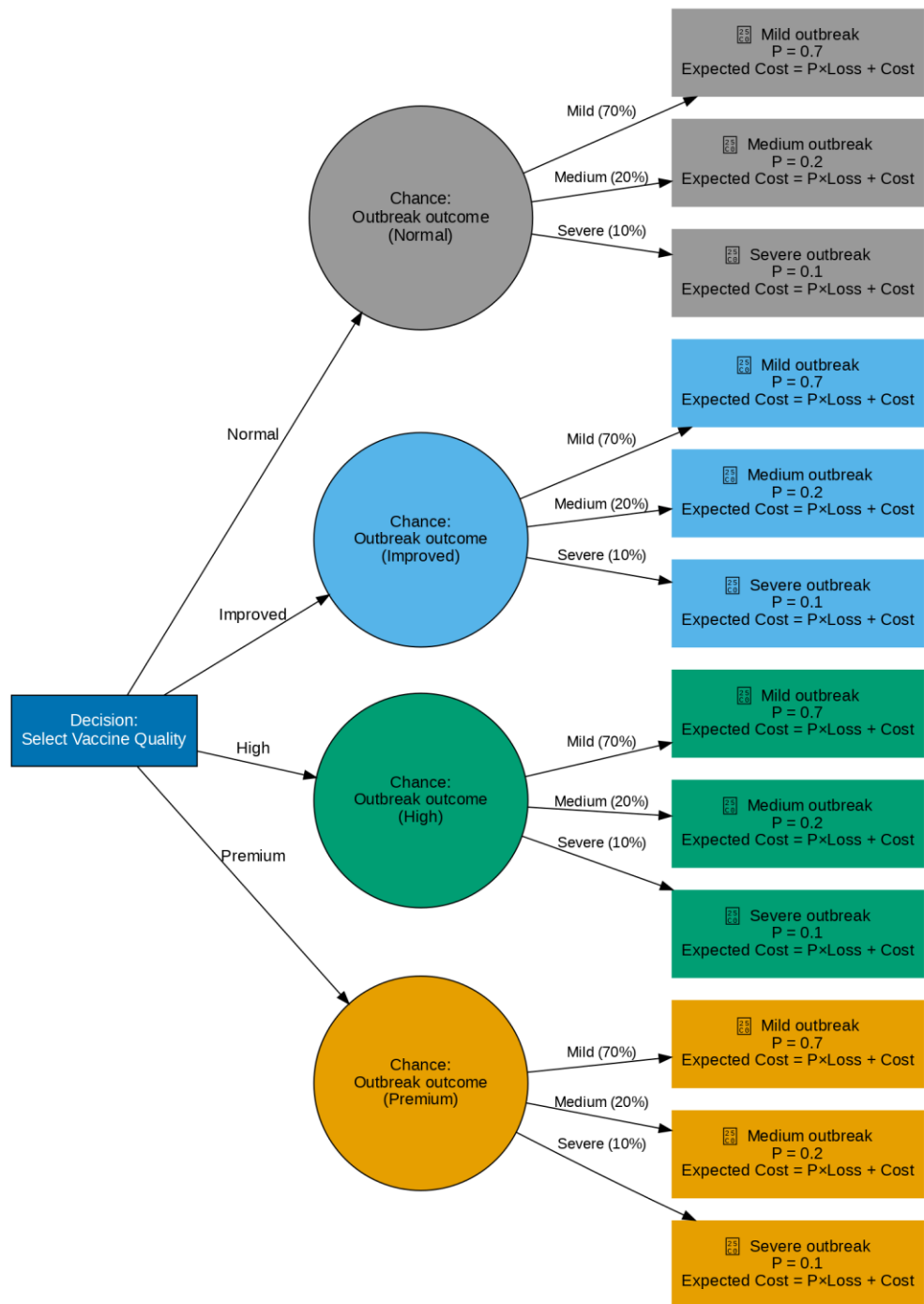- What else?

Photo: www.lemonde.fr/

Stochastic decision-tree model: choosing FMD vaccine

- A decision-tree stochastic model developed to simulate expected total costs, net benefits, and benefit–cost ratios under uncertainty.

- Three baseline outbreak probability scenarios were evaluated representing different epidemiological environments:
  - Severe impact, low prob (10%),
  - Medium impact, med prob (30%)
  - Mild impact, high prob (70%)

Analytical Framework

Compared four vaccine tiers: Normal → Improved → High → Premium

Each defined by quality dimensions: Potency, Match, Quality Control

Efficacy Equation: $E = Potency \times Match \times QC$

Outbreak Probability After Vaccination:

- $P_{outbreak} = P_{baseline} \times (1 - E)$
- Expected Total Cost (ETC): $ETC = P_{outbreak} \times (L_{outbreak} + C_{control}) + C_{vaccine}$
- Efficacy values ranging from ~0.39 "Normal" to ~0.74 "Premium"). Current version assumes single-dose schedules and does not yet account for DIVA properties.

Economic structure & assumptions

Expected total cost incorporates both vaccination expenses and potential outbreak losses:

$$\text{ETC} = P_{\text{outbreak}} \times (\text{Loss}_{\text{per outbreak}} + \text{Control cost}) + (\text{Vaccine cost} \times \text{Number of doses})$$

$100K	**$5K**	**1,000**
Loss Per Outbreak	**Control Costs**	**Doses Per Herd**
Direct economic damage per affected herd	Reactive measures per outbreak event	Standard vaccination coverage target

- Monte Carlo simulation (10,000 runs):
- Estimated distributions of total cost (ETC), net benefit (NB), and benefit–cost ratio (BCR)

Core Indicators:

- $NB = ETC$ Normal $- ETC$ Scenario and
- $BCR = NB / C\text{vaccine}$

Dramatic cost reductions in high-risk settings

In high-risk contexts where baseline outbreak probability reaches reaches 70%, vaccine quality dramatically influences economic economic outcomes.
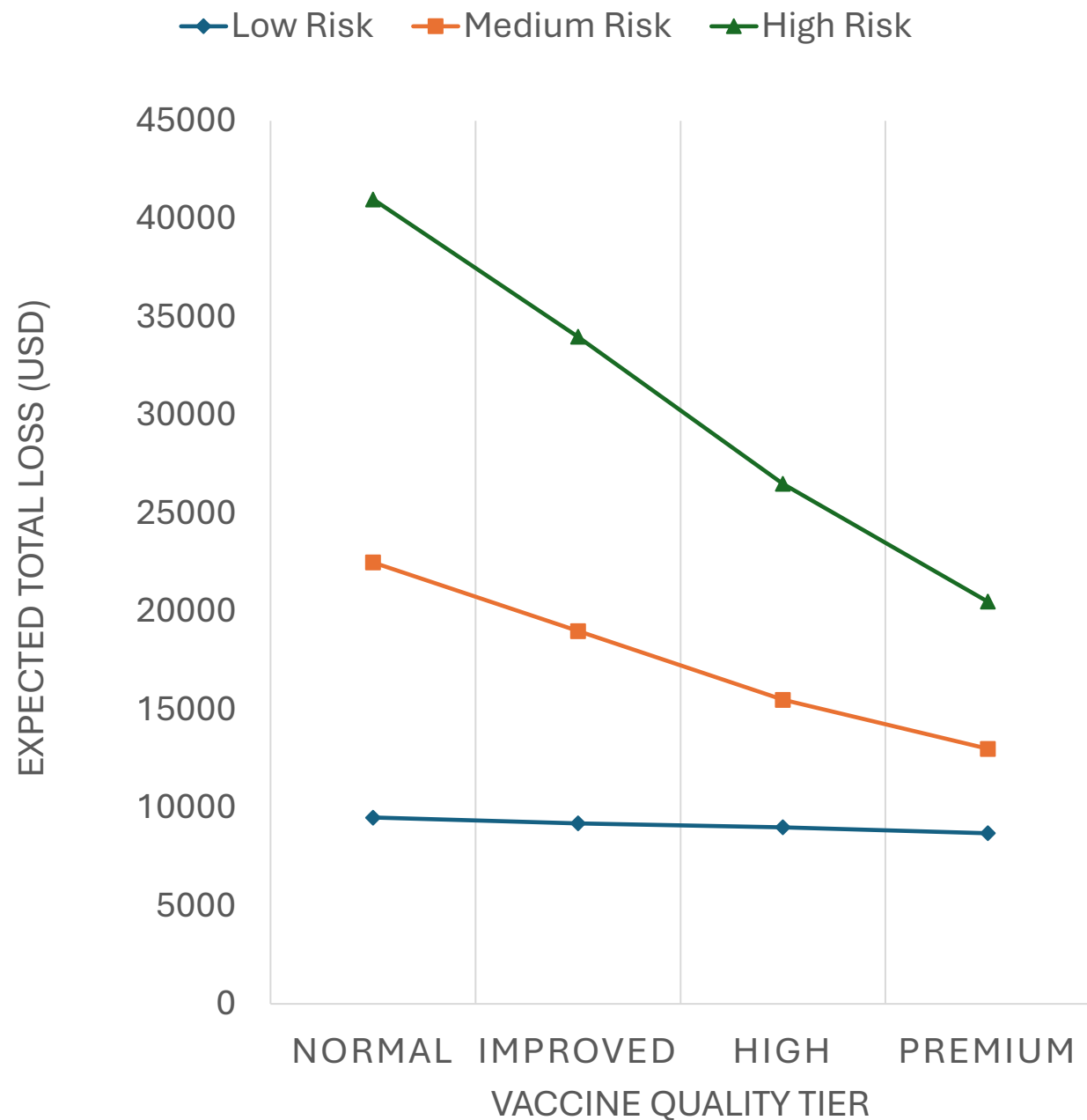
Normal Vaccine

$1.15 million expected total cost

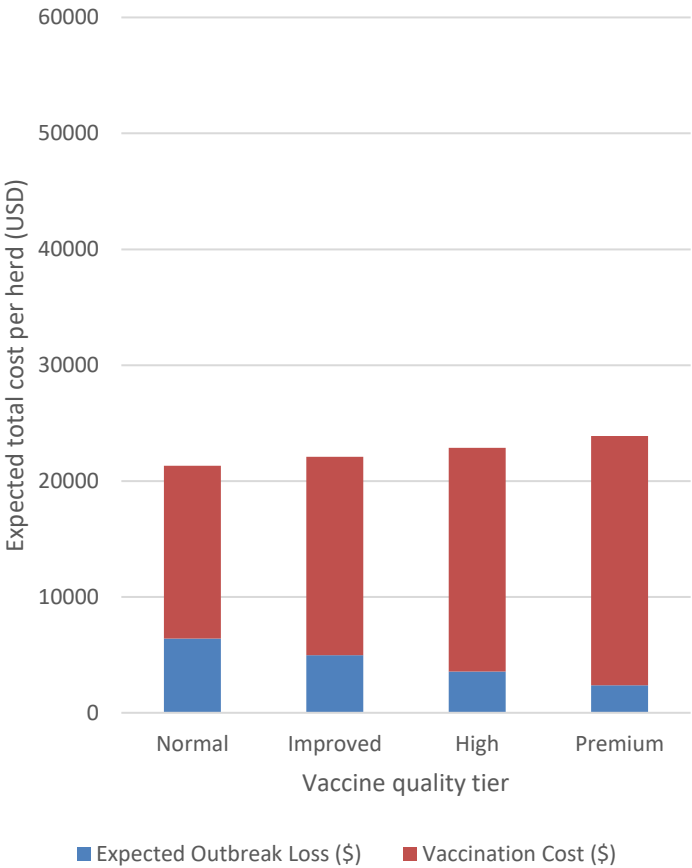Baseline scenario with standard quality

Premium Vaccine

$0.41 million expected total cost
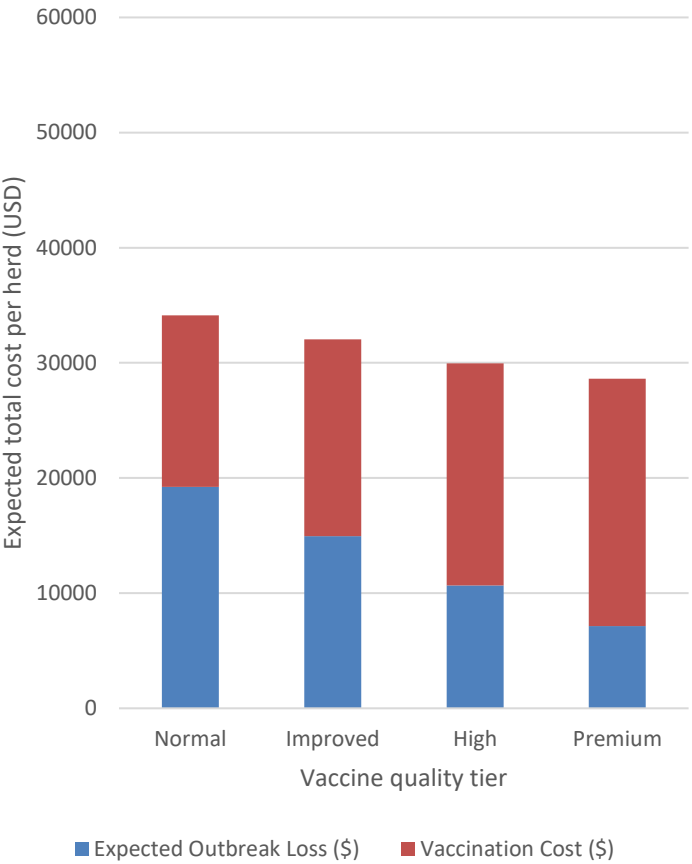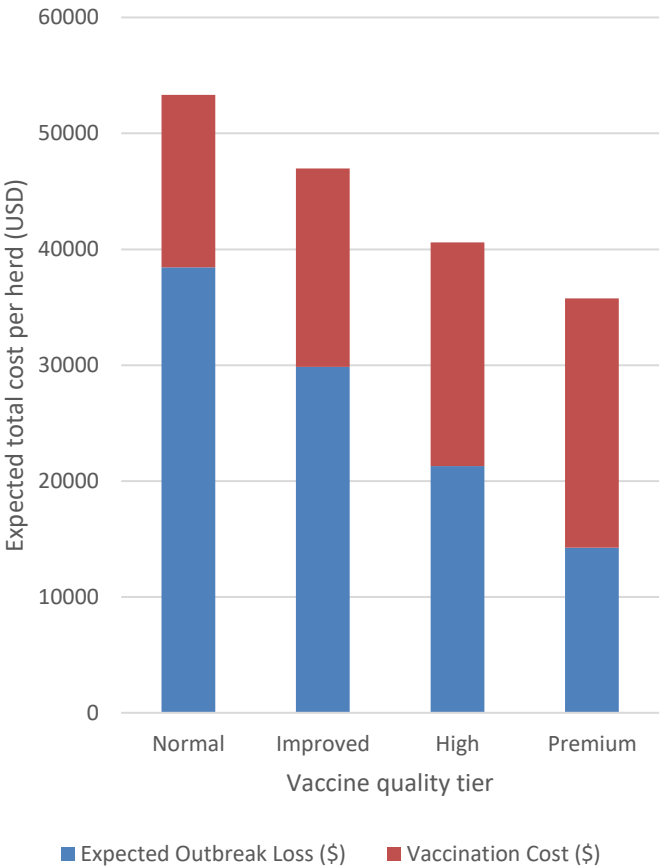
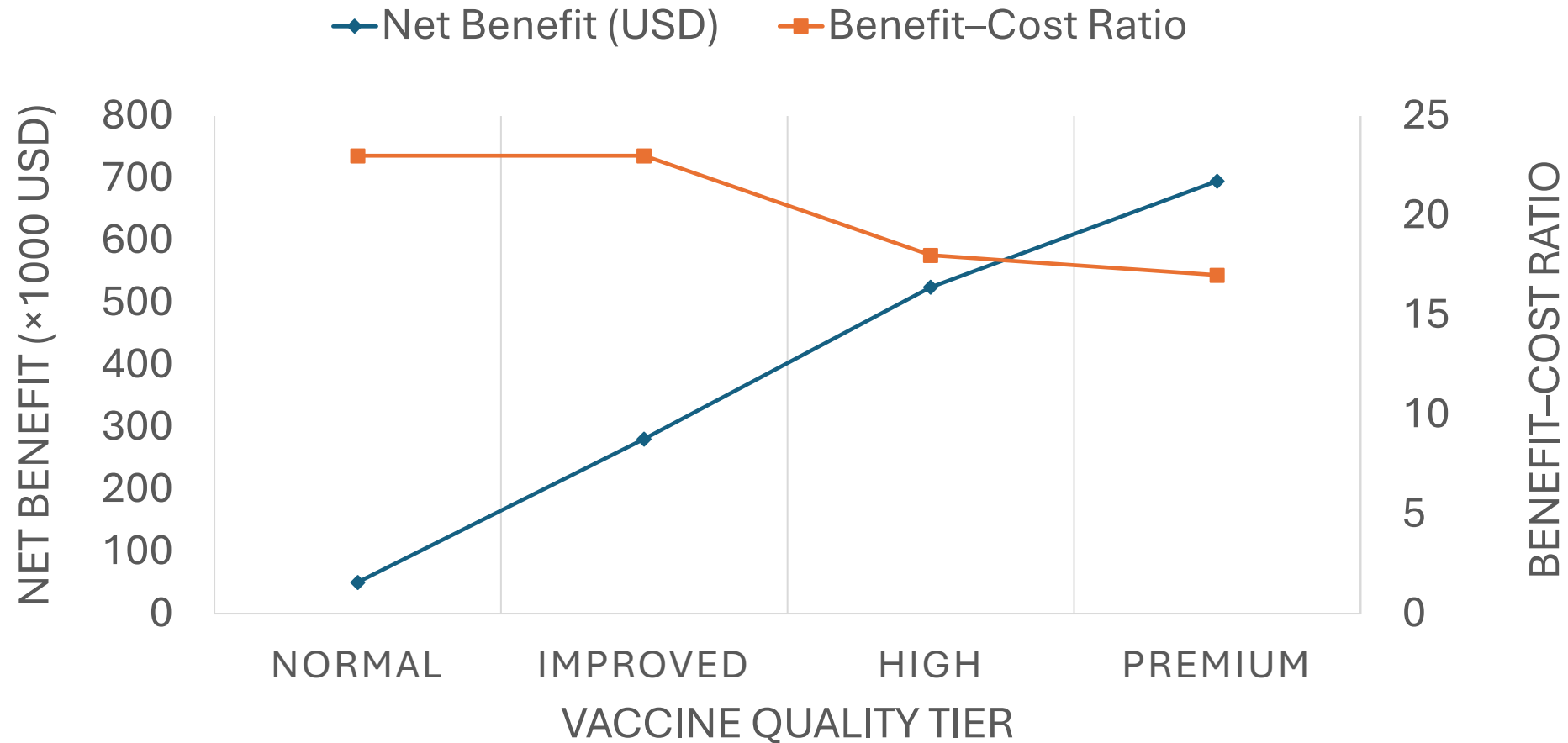64% reduction in economic losses

Cost composition

Risk level: Low

Risk level: Medium

Risk level: High

Cost-Effectiveness Across Risk Contexts

The economic justification for high-quality vaccines strengthens as outbreak risk increases, but benefits are evident even in low-risk settings.

Low Risk (10% baseline)

Premium vaccines save $1,031 per herd versus Normal quality. Modest but meaningful returns in stable environments.

Medium Risk (30% baseline)

Premium vaccines save $9,092 per herd versus Normal quality. Strong Strong economic case for quality investment.

High Risk (60% baseline)

Premium vaccines save $21,184 per herd versus Normal quality. Overwhelming economic advantage in endemic zones.
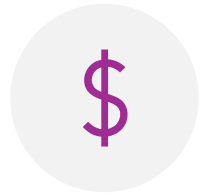
Lessons and implications

High-quality diagnostics and vaccines reduce expected losses and improve resilience.

Benefits increase non-linearly with risk.

Next: country-level calibration and integration with biosecurity economics.

Invest in quality, not just coverage.

Premium vaccines justified in high-risk regions.

Use economic evidence to guide priorities.

Key Takeaways

High-quality diagnostics & vaccines provide cost-effective tools tools for TADs control control

Especially critical in high-risk zones where outbreak probability and potential losses are elevated

Economic rationale extends beyond per-unite pricing

Preventing large-scale losses and avoiding trade disruptions yield far greater societal benefits than procurement savings

Implementation quality amplifies effectiveness

High quality surveillance, cold-chain integrity, coverage rates, and delivery system capacity determine whether diagnostics and vaccines achieve their potentials
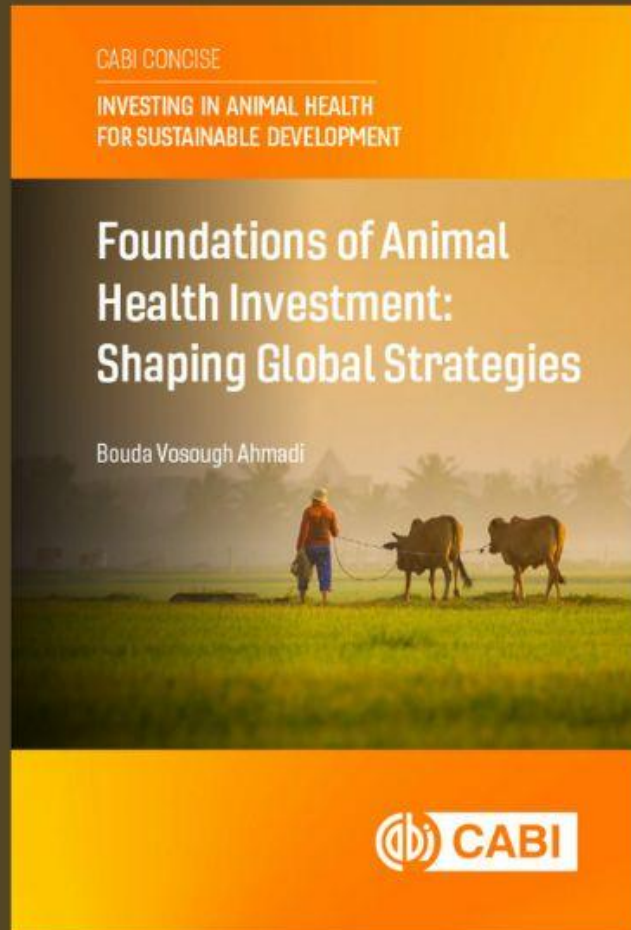
Wider societal benefits

The economic value of quality extends beyond individual herds to entire livestock systems, supporting food security and rural livelihoods worldwide.

THANK YOU

Protecting people, animals, and the environment every day