National Center for Emerging and Zoonotic Infectious Diseases

# Tools for Eliminating Dog-Mediated Human Rabies: Designing Effective Dog Vaccination Programs

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**Lead, Rabies Epidemiology Unit**
**CDC Poxvirus and Rabies Branch**

# Evolution of a Dog Vaccination Program

- **3 phases**
  1. Preparation
  2. Scale-up
  3. Sustainability

**Elimination of Dog-Mediated Human Rabies Deaths by 2030: Needs Assessment and Alternatives for Progress Based on Dog Vaccination**

Ryan M. Wallace*, Eduardo A. Undurraga, Jesse D. Blanton, Julie Cleaton and Richard Franka

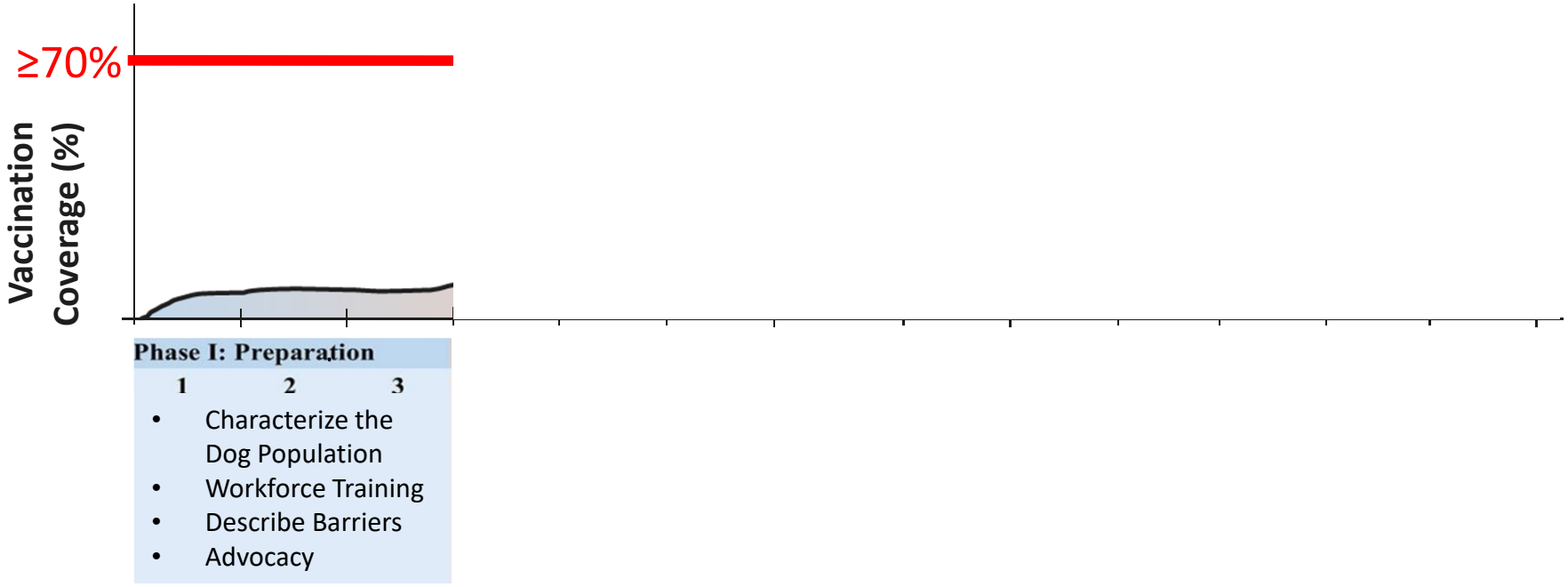
National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, GA, USA

caninerabiesblueprint.org

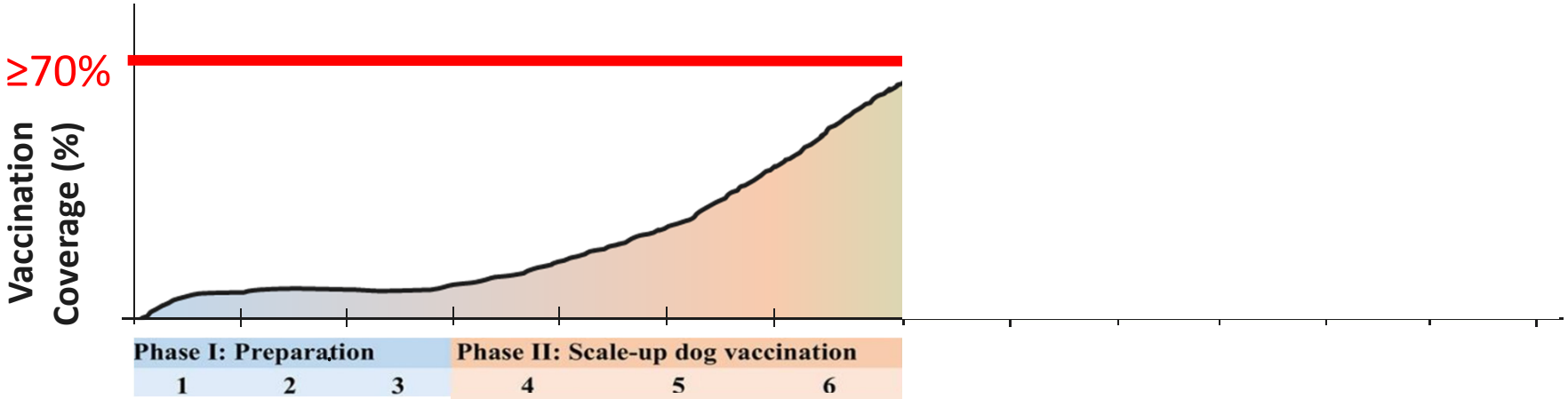
a blueprint for the control of rabies in dog populations

Wallace RM, et al. Elimination of Dog-Mediated Human Rabies Deaths by 2030: Needs Assessment and Alternatives for Progress Based on Dog Vaccination. Front Vet Sci. 2017;4:9.

# Evolution of Dog Vaccination Programs: Early Years

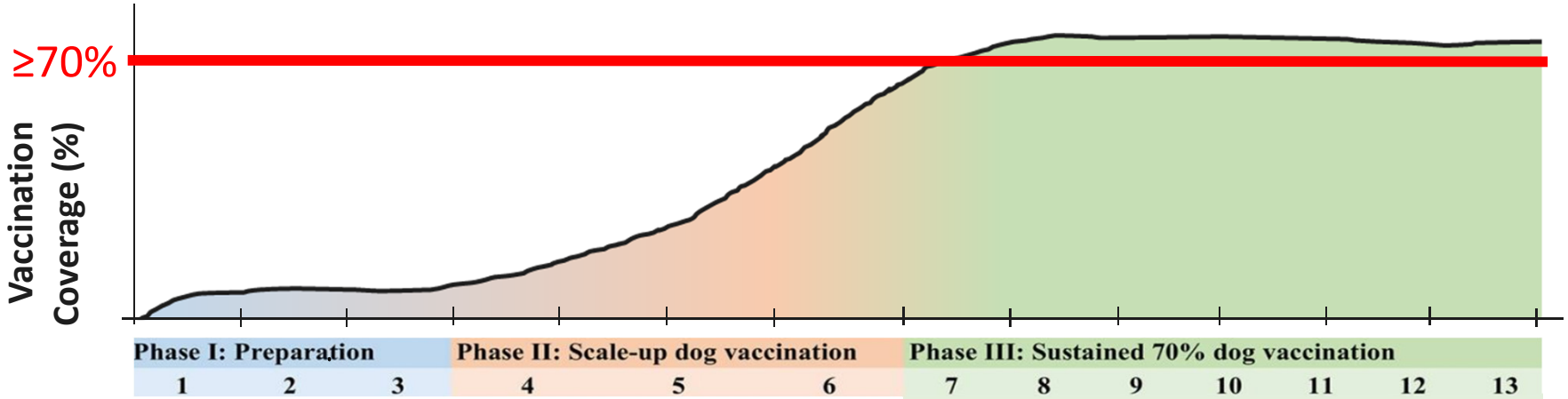


# Evolution of Dog Vaccination Programs: Middle Years



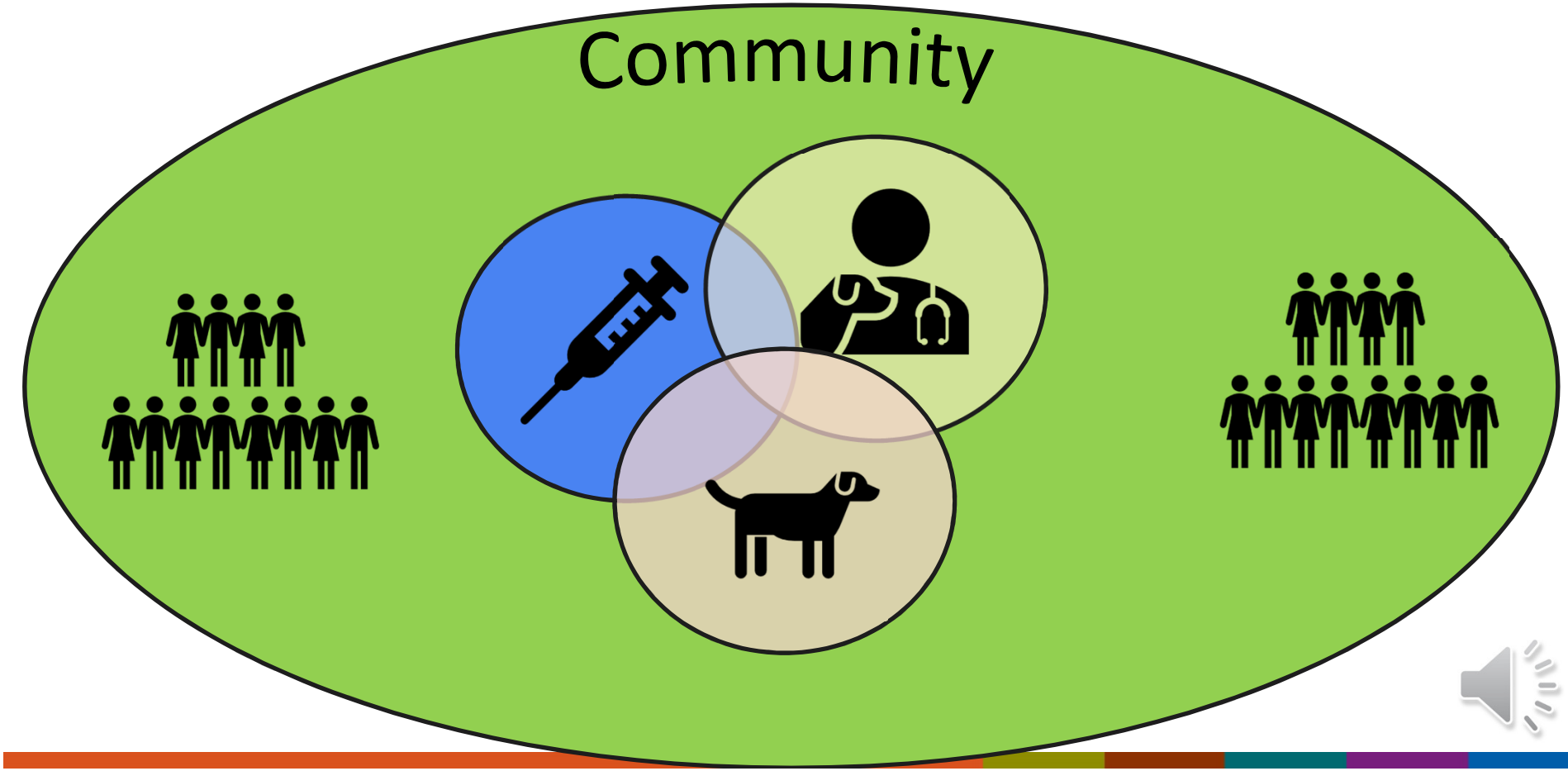

- Testing Vaccination Methods
- Developing Cost-Effective Vaccination Programs
- Scaling Up Sustainable Vaccination Programs

# Evolution of Dog Vaccination Programs: Later Years



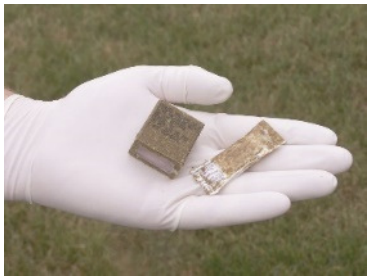

- Maintaining High Levels of Dog Vaccination until Cases are Eliminated
- Implementing Surveillance Systems to Establish Disease Burden
- Implementing Programs to Prevent Incursion

# Vaccines, Vaccinators, and Dogs



Parenteral Vaccines

Oral Vaccines

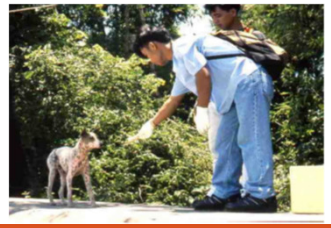


Central Point

Door to Door

Capture/Vaccinate/Release

Oral Vaccination



Confined

Semi-Confined

Community

Feral

Parenteral Vaccines

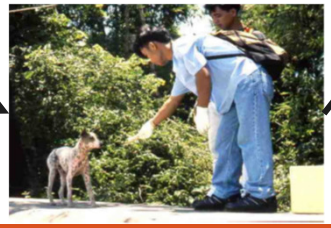
Oral Vaccines

Central Point

Door to Door

Capture/Vaccinate/Release

Oral Vaccination



Confined

Semi-Confined

Community

Feral

Parenteral Vaccines

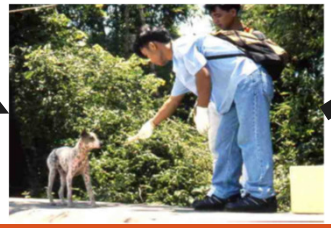
Oral Vaccines

Central Point

Door to Door

Capture/Vaccinate/Release

Oral Vaccination



Confined

Semi-Confined

Community

Feral

Parenteral Vaccines

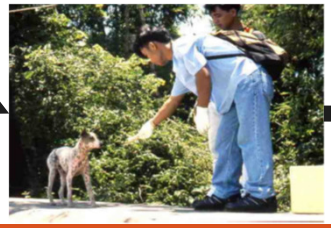
Oral Vaccines

Central Point

Door to Door

Capture/Vaccinate/Release

Oral Vaccination

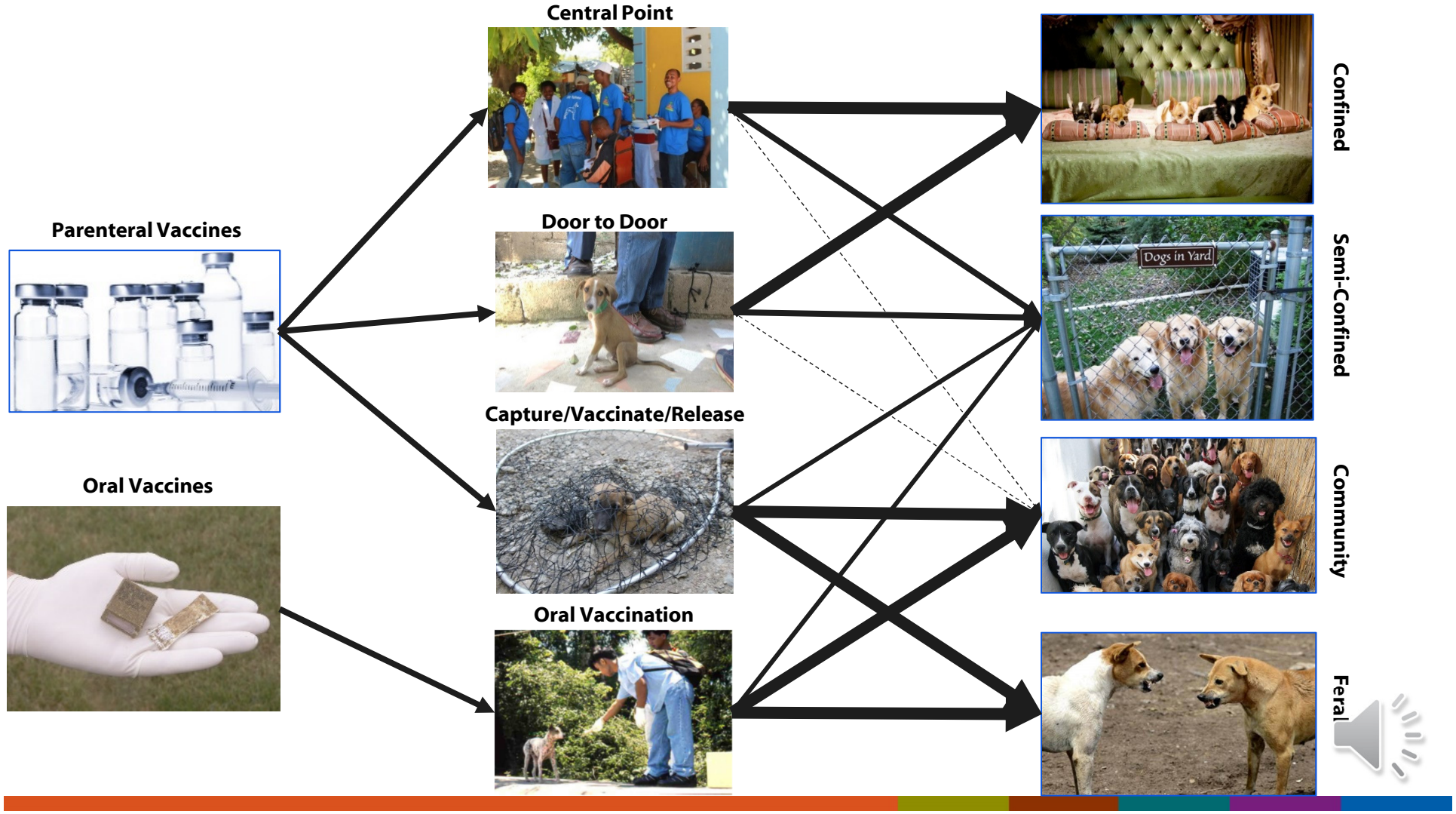


Confined

Semi-Confined

Community

Feral


Central Point
Door to Door
Capture/Vaccinate/Release
Oral Vaccination
Parenteral Vaccines
Oral Vaccines
Dogs in Yard
Confined
Semi-Confined
Community
Feral

# Vax-PLAN: A guide for designing effective vaccination

## Planning aid for the implementation of dog vaccination campaigns

### Input: Enter Values in White Cells

| 1. Describe the confinement of the dog population in the program area. | Number of Dogs | % |
|---|---|---|
| How many dogs are in the program area? | 600,000 | 100.0% |
| What proportion are **always** under owner confinement? | 60,000 | 10.0% |
| What proportion are only **sometimes** under owner confinment?* | 360,000 | 60.0% |
| What proportion are **always** free-roaming? | 180,000 | 30.0% |

| 2. Provide the number of vaccines you plan to procure. | Doses Procured | % |
|---|---|---|
| How many **parenteral** vaccines will be procured? | 500,000 | 99.0% |
| How many **oral** vaccines will be procured? | 0 | |

| 3. Allocate the vaccines to a vaccination strategy. | Doses Procured | % |
|---|---|---|
| What proportion of vaccines will be allocated to **Central Point** vaccination? | 165,000 | 33.0% |
| What proportion of vaccines will be allocated to **Door to Door** vaccination? | 165,000 | 33.0% |
| What proportion of vaccines will be allocated to **Capture, Vaccinate, Release**? | 165,000 | 33.0% |
| Proportion of vaccines allocated to **Oral** vaccination | 0 | 0.0% |

| 4. Describe the efficacy of the vaccines you have procured. | Percent Efficacious (%) |
|---|---|
| What is the efficacy of the **parenteral** vaccine? | 100% |
| What is the efficacy of the **oral** vaccine? | 100% |

| 5. Expected Vaccination Effectiveness by Method § | Vaccination strategy** | | | |
|---|---|---|---|---|
| **Confinement status:** | CPV | DDV | CVR | ORV |
| What is the expected coverage among dogs that are **always** confined? | 80% | 80% | 5% | 5% |
| What is the expected coverage among dogs that are only **sometimes** confined? | 60% | 60% | 80% | 80% |
| What is the expected coverage among dogs that are **never** confined? | 5% | 5% | 60% | 80% |

| 6. How confident are you in your responses to the input variables? | 5 |
|---|---|

### OPTIONAL: Suggested values for vaccination strategy table

| What is your current estimated program area vaccination coverage? | 45% | | | |
|---|---|---|---|---|
| **GDREP§ phase:** | Phase II b | | | |
| **Suggested values:** | CPV | DDV | CVR | ORV |
| Always confined | 80% | 80% | 5% | 5% |
| Semi-confined | 60% | 60% | 80% | 80% |
| Never confined | 5% | 5% | 60% | 80% |

**Vaccination campaign costs per vaccinated dog†**

Click button to estimate the average cost per dog vaccinated

Estimate value

### Results: calculated values

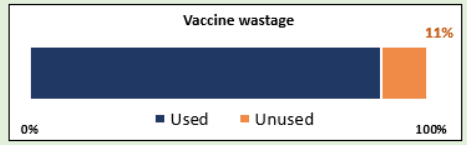
| Vaccination Doses by Strategy | Abbreviation | Procured | Used | Unused |
|---|---|---|---|---|
| Central Point Vaccination | CPV | 165,000 | 165,000 | - |
| Door to Door Vaccination | DDV | 165,000 | 108,000 | 57,000 |
| Capture, Vaccinate, Release | CVR | 165,000 | 165,000 | - |
| Oral Vaccine Handouts | ORV | - | - | - |

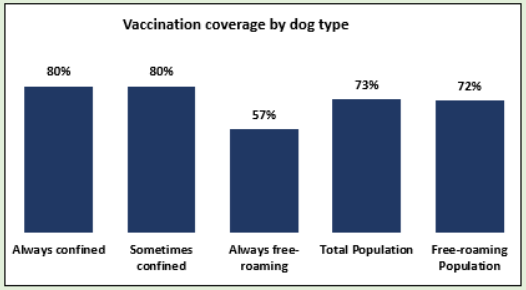
| Vaccination doses by dog type | Vaccinated | Unvaccinated | Percent | Confidence Lower | Confidence Upper | Immunized |
|---|---|---|---|---|---|---|
| Always confined | 48,000 | 12,000 | 80% | 74% | 86% | 80% |
| Sometimes confined | 288,000 | 72,000 | 80% | 74% | 86% | 80% |
| Always free-roaming | 102,000 | 78,000 | 57% | 51% | 63% | 57% |

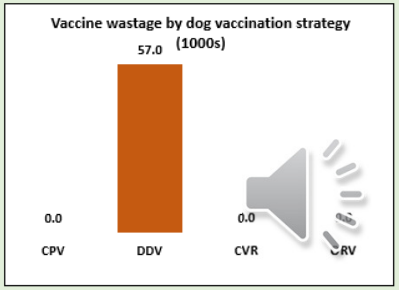
| Vaccination coverage by dog type | Dogs | Immunized | Percent | Confidence Lower | Confidence Upper | Immunized |
|---|---|---|---|---|---|---|
| Total Population | 600,000 | 438,000 | 73% | 67% | 79% | 73% |
| Free-roaming Population | 540,000 | 390,000 | 72% | 66% | 78% | 72% |

| Vaccine utilization | Procured | Used | Unused | Lower | Upper |
|---|---|---|---|---|---|
| | 500,000 | 88% | 11% | 5% | 20% |

| Economic costs | Total ($) |
|---|---|
| Cost per dog vaccinated | $ 3.01 |
| Total Campaign Cost | $ 1,318,656 |
| Lower bound | $ 833,856 |
| Upper bound | $ 1,811,743 |



# Campaign Costing Guide

## 9. Costs per dog vaccination campaign

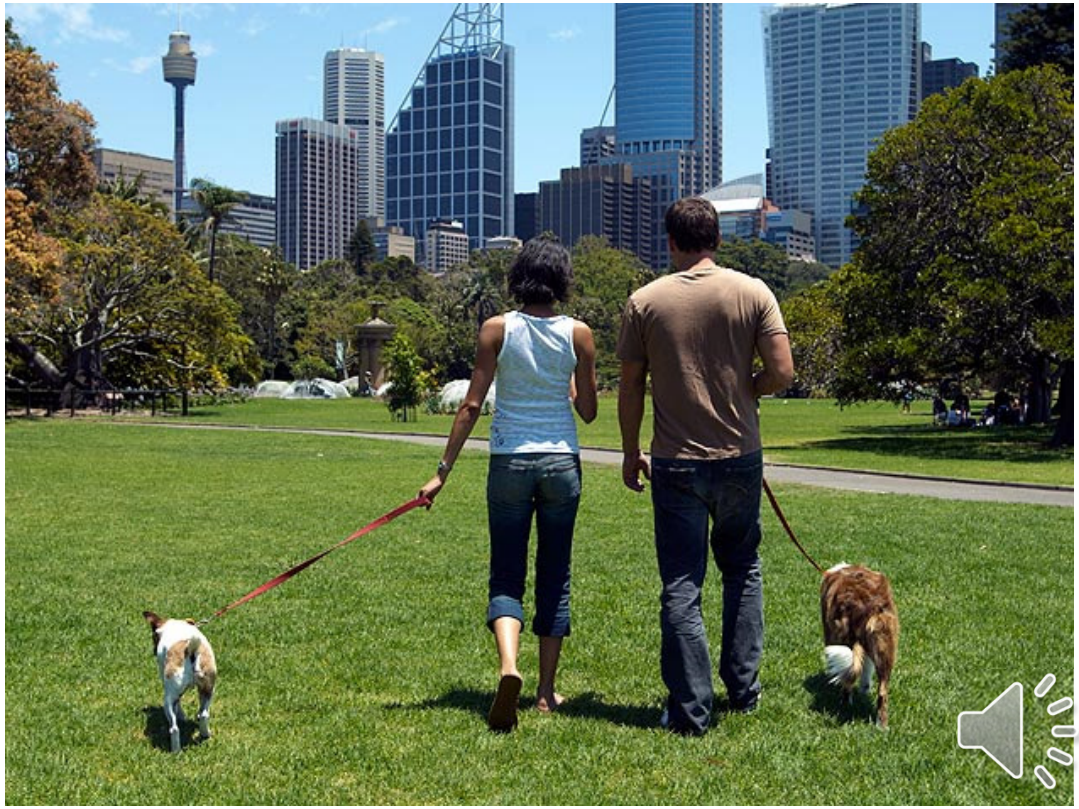
| Summary of dog vaccination costs (per dog vaccinated) | Total | | |
|---|---|---|---|
| | Lower bound | Average | Upper bound |
| **Average cost per dog vaccinated (calculated using worksheet)** | **$ 1.40** | **$ 2.10** | **$ 2.69** |
| | | | |
| **Total dogs vaccinated in pilot campaign** | | | **4,000** |
| Human resources | $ 0.10 | $ 0.14 | $ 0.18 |
| Human vaccines / PEP | $ 0.03 | $ 0.05 | $ 0.07 |
| Transport costs | $ 0.01 | $ 0.20 | $ 0.27 |
| Awareness campaign | $ 0.73 | $ 1.00 | $ 1.28 |
| Equipment | $ 0.07 | $ 0.09 | $ 0.12 |
| Dog vaccines (consumables) | $ 0.46 | $ 0.61 | $ 0.77 |

| Item | Units | Work days | Price/Unit | | | Total cost | | |
|---|---|---|---|---|---|---|---|---|
| | | | Lower | Average | Upper | Lower bound | Average | Upper bound |
| **Workers participating in campaign (per diem)** | | | | | | **$ 409** | **$ 562** | **$ 714** |
| Program manager | 0 | 5 | $12.00 | $18.00 | $24.00 | $ - | $ - | $ - |
| Informational supervisor | 1 | 5 | $12.00 | $18.00 | $24.00 | $ 60 | $ 90 | $ 120 |
| Vaccination supervisor (1 per 25,000 dogs) | 0.2 | 5 | $8.00 | $10.00 | $12.00 | $ 8 | $ 10 | $ 12 |
| Central Point technician | 7 | 5 | $6.00 | $8.00 | $10.00 | $ 211 | $ 282 | $ 352 |
| Door to Door technician | 2 | 5 | $7.00 | $10.00 | $13.00 | $ 62 | $ 88 | $ 114 |
| Capture/Vax/Release technician | 0 | 5 | $7.00 | $10.00 | $13.00 | $ - | $ - | $ - |
| ORV technician | 0 | 5 | $6.00 | $8.00 | $10.00 | $ - | $ - | $ - |
| Driver | 0.4 | 5 | $4.00 | $6.00 | $8.00 | $ 8 | $ 12 | $ 16 |
| Other Personnel | 2 | 5 | $6.00 | $8.00 | $10.00 | $ 60 | $ 80 | $ 100 |
| | | | | | | | | |
| **Transportation** | | | | | | **$ 55** | **$ 805** | **$ 1,080** |
| Government vehicle (including gasoline) | 0 | 5 | $10.00 | $15.00 | $20.00 | $ - | $ - | $ - |
| Other vehicle (ie rental, purchase, other) | 0.4 | 5 | $10.00 | $15.00 | $20.00 | $ 20 | $ 750 | $ 1,000 |
| Gasoline | 0.4 | 5 | $10.00 | $15.00 | $20.00 | $ 20 | $ 30 | $ 40 |
| Maintenance vehicle | 1 | 5 | $3.00 | $5.00 | $8.00 | $ 15 | $ 25 | $ 40 |
| Public transport | 0 | 5 | $1.30 | $1.60 | $1.90 | $ - | $ - | $ - |
| | | | | | | | | |
| **Awareness campaign** | | | | | | **$ 2,912** | **$ 4,014** | **$ 5,116** |
| Media (e.g. posters) | 5,000 | N/A | $0.48 | $0.60 | $0.72 | 2,400 | 3,000 | 3,600 |
| Air time (radio, car with speakers, etc.) | 0.2 | 2 | $30.00 | $35.00 | $40.00 | 12 | 14 | 16 |
| Other costs | 1 | N/A | $500.00 | $1,000.00 | $1,500.00 | 500 | 1,000 | 1,500 |
| | | | | | | | | |
| **Equipment** | | | | | | **$ 384** | **$ 573** | **$ 760** |
| Tables | 1 | N/A | $31.00 | $45.00 | $54.00 | $ 36 | $ 53 | $ 63 |
| Coolers | 4 | N/A | $15.00 | $18.00 | $21.00 | $ 66 | $ 79 | $ 92 |
| Dog handling (e.g., muzzles) | 0 | N/A | $0.00 | $0.00 | $0.00 | $ - | $ - | $ - |
| CVR Kit | 0 | N/A | $250.00 | $500.00 | $750.00 | $ - | $ - | $ - |
| First-aid | 4 | N/A | $5.00 | $7.00 | $10.00 | $ 22 | $ 31 | $ 44 |
| Central Vaccine Storage | 1 | 7 | $20.00 | $30.00 | $40.00 | $ 140 | $ 210 | $ 280 |
| CP/DD Bite PEP (1 in 2,000) | N/A | 2 | $60.00 | $100.00 | $140.00 | $ 120 | $ 200 | $ 280 |

# Example 1: High Income, Urban Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 80% confined
  - 20% semi-confined
- Vaccinators
  - 50 dogs per day
- Method
  - 20% Central Point
  - 80% CVR
- 4,000 Vaccines



# Example 1a: High Income, Urban Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 80% confined
  - 20% semi-confined
- Vaccinators
  - 50 dogs per day
- Method
  - 20% Central Point
  - 80% CVR
- 4,000 Vaccines

**CAMPAIGN RESULTS**

- Vaccination Coverage
  - Total: **32%**
  - Free Roaming Dogs: **80%**
  - Vaccine Wastage: **2,400 doses**
- Campaign Costs
  - Total Cost: **$10,844**
  - Cost per Dog: **$6.78**

# Example 1b: High Income, Urban Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 80% confined
  - 20% semi-confined
- Vaccinators
  - 50 dogs per day
- Method
  - 80% Central Point
  - 20% CVR
- 4,000 Vaccines

**CAMPAIGN RESULTS**

- Vaccination Coverage
  - Total: **80%**
  - Free Roaming Dogs: **80%**
  - Vaccine Wastage: **0 doses**
- Campaign Costs
  - Total Cost: **$11,790**
  - Cost per Dog: **$2.98**

# Example 2: Low Income, Urban Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 10% confined
  - 40% semi-confined
  - 50% community
- Vaccinators
  - 50 dogs per day
- Method
  - 80% Central Point
  - 20% CVR

# Example 2b: Low Income, Urban Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 10% confined
  - 40% semi-confined
  - 50% community
- Vaccinators
  - 50 dogs per day
- Method
  - 20% Central Point
  - 80% CVR

**CAMPAIGN RESULTS**

- Vaccination Coverage
  - Total: **70%**
  - Free Roaming Dogs: **69%**
  - Vaccine Wastage: **500 doses**
- Campaign Costs
  - Total Cost: **$20,781**
  - Cost per Dog: **$5.94**

# Example 2c: Low Income, Urban Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 10% confined
  - 40% semi-confined
  - 50% community
- Vaccinators
  - 50 dogs per day
- Method
  - 20% Central Point
  - 80% Oral Vaccines

**CAMPAIGN RESULTS**

- Vaccination Coverage
  - Total: **80%**
  - Free Roaming Dogs: **80%**
  - Vaccine Wastage: **0 doses**
- Campaign Costs
  - Total Cost: **$12,065**
  - Cost per Dog: **$3.02**

# Example 3: Rural Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 10% confined
  - 90% semi-confined
- Vaccinators
  - 50 dogs per day
- Method
  - 80% Central Point
  - 20% Door to Door

# Example 3a: Rural Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 10% confined
  - 90% semi-confined
- Vaccinators
  - 50 dogs per day
- Method
  - 80% Central Point
  - 20% Door to Door

**CAMPAIGN RESULTS**

- Vaccination Coverage
  - Total: **62%**
  - Free Roaming Dogs: **60%**
  - Vaccine Wastage: **900 doses**
- Campaign Costs
  - Total Cost: **$7,566**
  - Cost per Dog: **$2.44**

# Example 3b: Rural Community

**CAMPAIGN DESIGN**

- Dog Population
  - 5,000 dogs
  - 10% confined
  - 90% semi-confined
- Vaccinators
  - 100 dogs per day
- Method
  - 80% Central Point
  - 20% Door to Door

**CAMPAIGN RESULTS**

- Vaccination Coverage
  - Total: **80%**
  - Free Roaming Dogs: **78%**
  - Vaccine Wastage: **0 doses**
- Campaign Costs
  - Total Cost: **$8,397**
  - Cost per Dog: **$2.10**

# Where to find this tool?

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6805755/
  - Published in Epidemiology and Infection, 2019
- Contact the Co-Authors with questions or updated versions:
  - Ryan Wallace – CDC: EUK5@cdc.gov
  - Andy Gibson – Mission Rabies: andy@missionrabies.com
- Online at: https://rabiestaskforce.com/toolkit/vaxplan

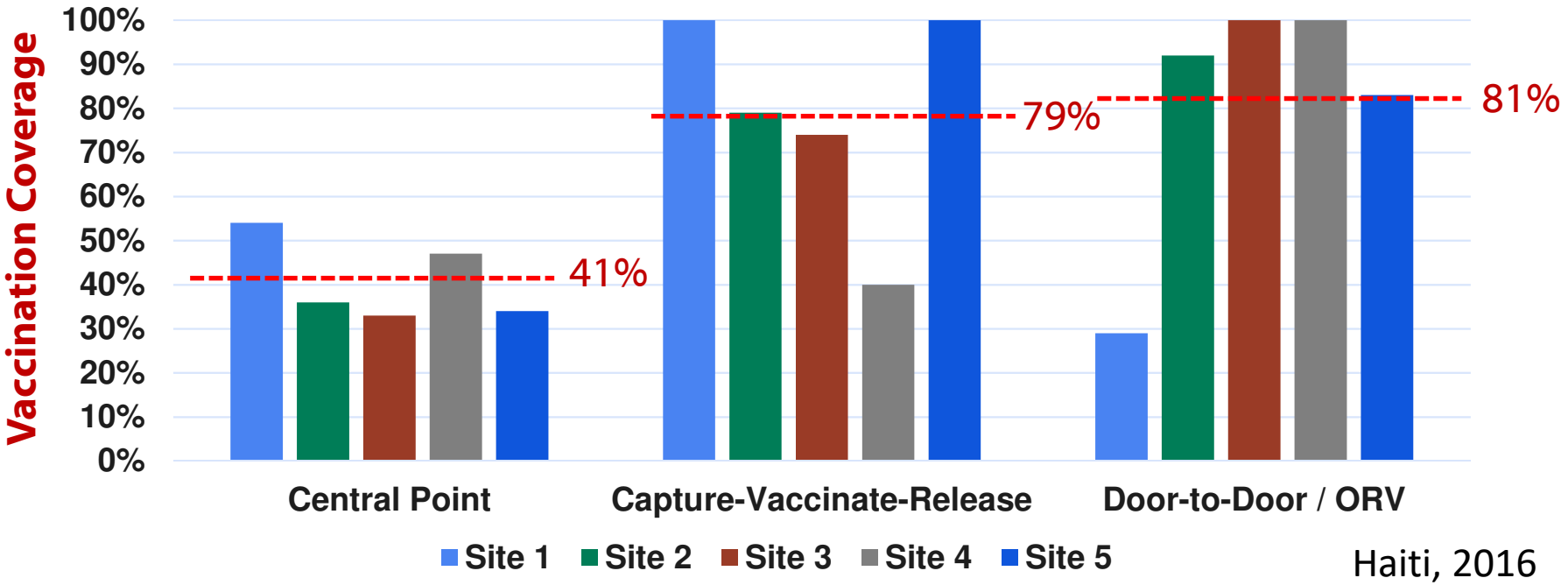
# Summary

- Vax-PLAN was validated against 13 international campaigns, and show to be highly accurate (see publication)
- In most settings, dog populations are diverse, necessitating a mixed-methods approach and well-trained vaccination staff
- Community support for vaccination programs can result in reduced program costs, if less intensive methods can be conducted
- Vaccination programs should be viewed in terms of multiple years, or decades.
  - Year to year planning and budgeting often results in delays or missed vaccination campaigns
- The Vax-PLAN tool can be used at all phases of a vaccination program, both for planning and evaluation

# Acknowledgements


- Mission Rabies
  - Andy Gibson
  - Luke Gamble
- CDC
  - Jesse Blanton
  - Eduardo Undurraga
  - Emily Pieracci
- Humane Society International
  - John Boone
  - Haiti Ministry of Agriculture and Rural Natural Development
  - Mission Rabies Goa Vaccination Team
  - Mission Rabies Malawi Vaccination Team
  - Mission Rabies Sri Lanka Vaccination Team
  - Global Alliance for Rabies Control (Daniel Stewart)

# Phase II: Alternative Vaccination Evaluation




Haiti, 2016

# Phase I: Advocacy

## Summary of results from the analysis: dog vaccination campaign

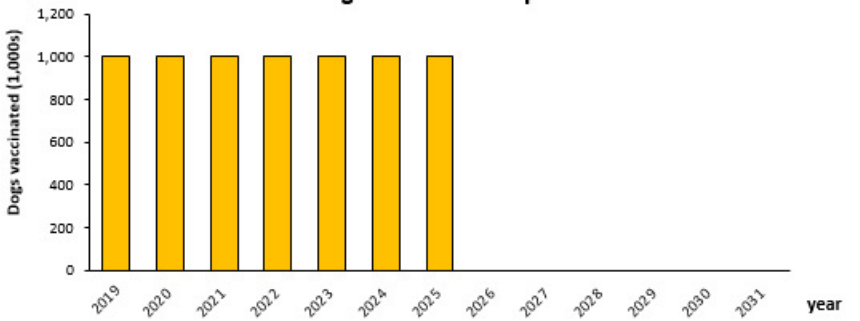
| | |
|---|---|
| **Resources needed (annual)** | |
| Total dog population | 1,428,142 |
| Dogs currently vaccinated annually | 999,700 |
| Dogs unvaccinated | 428,443 |
| Number of additional vaccinated dogs required | - |
| Average cost per dog vaccinated | USD 2.18 |
| **Total vaccination costs to eliminate** | |
| Net present value (NPV) Phase I | USD 0 |
| Cost to complete Phase II | USD 0 |
| Cost to complete Phase III | USD 15,255,416 |
| Total Dog Vaccination Costs for Elimination | **USD 15,255,416** |
| *Total vaccination costs (lower-upper)* | *(7,837,645 - 17,494,743)* |
| **Additional vaccination costs required (Total)** | **USD 0** |
| *Range (lower-upper)* | *(-)* |
| **Total surveillance and PEP costs** | |
| Total surveillance and PEP costs | **USD 2,517,101** |
| *NPV of dog rabies elimination (lower-upper)* | *(2,013,681 - 3,020,521)* |
| **Additional surveillance & PEP costs (Total)** | **USD 2,249,324** |
| *Range (lower-upper)* | *(1,799,459 - 2,699,189)* |
| **TOTAL DOG VACCINATION & SURVEILLANCE COSTS TO DECLARE ELIMINATION** | |
| **USD 17,772,516** | |
| *Range (lower-upper)* | *(14,218,013 - 21,327,020)* |
| **End of Human Rabies Deaths** | **2021** |
| **End of Canine Rabies Deaths** | **2024** |
| **Declaration of Canine Rabies Freedom** | **2026** |

**Cost Effectiveness Indicator**[₹]

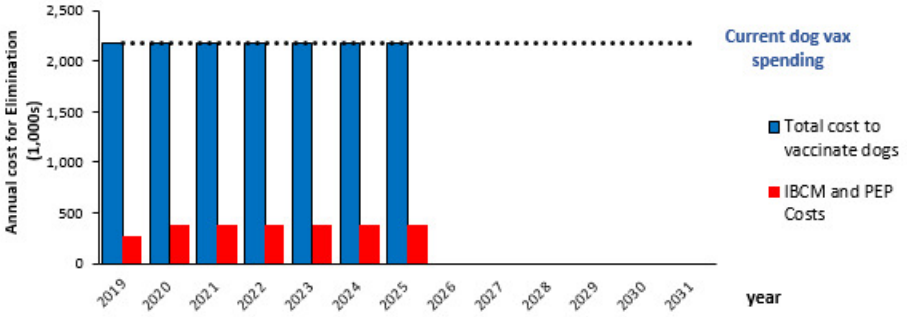
**Deaths Averted**
(30 years post-elimination)
**2,610**

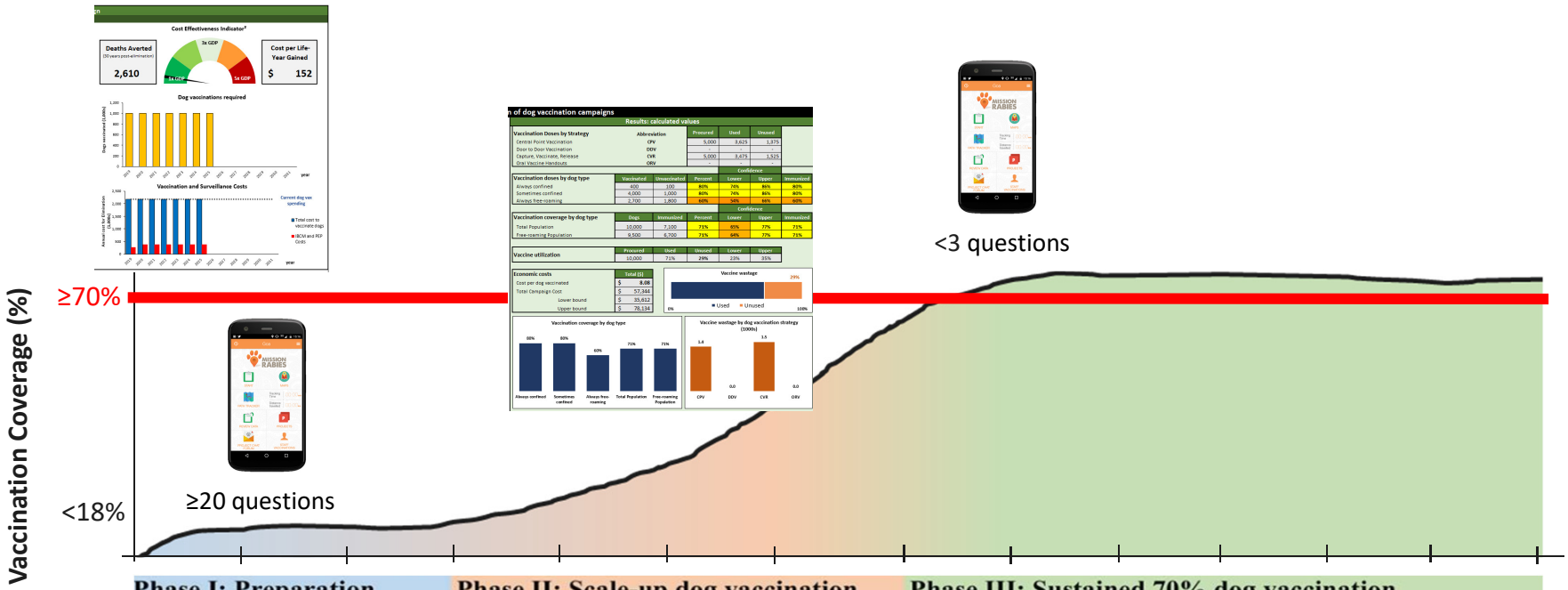
**Cost per Life-Year Gained**
**$ 152**

**Dog vaccinations required**

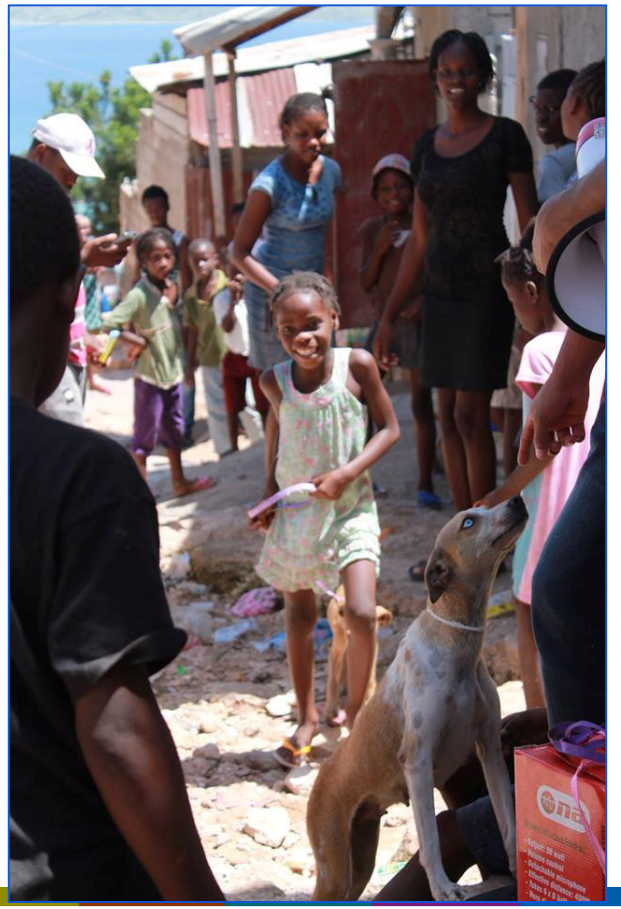



**Vaccination and Surveillance Costs**






| Phase I: Preparation | Phase II: Scale-up dog vaccination | Phase III: Sustained 70% dog vaccination |
|---|---|---|
| 1 2 3 | 4 5 6 | 7 8 9 10 11 12 13 |
| • Characterize the Dog Population<br>• Workforce Training<br>• Understanding Barriers | • Testing Vaccination Methods<br>• Developing Cost-Effective Vaccination Programs<br>• Scaling Up Sustainable Vaccination Programs | • Maintaining High Levels of Dog Vaccination until Cases are Eliminated<br>• Implementing Surveillance Systems to Establish Disease Burden<br>• Implementing Programs to Prevent Incursion |

# Considerations for Planning Effective Dog Vaccination

- Describe your **dog population**
  - *Confinement*: Confined, Sometimes, Roaming
  - *Ownership*: Owned, Community Owned, Feral
  - *Accessibility*
- Choose Appropriate **Vaccination Methods**
  - Fixed Point, Door to Door, CVR, ORV
- Choose **High Quality Vaccines**
  - Efficacy, thermostability, expiration dates
- Identify Your **Workforce**
- Understand Community **Buy-In**