Health economic modelling to inform arbovirus screening of donated blood

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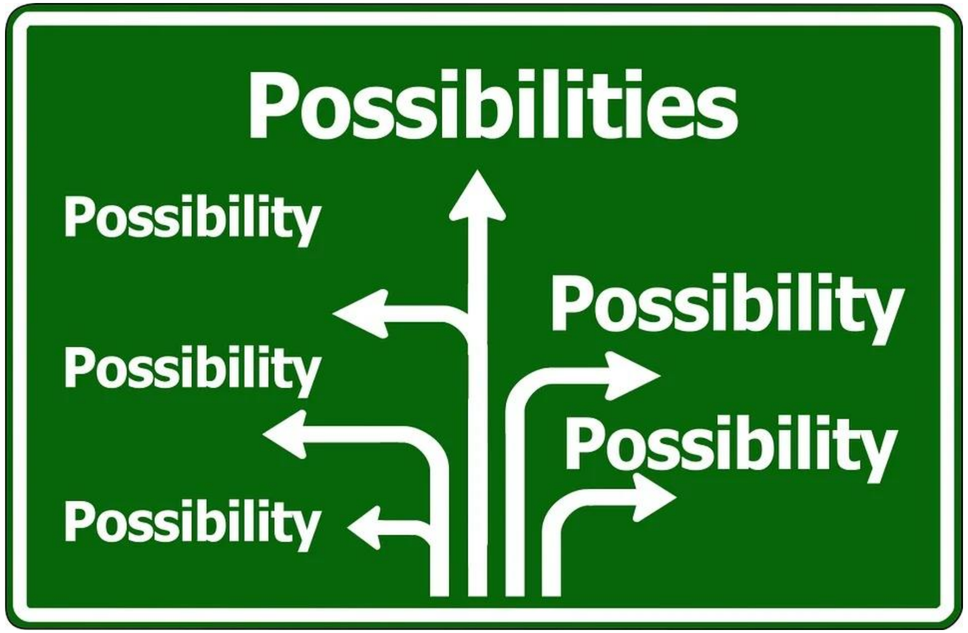
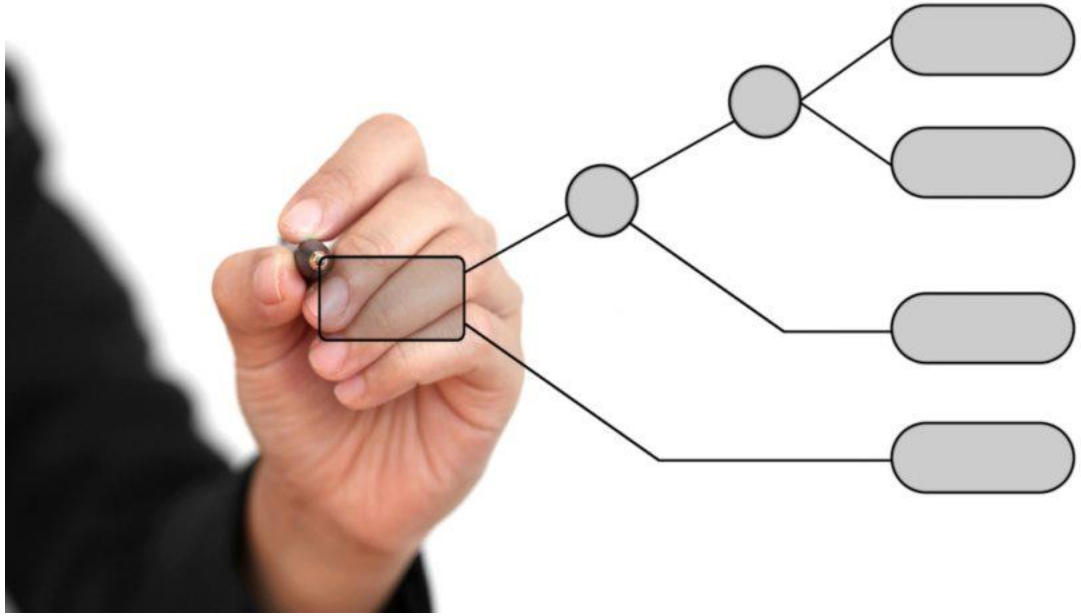
Fundamental question in decision modelling



How do we choose which strategies and interventions to implement?

Decision analytic models

- Synthesize evidence with uncertainty
- Make assumptions & trade-offs explicit
- Inform effective, efficient (& equitable) use of finite resources



Ins and outs of a decision analysis

Estimate relevant outcomes of alternative strategies

Inputs
- Primary data
- Secondary data
- Expert opinion
- Assumptions

→

Decision-analytic model
Systematically integrate and analyze inputs

→

Output
Differences in outcomes under each strategy

In a **health economic** model, **cost** is among the estimated outcomes

Annals of Internal Medicine

ORIGINAL RESEARCH

Screening the Blood Supply for Zika Virus in the 50 U.S. States and Puerto Rico

A Cost-Effectiveness Analysis

W. Alton Russell, MS; Susan L. Stramer, PhD; Michael P. Busch, MD, PhD; and Brian Custer, PhD

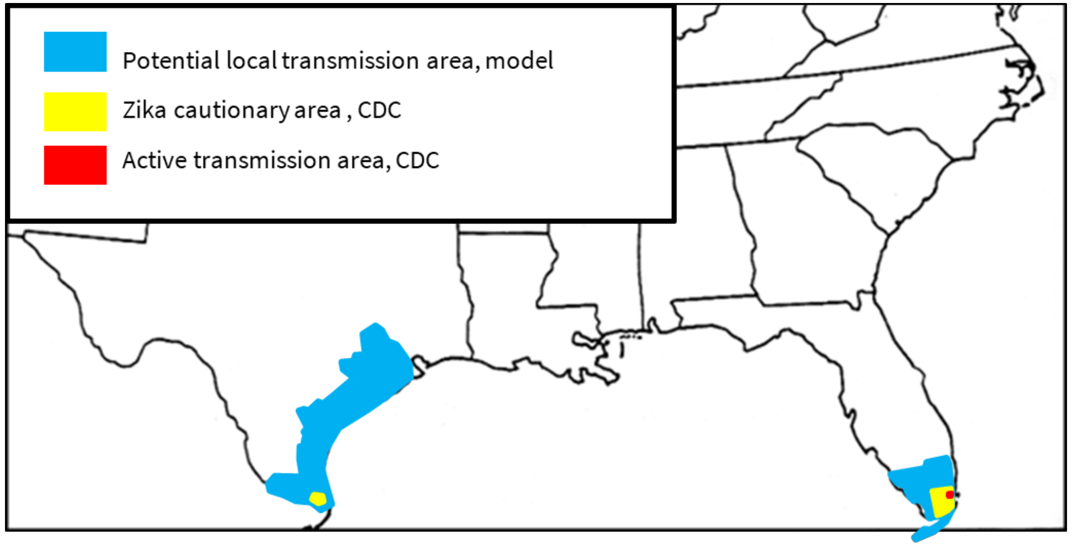
Russell et. al. 2019, 10.7326/M18-2238

Key events in U.S. Zika outbreak and blood safety response

- **March 2016**: Screening begins in Puerto Rico
- **Aug 2016**: Guidance issued for universal screening in all states
- **Dec 2016**: Implementation complete in all states
- **June 2017**
- **Aug 2017**

Florida local transmission (Aug 2016 – June 2017)

Texas local transmission (Dec 2016 – Aug 2017)



Should the U.S. spend >$125 million a year to screen for Zika?

Screening policies

Puerto Rico

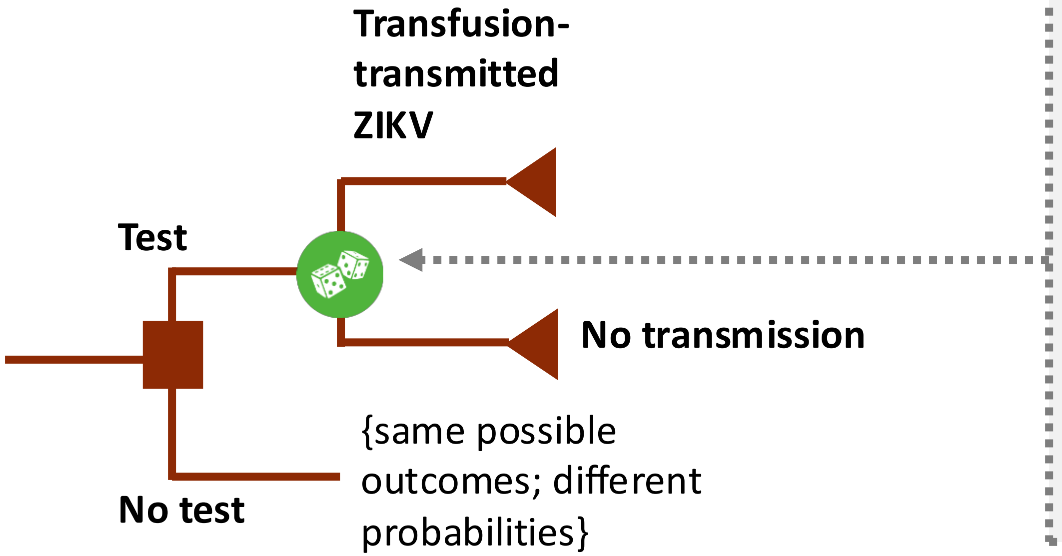
	Low mosquito season	High mosquito season
No screening	NS	NS
Universal MP	MP	MP
Universal ID	ID	ID
½-MP	NS	MP
½-ID	NS	ID
½-MP-ID	MP	ID

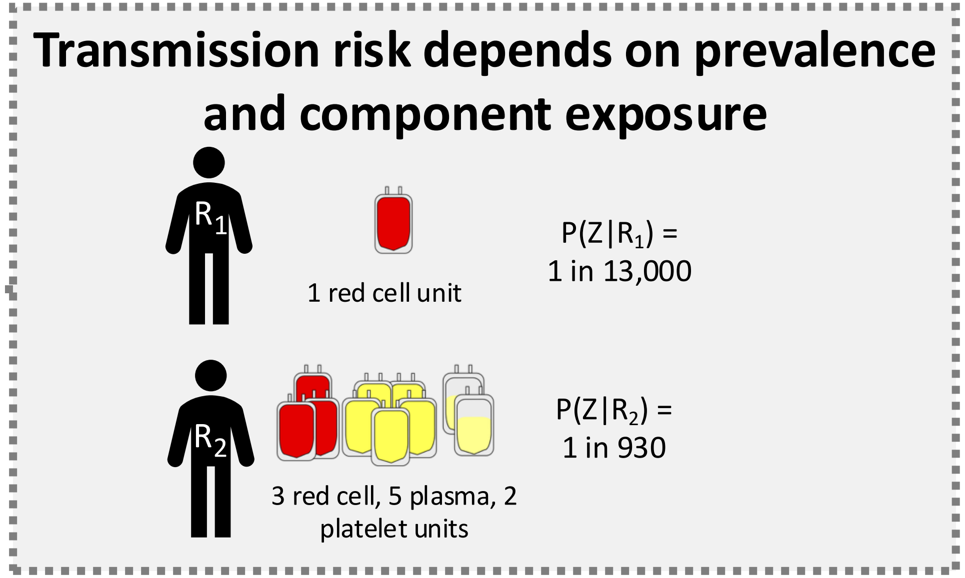
50 states

	Potential local exposure	Potential travel exposure	No known exposure
No screening	NS	NS	NS
Universal MP	MP	MP	MP
Universal ID	ID	ID	ID
Location-adaptive MP	MP	NS	NS
Location-adaptive ID	ID	NS	NS
Travel-adaptive MP	MP	MP	NS
Travel-adaptive ID	ID	ID	NS

NS = no screening; MP = mini-pooled; ID = individual donation

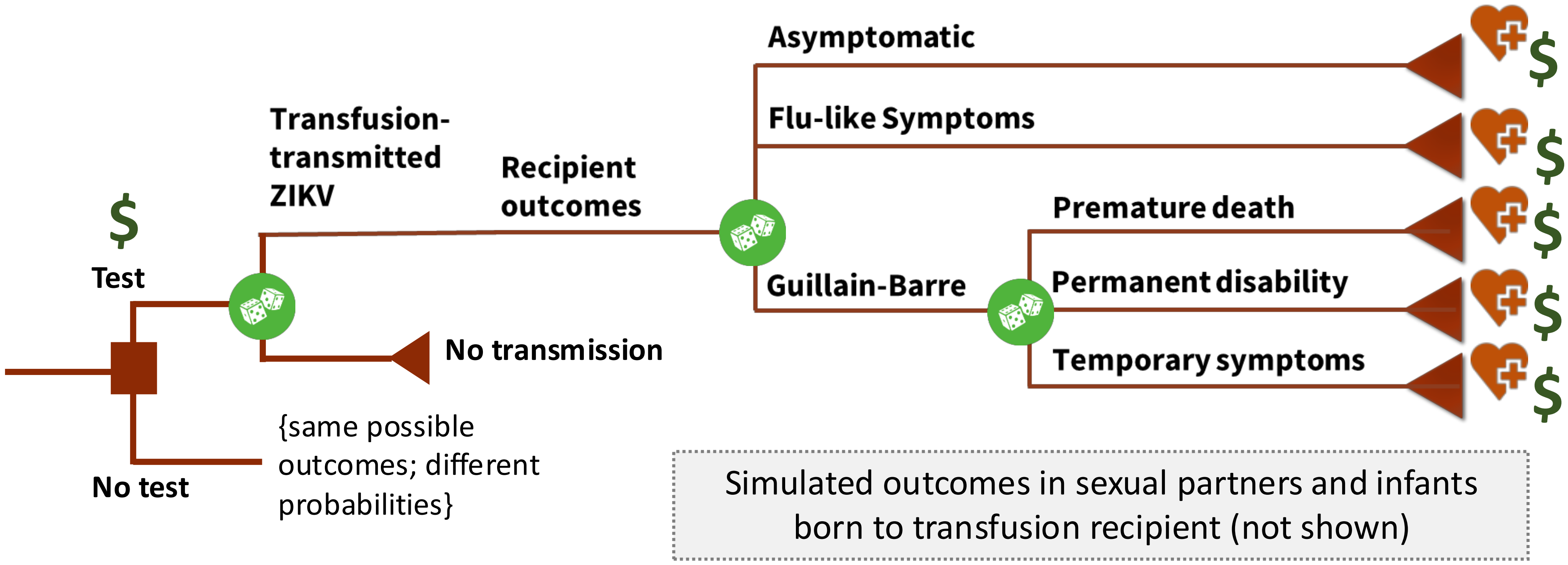
Method: simulated decision tree





- Sample transfusion recipients (age, sex, units transfused)
- Calculate transmission risk, costs, survival, and quality-adjusted life years (QALYs)

Method: simulated decision tree



- Sample transfusion recipients (age, sex, units transfused)
- Calculate transmission risk, costs, survival, and quality-adjusted life years (QALYs)

Willingness-to-pay threshold

- In US, common cost-effectiveness thresholds are **$50 to $150 thousand** per quality-adjusted life year (QALY) gained.
- In transfusion safety, **$1M per QALY** is commonly used
  - **Revealed preference**: Implemented transfusion-transmitted infection interventions interventions routinely cost this much or more
  - **Iatrogenic harm:** Should we pay more to prevent harms caused by health care?
  - **Public perception:** Could a lack of trust in blood safety have broader consequences?

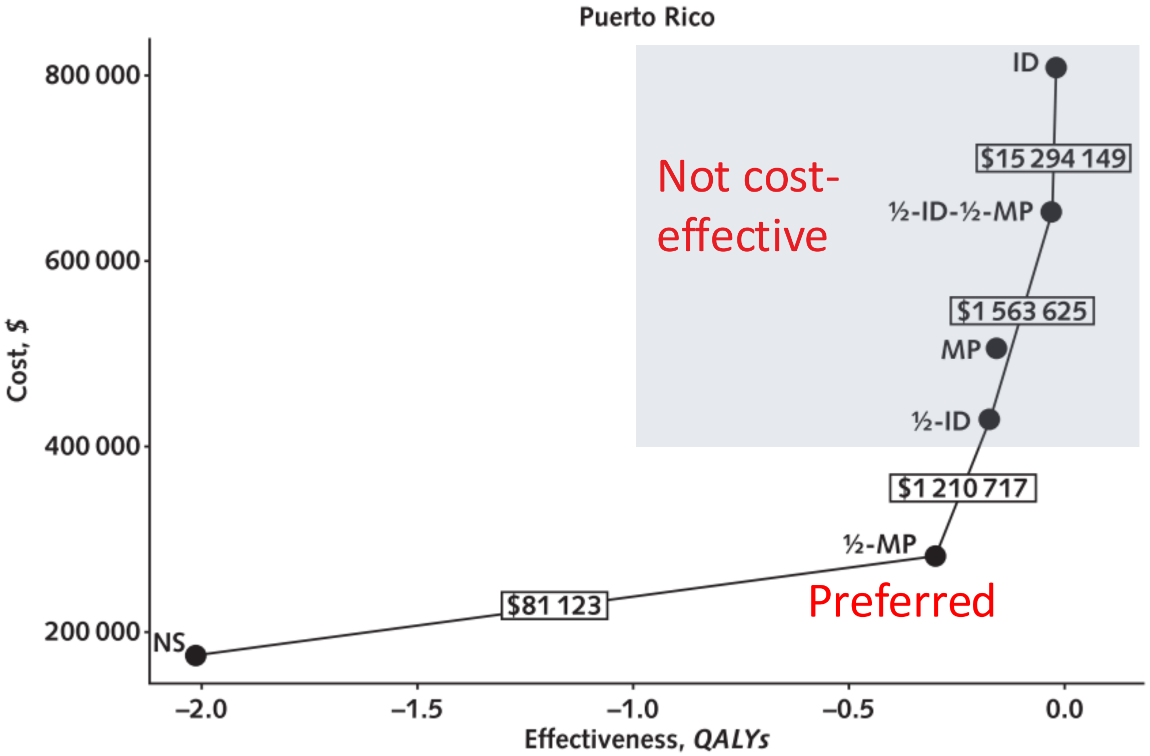
Results: Cost-effectiveness

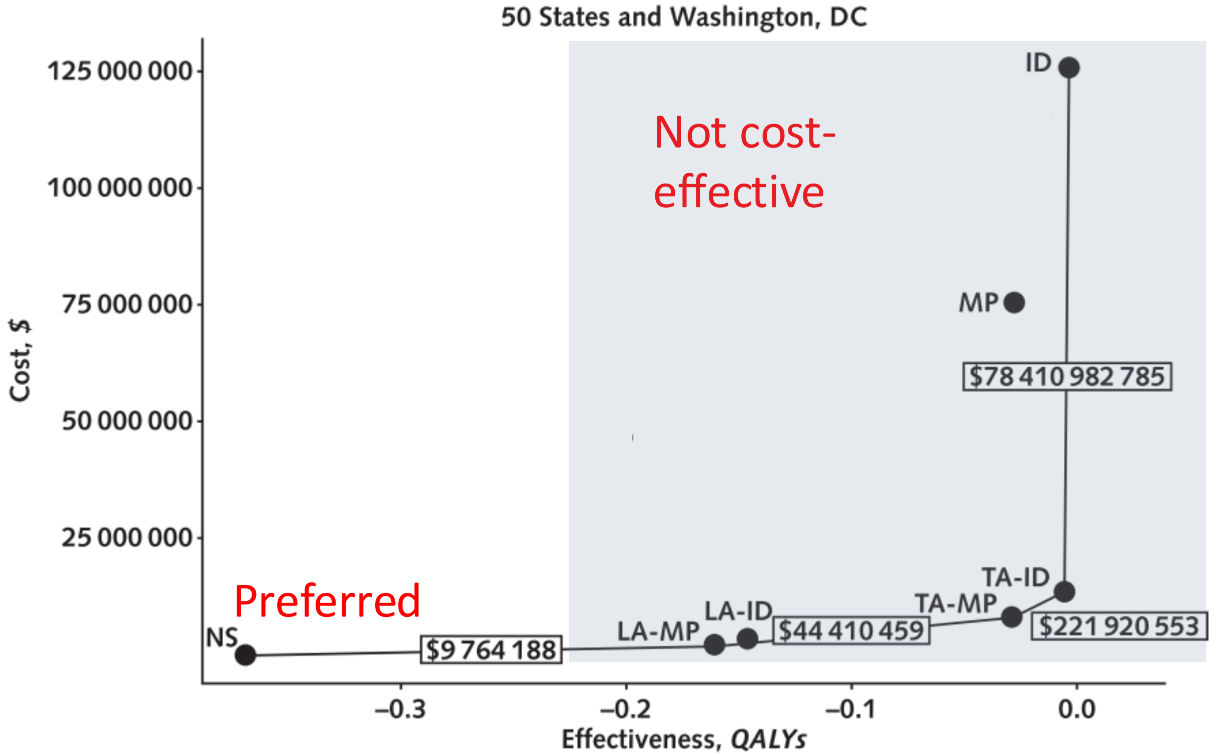
Puerto Rico

- Minipooled testing in high mosquito season preferred
- Individual donation testing in high mosquito season close to $1 million threshold

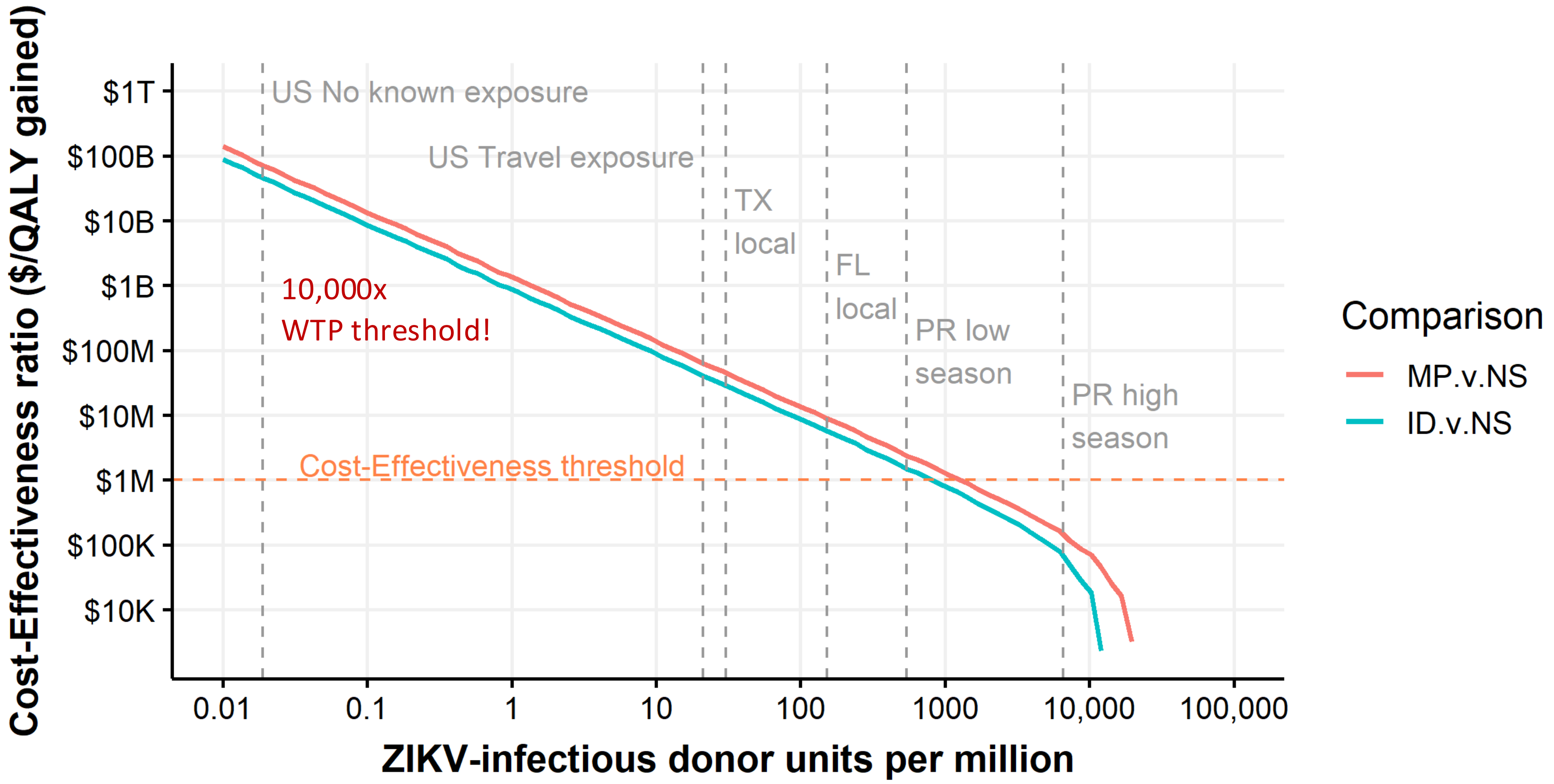
50 States

- Universal individual donation testing cost over $125 million annually
- No screening policy cost-effective





Cost-effectiveness of screening depends on prevalence



Log scales

Our (limited) policy impact

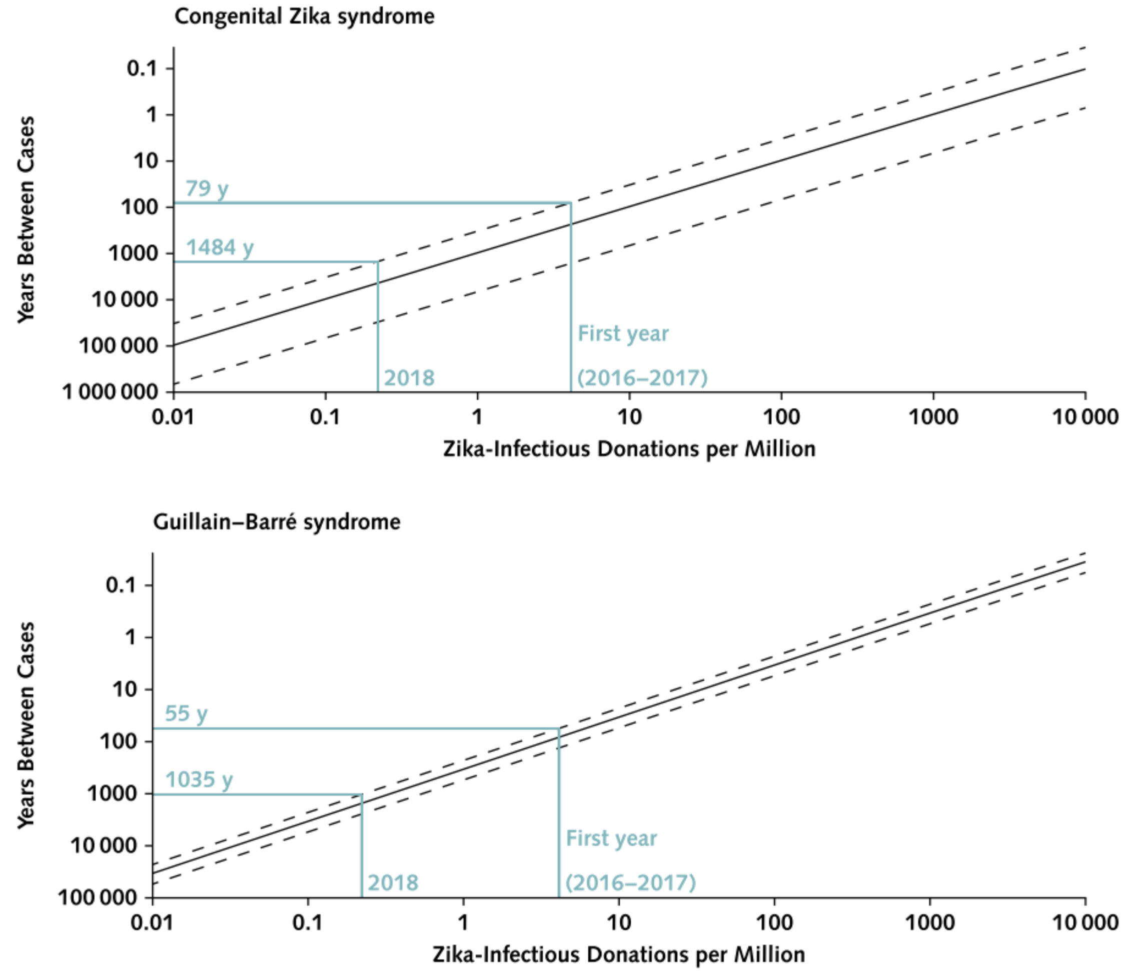
- **July 2018** ID-NAT to MP-NAT
- **Jan 2019** CEA published
- **April 2019** BPAC meeting
  - "We have no risk model for serious adverse events"
  - Maintain status quo, revisit in 1 year
- **May 2020** BPAC cancelled
- **Feb 2021** Follow-up research letter
  - Cost: $8M-$13M a month
  - Yield: 3 in 2018; 0 in 2019-20
  - Risk of serious adverse events very low
- **May 2021** NAT requirement removed

Letters | 16 February 2021

Estimating the Effect of Discontinuing Universal Screening of Donated Blood for Zika Virus in the 50 U.S. States

Author: W. Alton Russell, MS AUTHOR, ARTICLE, & DISCLOSURE INFORMATION

Publication: Annals of Internal Medicine • Volume 174, Number 5 • https://doi.org/10.7326/M20-6879



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Abbreviations: MP minipooled; ID individual donation; NAT nucleic acid test; CEA cost-effectiveness analysis; BPAC blood products advisory committee

What about West Nile virus?

Annals of Internal Medicine | Article

The Cost-Effectiveness of Screening the U.S. Blood Supply for West Nile Virus

Brian Custer, PhD; Michael P. Busch, MD, PhD; Anthony A. Marfin, MD, MPH; and Lyle R. Petersen, MD, MPH

Annals of Internal Med. 2005;143(7):486-492

MP-NAT for half the year
$0.13M – $0.54M per QALY gained
Targeted ID-NAT during local outbreaks
$0.02M to $1.0M per QALY vs no test
$15M to $64M per QALY vs. ½ MP-NAT

OPEN ACCESS Freely available online | PLoS MEDICINE

Cost-Effectiveness of Alternative Blood-Screening Strategies for West Nile Virus in the United States

Caroline T. Korves[1,2*], Sue J. Goldie[3], Megan B. Murray[1,4]

Plos Med. 2006;3(2):221-221

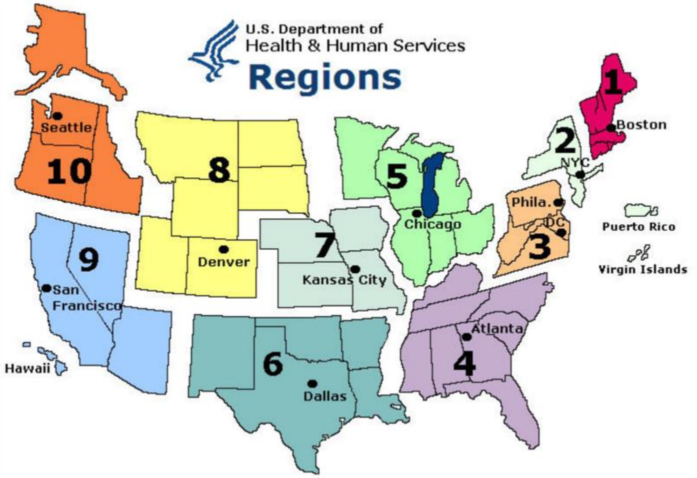
Low infection, short season scenario:
No NAT dominates
High infection scenario:
Seasonal ID-NAT of donations designated for immune compromised patients is cost-saving
Assumed assay sensitivity <45%

Updated WNv analysis (in progress)

Estimate historic health-economic outcomes of WNv MP- and ID-NAT based on NAT yield observed from 2016 to 2024 by:

4 donation types × **10 regions** × **2 seasons** × **9 years**

Donation type
Whole blood + DRBC
Apheresis plasma
Apheresis platelet (no PRT)
Apheresis platelet (with PRT)



Seasons
Transmission season (June to Nov)
Outside transmission season (rest of year)

Years
2016 to 2024

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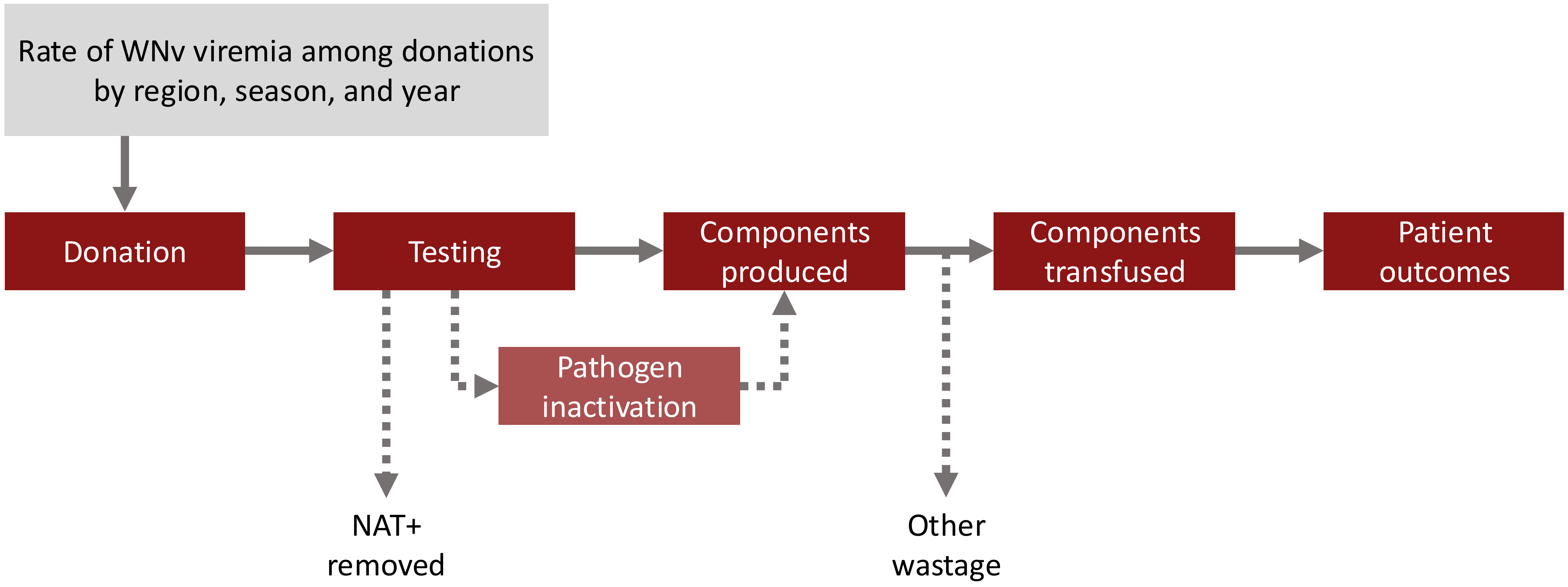
Process simulated



Modelling approach

Donation → Testing → Components produced → Components transfused → Patient outcomes

Testing ⇣ NAT+ removed

Donation	Components produced
Whole blood	1 FFP 1 RBC 0 PLT
Apheresis double RBC	2 RBC
Apheresis plasma	1 FFP
Apheresis platelet	2 PLT
Apheresis PR platelet	2 PLT

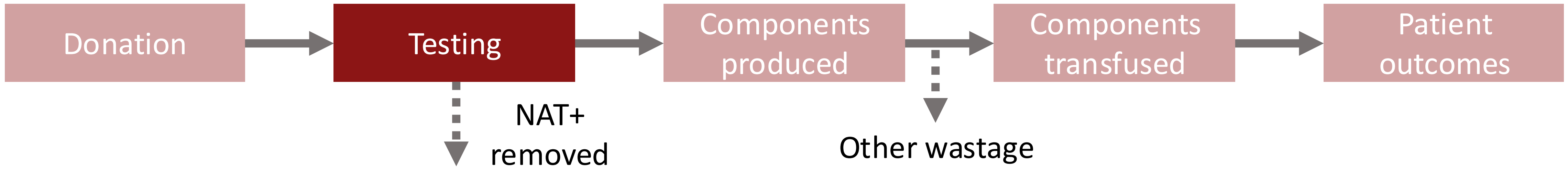
Annual USA donations/transfusions estimated from National Blood Collection and Utilization Survey (NBCUS) 2015, ‘17, ‘19, ’21, ’23

Number of presumed viremiic donations by state/month/year obtained from CDC Arbonet

Assumed

- All apheresis RBC donations in NBCUS were double RBC
- No pooled PLT units produced from whole blood donations

Modelling approach

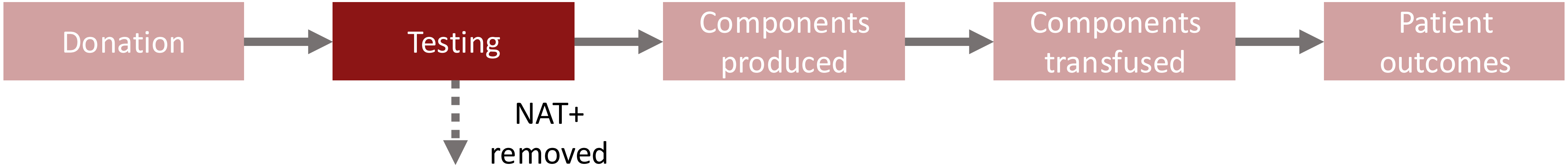


Donation	Components transfused	Replacement cost
Whole blood	0.56 FFP 0.92 RBC 0 PLT	$257
Apheresis double RBC	1.83 RBC	$429
Apheresis plasma	0.62 FFP	$61
Apheresis platelet	1.69 PLT	$1077
Apheresis PR platelet	1.78 PLT	$1250

Assumed

- Cost to replace discarded donation is the average cost paid by hospital for resulting components after accounting for wastage
- No pre-hospital wastage for non-RBC components (not reported by NBCUS)

Modelling approach

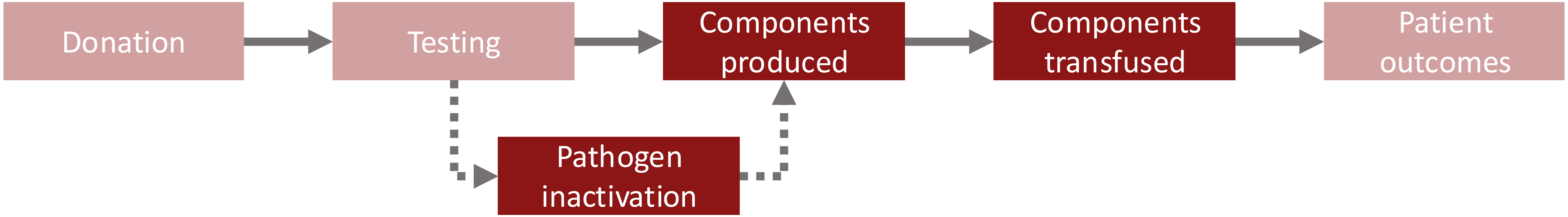


Test	Per-donation cost	Sensitivity	Specificity
ID-NAT	$23	99%	99.97%
MP-NAT	$12	95%	99.97%

Assumptions

- A true positive MP-NAT pool undergoes ID-NAT testing.
  - If a donation in the MP is ID-NAT+, all ID-NAT- donations are released for transfusion
  - If no donations are ID-NAT+, all donations in the MP are discarded

Modelling approach

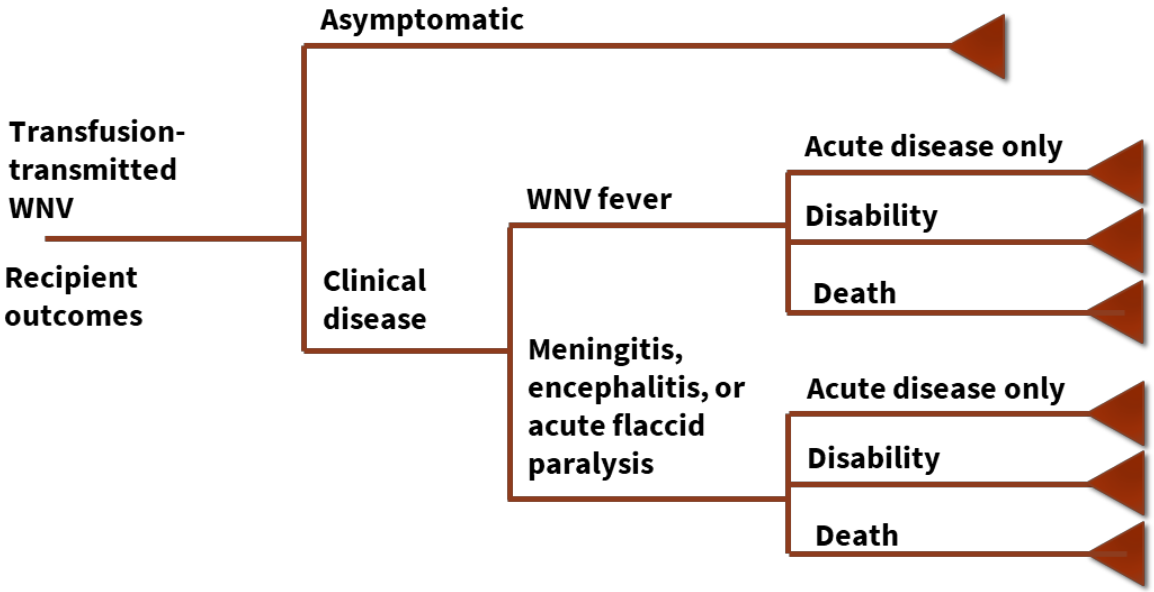


- **<u>All</u>** WNv viremic donations would transmit to **<u>all</u>** exposed patients
- WNv transmission risk reduced by 80% to 93% with platelet pathogen reduction (Grégoire et. al. 2022 *Transfusion*)

Modelling approach

Donation → Testing → Components produced → Components transfused → **Patient outcomes**

- Simulated decision tree repurposed from Russell, Custer, Brandeau 2021 *Health Care Mgmt Sci*
- Simulated patient harms from WNV
  - Risk of transfusion-transmission, symptoms/sequelae, death
  - Healthcare and productivity costs in 2019 USD
  - Quality adjusted life years lost

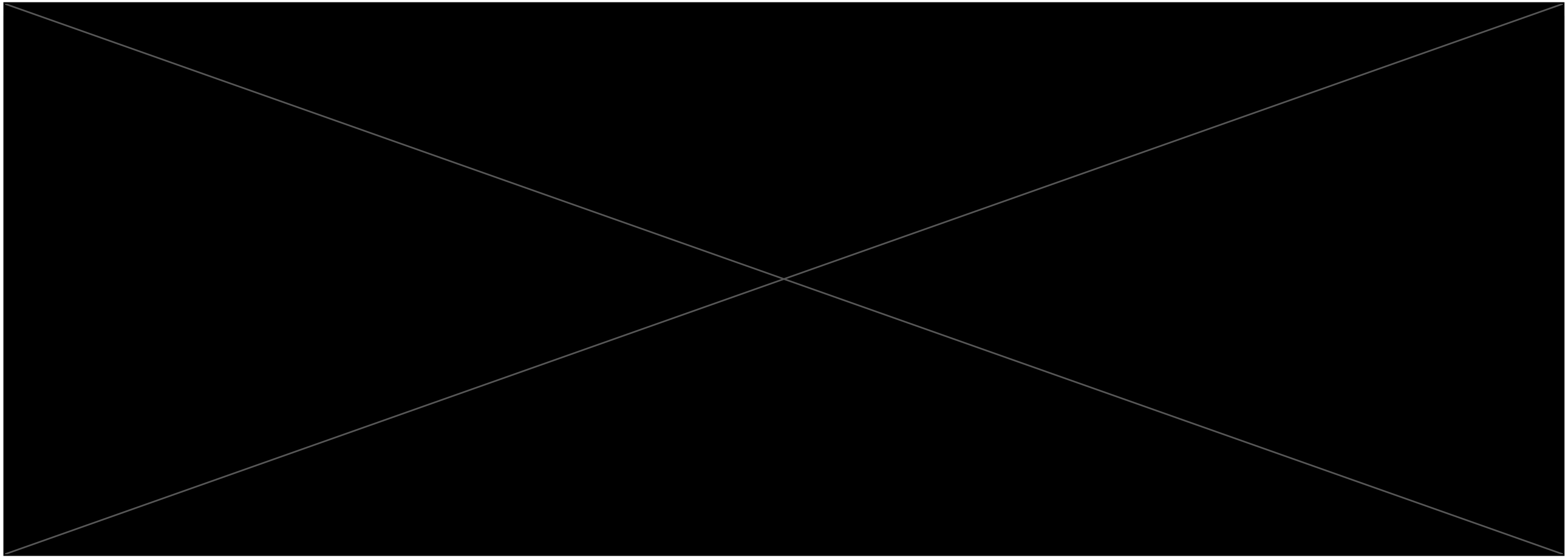


DISCLAIMER

- Preliminary, first-pass analysis with simplifications
- Estimates will change as analysis is refined
- Sharing to give a **birds-eye-view** of how results differ by donation, season, region, and year.

Expected WNV transmissions by strategy, donation type, and rate of WNV viremia

Cost-effectiveness ratios by strategy, donation type, and rate of WNV viremia



MP-NAT cost-per-QALY **during transmission season** by year, region, donation type

MP-NAT cost-per-QALY **outside transmission season** by year, region, donation type

[redacted]

Limitations (which apply to all TTID cost-effectiveness analyses I know of)

Captures cost per direct benefit (health gains/risks averted for patients receiving screened blood)

Ignores **value of information** gained from testing

Historic estimates are not directly applicable for planning

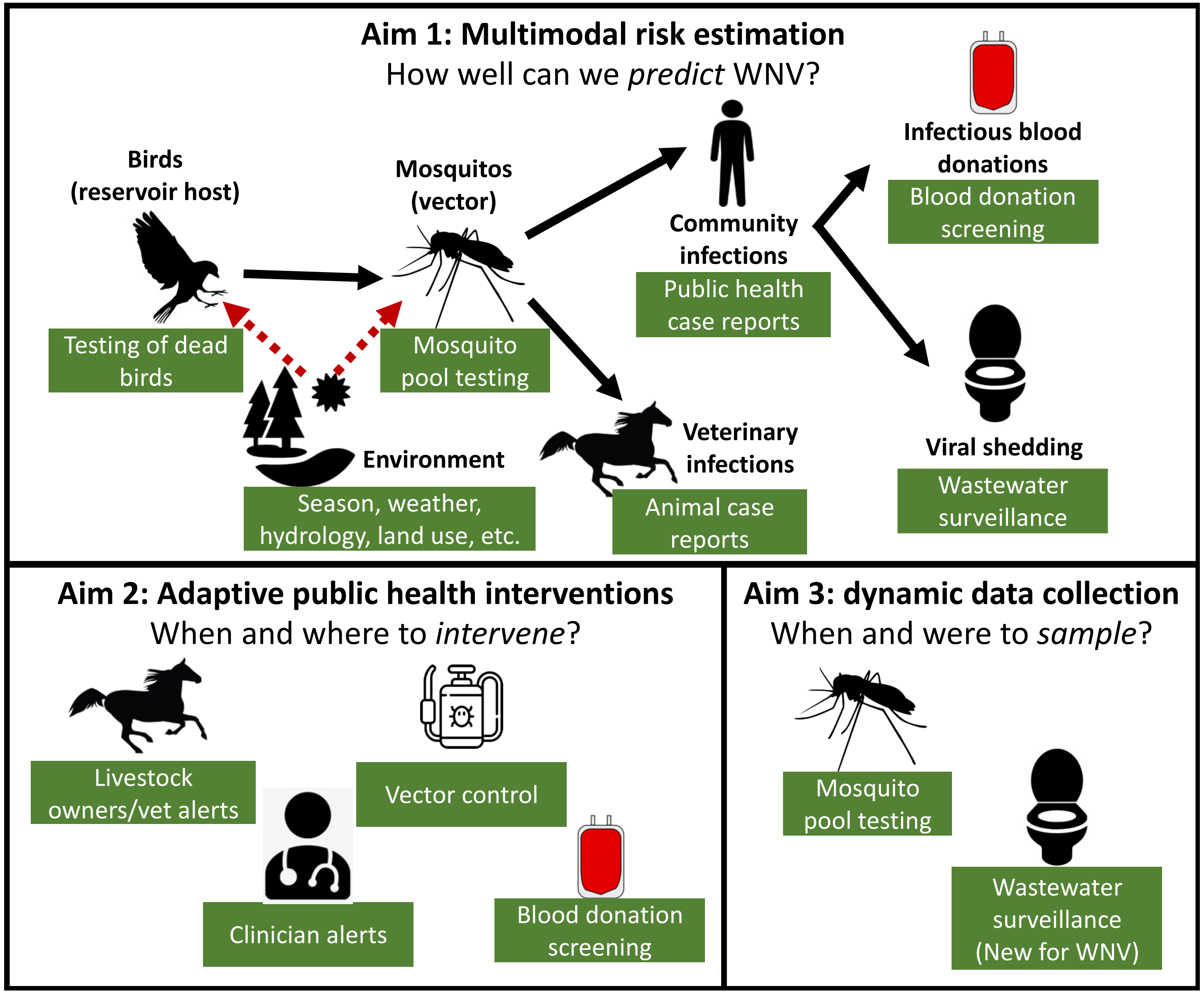
What if the epidemiology is different this year?

Final thoughts

- Transfusion-transmitted infection prevention routinely exceeds typical cost-effectiveness thresholds
  - Perhaps justified — partially.
- Decision analyses often ad hoc, researcher initiated, and underappreciated by policymakers
  - Could be co-developed with policymakers
- Risk (and, therefore, cost-effectiveness) highly variable
  - Integrating risk prediction + decision analysis might better inform public health planning

Future work: Dynamic arbovirus surveillance and mitigation

Combine **probabilistic forecasting model** and **decision-analytic modelling** to enable adaptive public health planning

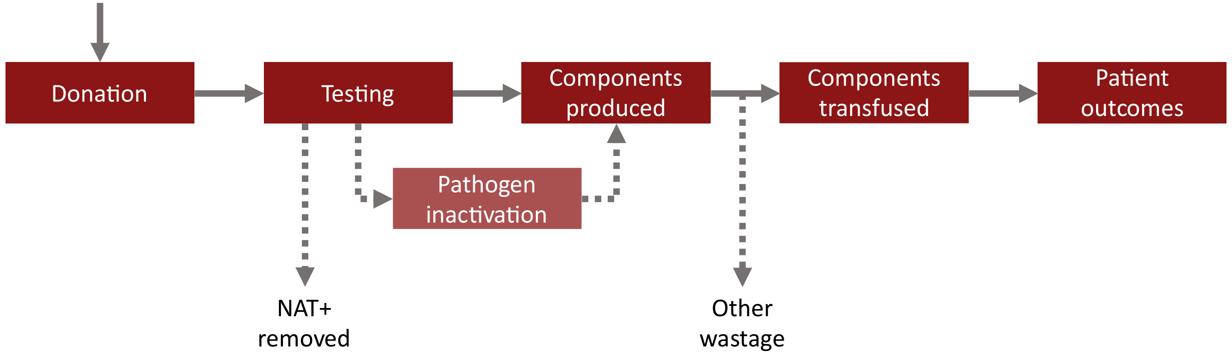


Seed grant from

McGill | GLOBAL HEALTH PROGRAMS

M[i][4] Interdisciplinary Initiative in Infection and Immunity

Thank you!



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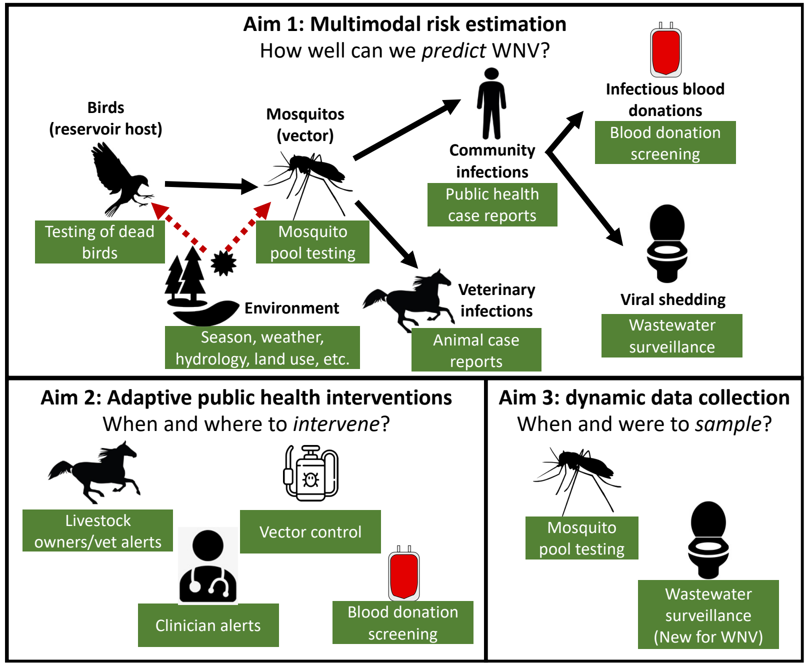
- Ethan McNally
- Supun Manathunga

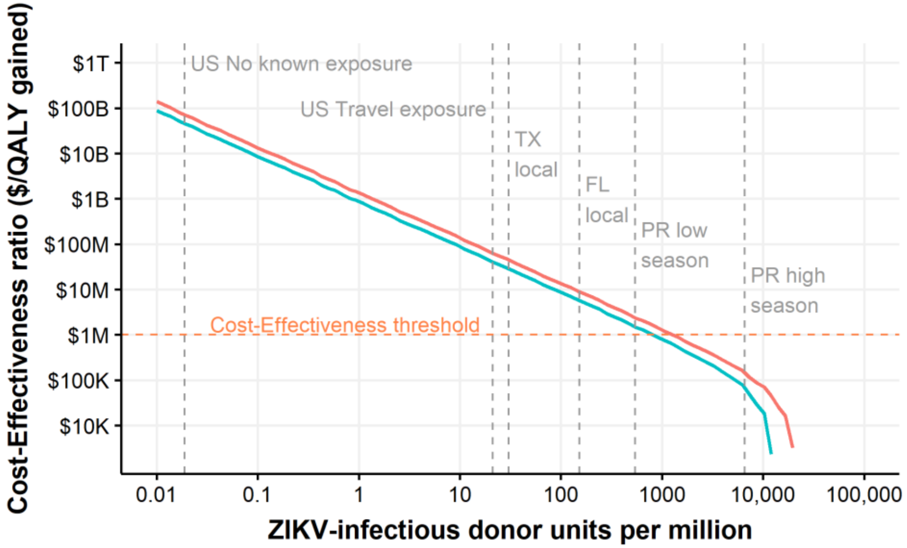
Vitalant

- Brian Custer
- Mike Busch

Creative Testing Solutions

- Marion Lanteri





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