Cost-effectiveness of live attenuated chikungunya vaccine among adults living in US territories

Kelly Kilburn, PhD, Martin I. Meltzer, PhD, Seonghye Jeon, PhD, Susan L. Hills, MBBS, MTH, Bishwa B. Adhikari, PhD, Nicole P. Lindsey, MS, J. Erin Staples, MD, PhD

June 27th, 2024

National Center for Emerging Zoonotic and Infectious Diseases

Conflicts of Interest Statement

- **Authors have no known conflict of interests**

- **The findings and conclusions in this presentation are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.**

Outline

- Research question
- Methods
- Results
- Sensitivity analyses
- Limitations
- Summary

Research Question

- **What is the cost-effectiveness of using a single dose of the live attenuated chikungunya vaccine among the population aged ≥18 years in US territories* that previously experienced an outbreak of chikungunya?**

*American Samoa, Puerto Rico (PR), and US Virgin Islands (USVI)

Methods

Economic Model

- **Population-based model**
  - Entire population of three US territories in model
- **Time step: 1 year**
- **Analytic time horizon: 30 years starting in 2024**
- **Discount rate: 3%**
- **Perspectives: societal and healthcare payer**
- **One chikungunya outbreak occurring in 2034**

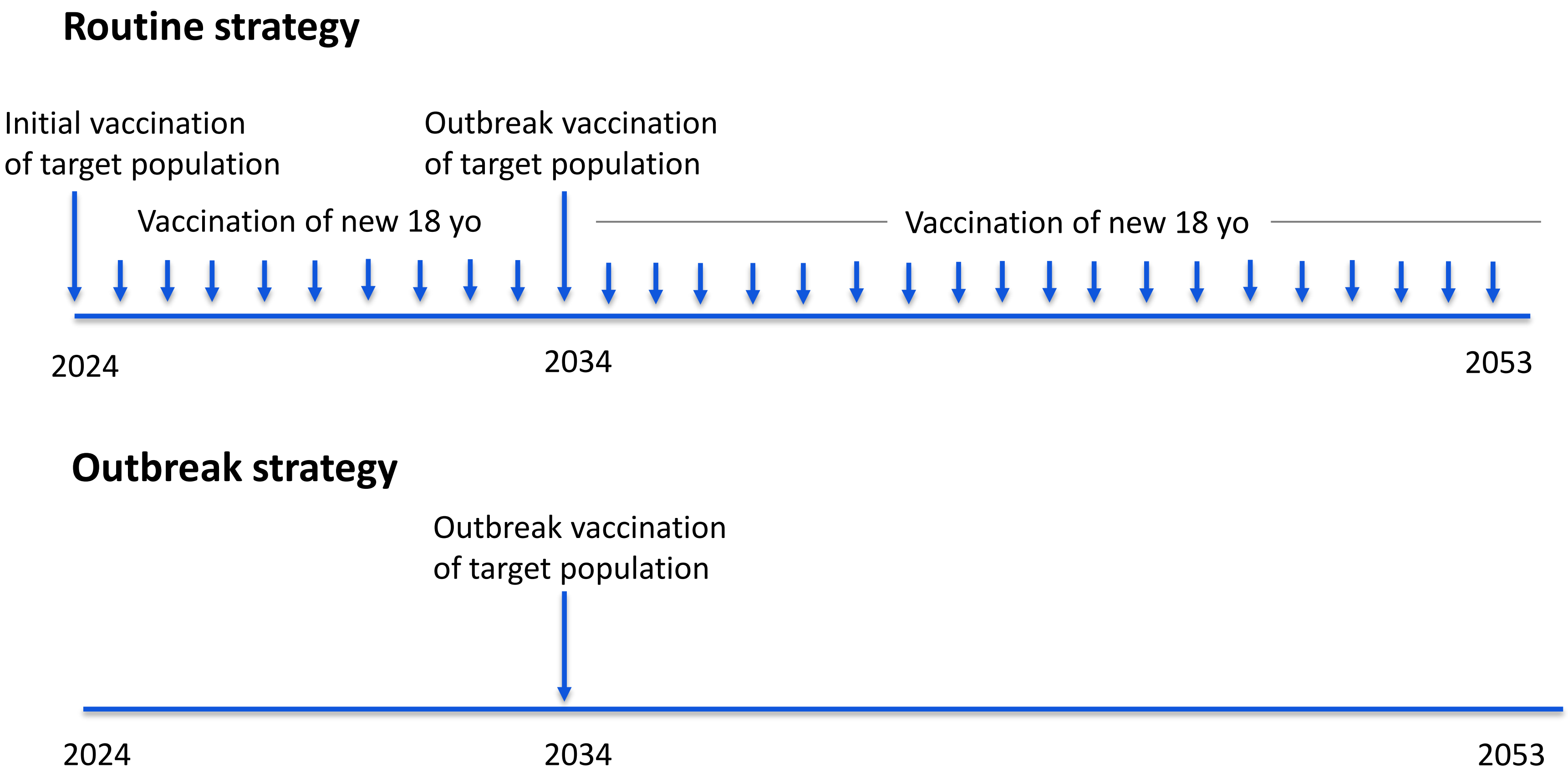
Intervention

- **Use of live-attenuated chikungunya vaccine**

	Strategy 1: Routine Vaccination	Strategy 2: Outbreak Vaccination
Annual Vaccination	Yes	No
Coverage rate[1]	20%	--
Outbreak campaign in 2034	Yes	Yes
Coverage rate[2]	70%[3]	70%

1 Routine coverage rate range based on annual influenza vaccine uptake in Puerto Rico (CDC data)
2 Outbreak coverage rate range based on Covid-19 vaccine uptake in Puerto Rico (CDC data)
3 Total coverage rate for outbreak year considers routine vaccinations from all prior years and vaccinations during outbreak. Individuals are vaccinated only once.

Strategy Comparison



Outcomes

- **Estimated population-level health outcomes**
  - Symptomatic cases
  - Hospitalizations
  - Chronic joint pain cases
  - Deaths
  - Quality-adjusted life-years (QALYs) lost

- **Estimated economic outcomes**
  - Societal costs – vaccination, medical, and lost productivity costs
  - Healthcare payer costs – vaccination and medical costs

Analysis Approach

- **Calculated incremental cost-effectiveness ratios comparing vaccination to no vaccination**
  - Measured as $ per each outcome averted (or QALYs gained)

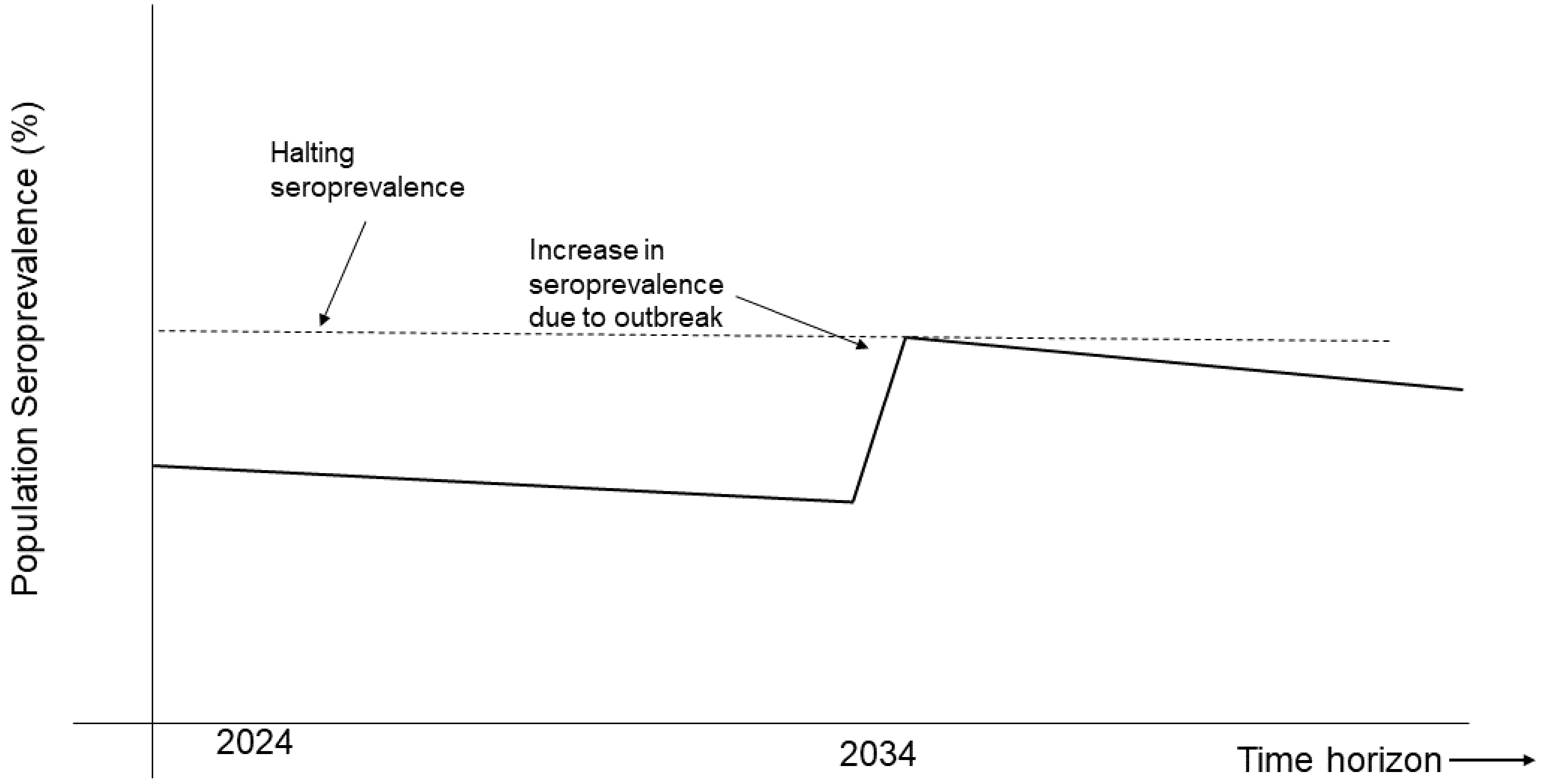
- **Monte Carlo simulation with 1,000 replications to estimate results with 95% CIs using @Risk software**

- **Conducted sensitivity analyses (univariate and scenario)**

Model Assumptions

Lifelong Immunity and Halting Seroprevalence

- **Chikungunya virus infection confers lifetime immunity**
- **Outbreak would stop once certain level of population is infected (halting seroprevalence)**



Model Inputs

Infection Inputs

Variable	Value	Range		Source
		Low	High	
Baseline seroprevalence*	31%	18%	42%	USVI[1] and PR[2] data
% symptomatic among infected	72%	53%	97%	USVI data[1]

USVI – US Virgin Islands; PR – Puerto Rico

* Level of population immunity from prior outbreak in adult population. By 2024, baseline seroprevalence has waned to 28% in population.

1. Hennessey MJ, et al. Amer J Trop Med Hyg, 2018; 99:1321-1321.
2. Adams LE, et al. PLOS NTD. 2022; 16:e0010416-e0010416.

Health Outcome Inputs

Variable	Value	Range		Source
		Low	High	
% care-seeking	43%	30%	82%	USVI data[1]
% hospitalized*	10%	5%	15%	USVI data[1]
% with chronic joint pain⁺	35%	19%	61%	Metanalysis[2]
% death^	1%	0.1%	3%	PR data[3]

USVI – US Virgin Islands, PR – Puerto Rico

* of those seeking care

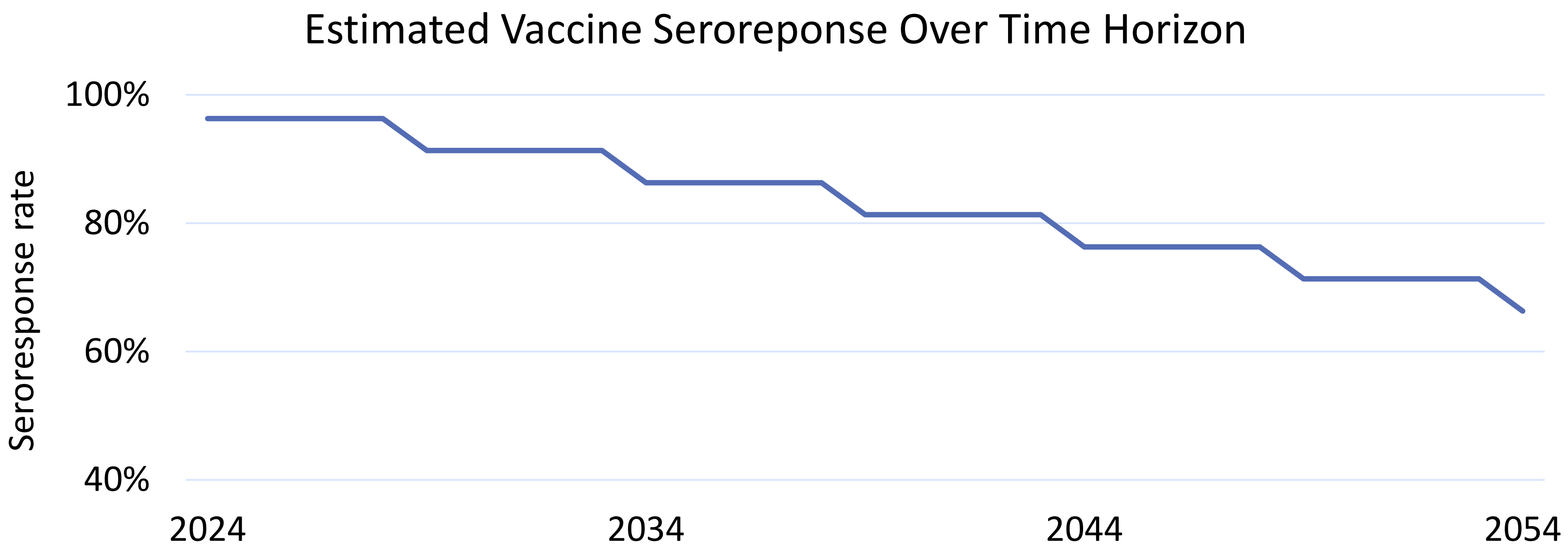
⁺ 6 months after infection

^ of those hospitalized

1 Hennessey MJ, et al. Amer J Trop Med Hyg, 2018; 99:1321-1321.; Hennessey MJ, et al. Centers for Disease Control and Prevention, 2015.
2 Lindsey NP. ACIP presentation. 2023
3 Sharp TM, et al. J Infect Dis. 2016; 214: S475-S481

Vaccine Seroresponse

- **Vaccine seroresponse rate of 96.3% (clinical trial data)[1]**
- **Decay in vaccine seroresponse rate of 5 percentage points every 5 years based on other live attenuated or chimeric vaccines[2]**



1. Schneider M, et al. Lancet. 2023; 401:2138-2147.
2. Lindsey NP, et al. J Travel Medicine. 2018; 25:tay108; Desai KL, et al. Vaccine. 2012; 30:2510-2515.

QALY Inputs

Variable	Time	Weight (range)	QALYs Lost (range)	Source
Non-hospitalized case*^	7 days	0.63 (0.19-0.91)	0.01 (0.002-0.016)	Dengue[1]
Hospitalized case*	14 days	0.56 (0.19-0.91)	0.02 (0.004-0.031)	Dengue[1]
Chronic joint pain case	1 year	0.76 (0.65-0.90)	0.24 (0.10-0.35)	Chikungunya and rheumatoid arthritis[2,3]

QALY – quality-adjusted life-year; QALY losses due to death are included and include loss beyond time horizon of model
*Weights for acute disease based on dengue; no weights available for chikungunya
^All symptomatic cases had QALY losses regardless of care-seeking behavior

1 Zeng W, et al. Am J Trop Med Hyg. 2018; 99:1458-1465.
2 Couzigou B, et al. Am J Trop Med Hyg. 2018; 99:182-190.
3 Sorensen J, et al. Value Health. 2012; 15:334-339

Sensitivity Analyses Methods

Sensitivity Analyses

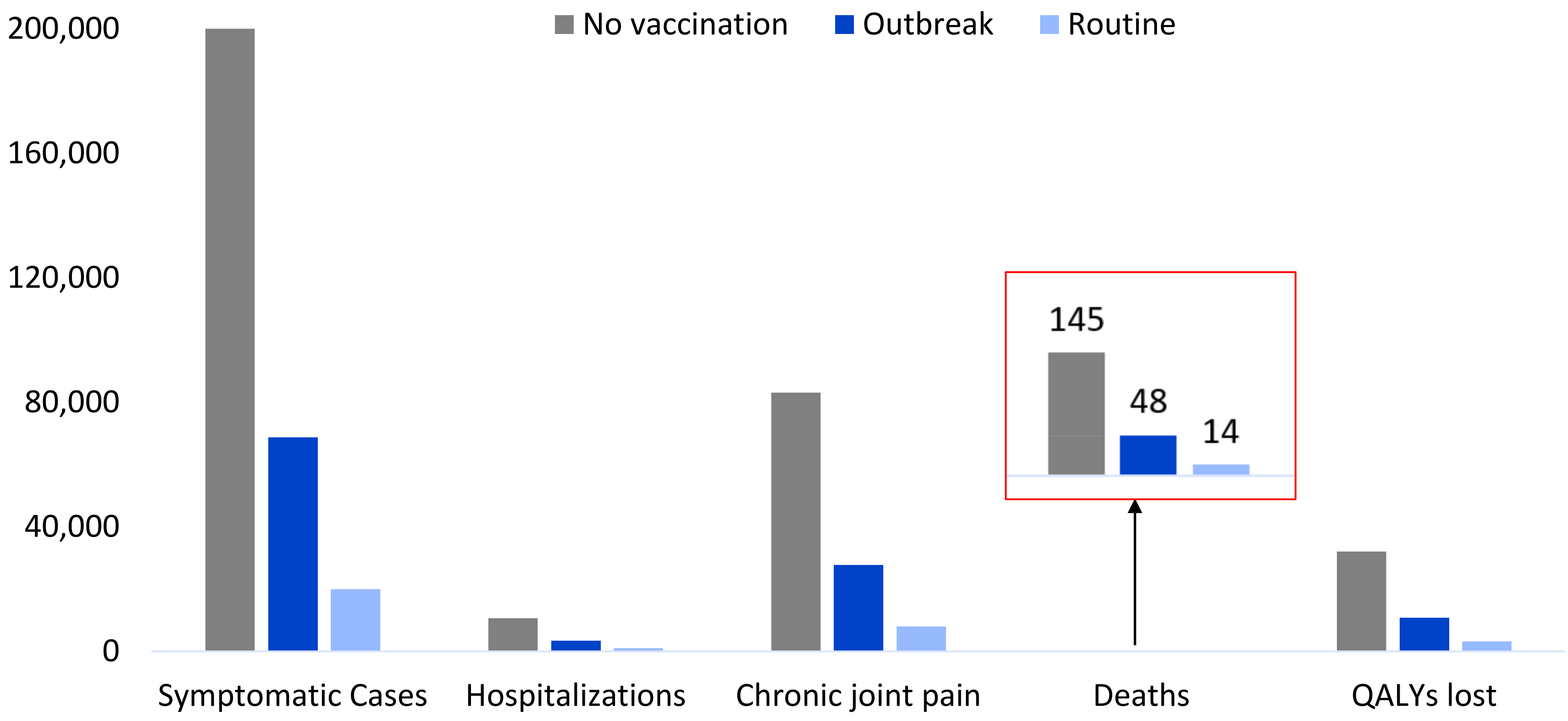
- **Univariate (one-way) analysis**
  - Varied one parameter at a time and calculated mean $/QALY gained using low (1%) and high (99%) values of input distributions
- **Scenario analyses**
  - Altered year of outbreak to 2029 or 2039 (base: 2034)
  - Altered halting seroprevalence to 30%[1] or 80%[2] (base: 40%)
  - Altered vaccination coverage
    - Routine 10% or 30% (base: 20%)
    - Outbreak 50% or 85% (base: 70%)

1 Hennessey MJ, et al. Amer J Trop Med Hyg, 2018; 99:1321-1321 & Adams LE, et al. PLOS NTD. 2022; 16:e0010416-e0010416
2 Jamaican MoH. JHLSIII, 2018

Results

Heath Outcomes

- **Outbreak strategy averts 67% of health outcomes**
- **Routine strategy averts 90% of health outcomes**



Vaccination Doses and Costs*

- **More doses delivered in routine strategy during 30-year time horizon than outbreak strategy**

- **Base scenario vaccination costs**
  - **Routine strategy**: $436 million
  - **Outbreak strategy**: $356 million

*Vaccination costs include vaccines, administration, and adverse event costs
All costs converted to 2023 $US

Total Costs

Outcome	Strategy	Total costs, No vaccine (millions)	Total costs, Vaccine (millions)	Difference
Societal Costs*	Routine	$566	$496	-12%
	Outbreak	$566	$547	-3%
Healthcare Payer Costs^	Routine	$269	$465	73%
	Outbreak	$269	$449	67%

All costs converted to 2023 $US

* Societal costs include vaccination costs, direct medical costs, and indirect costs due to lost productivity.

^ Healthcare payer costs include vaccination costs and direct medical costs.

Cost-effectiveness, Societal Perspective

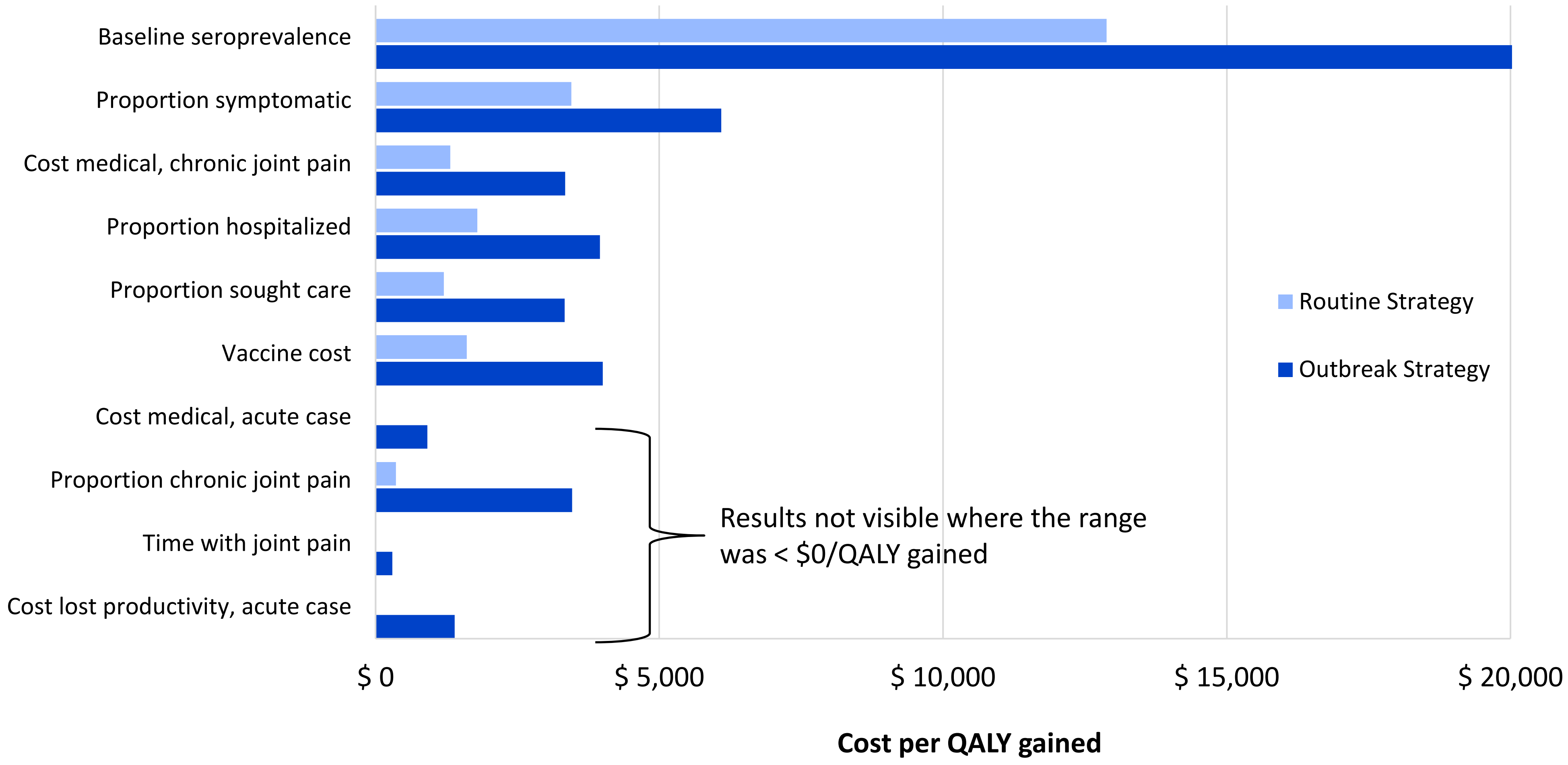
	Symptomatic Case	Hospitalization	Chronic joint pain case	Death	QALY gained
	Mean cost per outcome averted [95% CI]				
Routine Strategy	Cost savings	Cost savings	Cost savings	Cost savings	Cost savings
Outbreak Strategy	Cost savings	$2,315 [$1K, $4K]	$5 [Cost savings, $200]	$373,054 [$173K, $573K]	$59 [Cost savings, $1K]

Sensitivity Analyses Results*

*Presented from societal perspective

Univariate Sensitivity Analysis, Routine Strategy

Top 10 influential inputs, ranked by impact to mean $/QALY gained



Sensitivity Analysis for Outbreak Timing*

	Routine strategy	Outbreak strategy
	Mean $/QALY gained [95% CI]	
Outbreak occurs in 2029	Cost savings	$3,829 [$3K, $4.6K]
Outbreak occurs in 2039	Cost savings	Cost savings

*Base scenario had outbreak occurring in 2034

Scenario Analysis Varying Halting Seroprevalence and Vaccination Coverage*

- **30% halting seroprevalence: all scenarios have net positive costs**
  - **Low vaccination** has the lowest cost per QALY gained
- **40% halting seroprevalence (base value): high vaccination has net costs, base and low vaccination result in cost savings**
  - **Low vaccination** has the lowest cost per QALY gained
- **80% halting seroprevalence: all scenarios result in cost savings**
  - **High vaccination** has lowest cost per QALY gained

*Vaccination Coverage Rates:
Base vaccination= 20% routine, 70% outbreak; Low vaccination= 10% routine, 50% outbreak; High vaccination= 30% routine, 85% outbreak

Limitations and Summary

Limitations

1. No efficacy or effectiveness data available for current vaccine; data planned to be generated in post-licensure studies

2. Limited evidence on outbreak frequency (i.e., when and how many) in same geographical locations

3. QALY health utility weights mostly from dengue as proxy since no weights determined for acute chikungunya

Summary

- Chikungunya vaccine use in US territories would avert 67-90% of cases and associated health outcomes versus no vaccination
- Cost of intervention would range from $356 to $436 million depending on strategy used
- Routine strategy had cost savings for each outcome while outbreak strategy had mostly net positive costs in base scenario
- Results most affected by baseline and halting seroprevalence

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov