Workshop on the harmonisation of FMD vaccination strategy in North Africa

Keith Sumption, Chris Bartels, Nick Lyons and Fabrizio Rosso

EuFMD

A vaccination strategy is a process

PLAN – understand risks

- Outbreak investigation, sero-surveys

APPLY

- Vaccination strategies

CHECK – monitoring

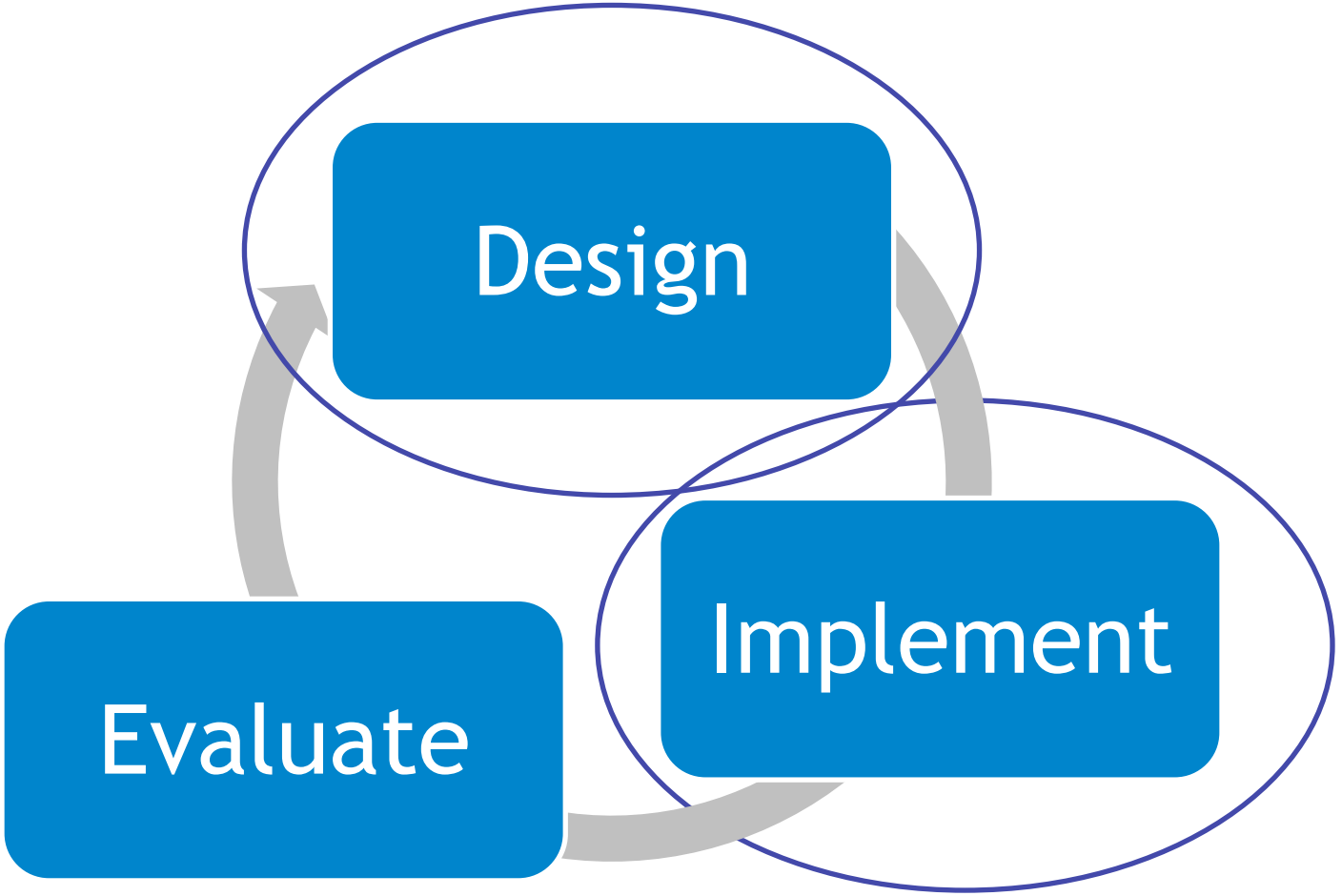
- vaccine and vaccination
  - Vaccination coverage
  - Vaccine failure
  - Vaccine quality assessment

ACT – evaluate and redesign

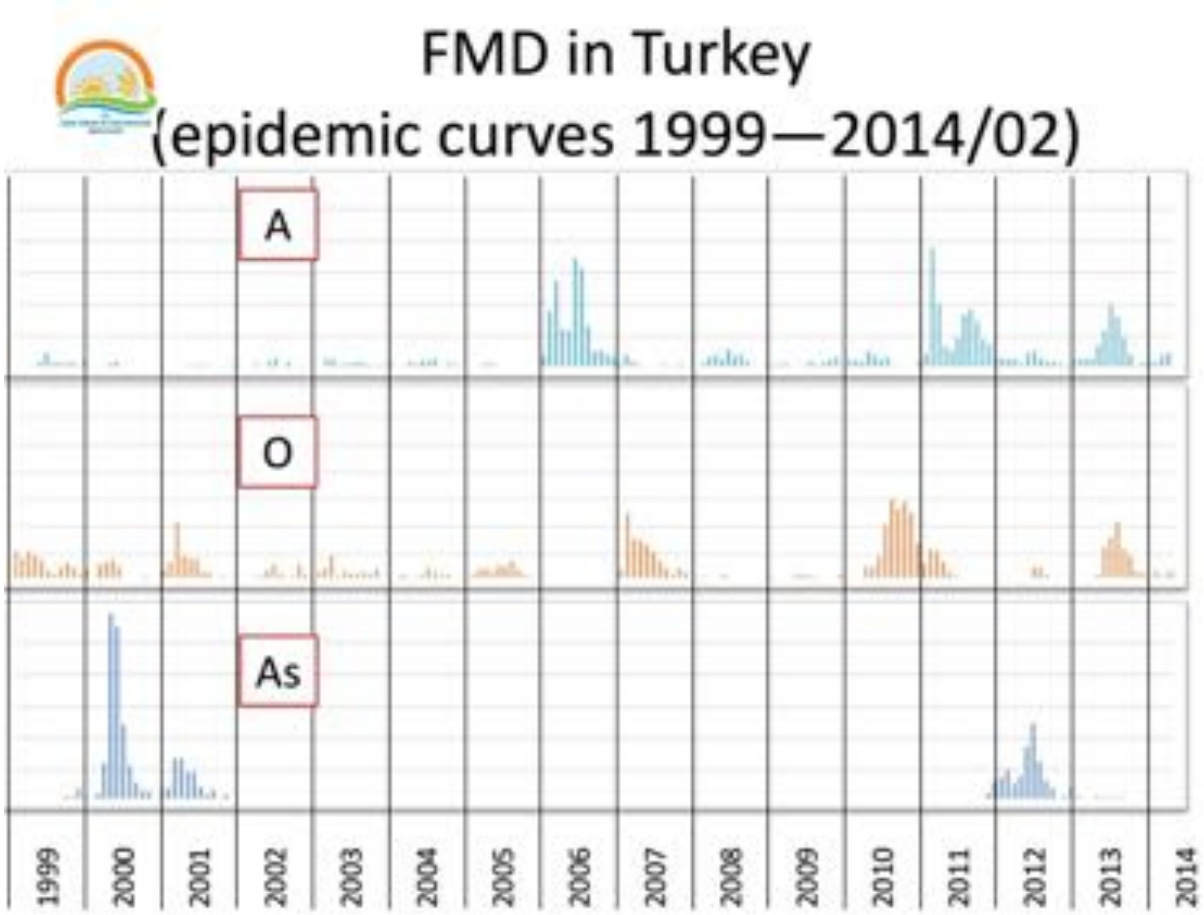
- Risk-based or targeted

Phases of a vaccination programme

- equally important -



NOTE: Disease phase of FMD epidemics are naturally short. But circulation does not naturally disappear...



Structure

Design -what do we want?

Implementation: how do we deliver it?

Monitoring: is it working?

Evaluation: do we need to change anything?

Strategy: a plan of action designed to achieve a long-term or overall Goal

An action that managers take to attain one or more of the organization's goals.

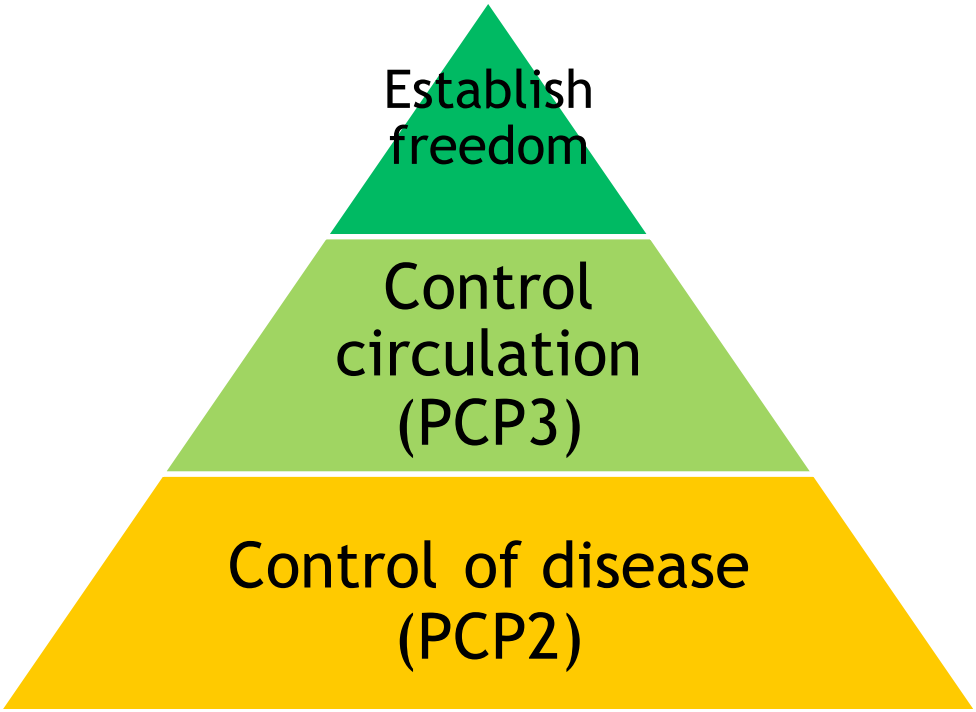
Strategy bridges the gap between "where we are" and "where we want to be".

Harmonised strategies

Require a *common vision*: what are the GOALs to achieve

Do NOT mean countries do the same actions

But do require that national actions work towards achieving the same goal



Examples: EuFMD Strategy for the Control of FMD in Europe (1954-):

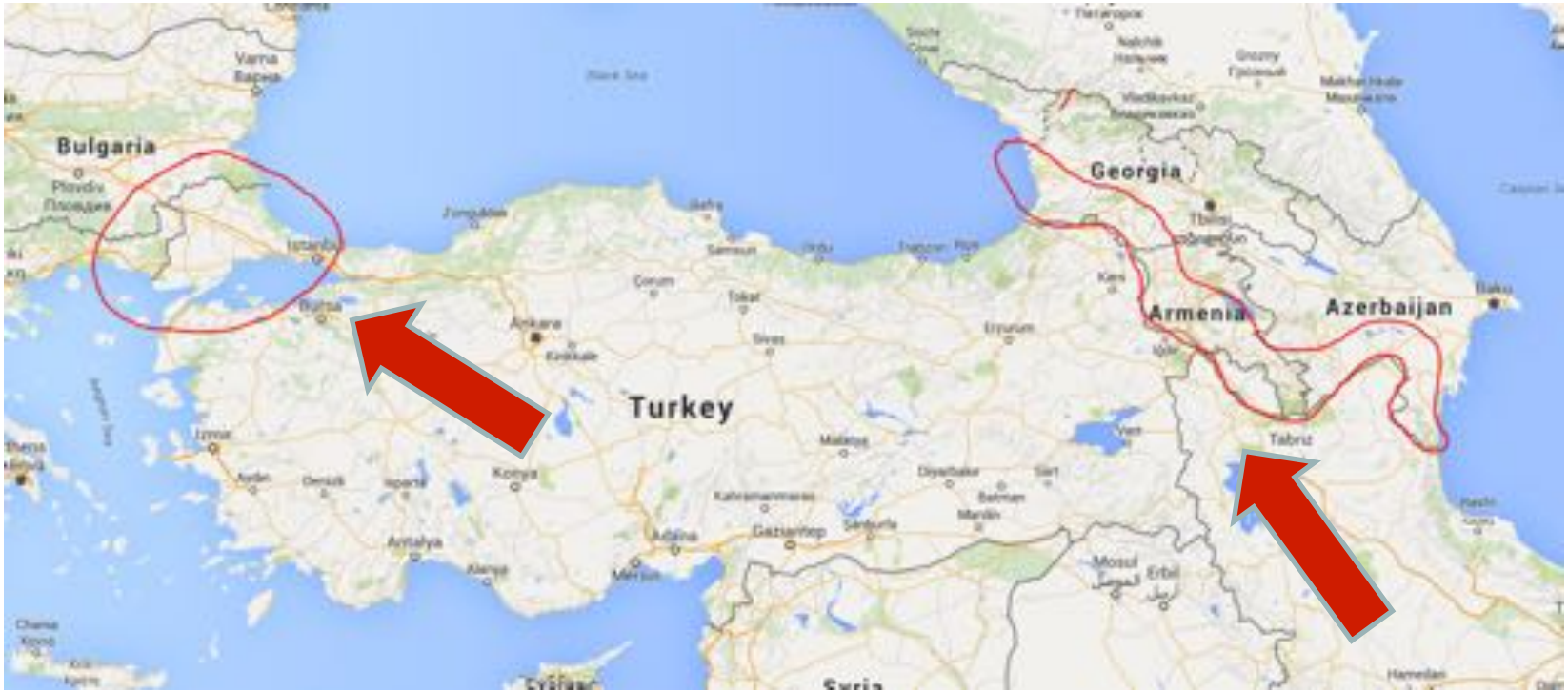
Common vision: to control FMD in Europe by effective national actions

Members undertake to control foot-and-mouth disease with a view to its ultimate eradication by the institution of suitable quarantine and sanitary measures and by one or more of the following methods:

- *a slaughter policy;*
- *slaughter together with vaccination;*
- *maintenance of totally immune cattle population by vaccination; other susceptible livestock may be vaccinated.*
- *vaccination in zones surrounding outbreaks.*

NOTE: in the strategy if “”total immunity”” in cattle could not be maintained SLAUGHTER of infected herds (+vaccination) was expected to be rigourously undertaken.

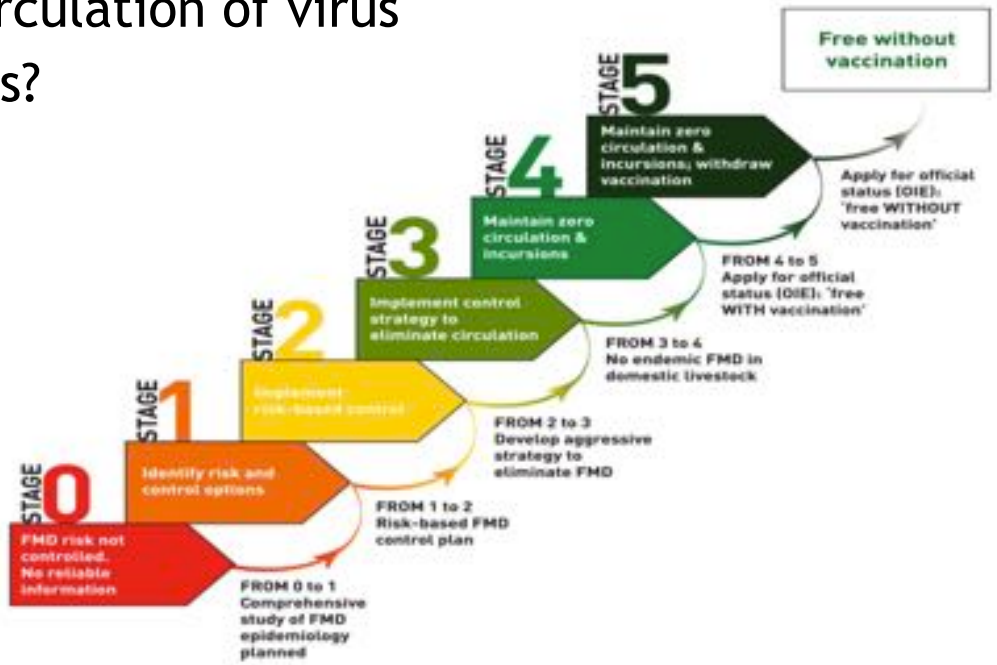
The EuFMD strategy also included special vaccination actions at the borders – Thrace (1962-) and TransCaucasus (1999-2012) funded by member states and EU



What is the objective of the vaccination – within a framework of limited resources?

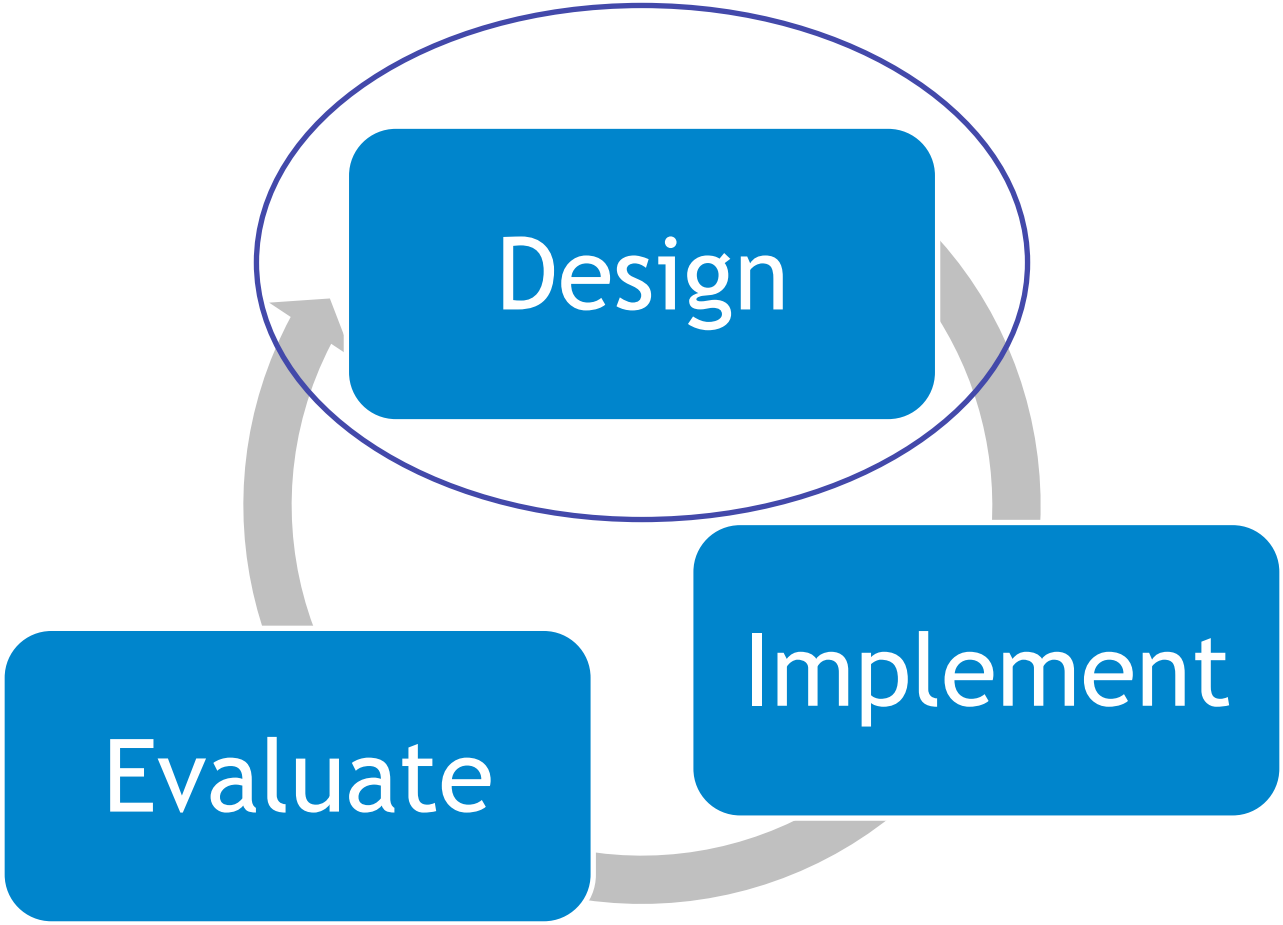
The strategy used will depend upon the objective of the campaign:

- Reducing the level or impact of clinical disease
- Reducing the circulation of virus
- Other objectives?



Phases of a vaccination programme

- equally important -



Designing of the strategy

✓Definition of the objectives

✓Identification of interested parties

✓Identification of resources needed

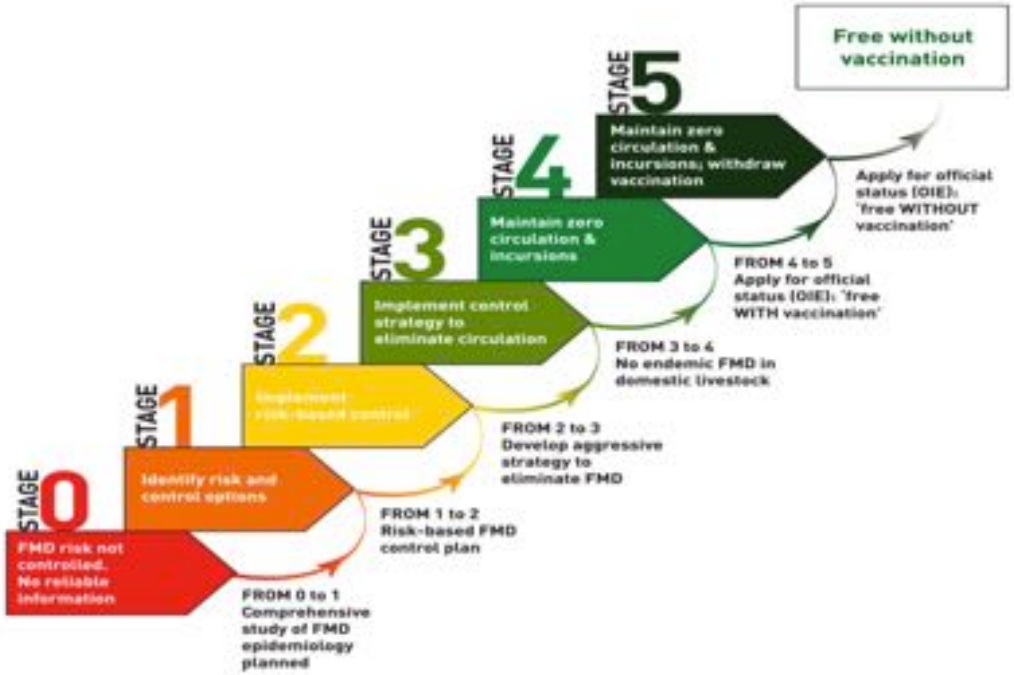
✓Definition of timelines

✓Evaluation and selection of suppliers

✓Identification of short - long term risks

What is the objective of the vaccination?

The strategy used will depend upon the objective of the campaign – reducing impact (PCP stage 2), or virus circulation (stage 3/4)



Control of disease vs Control over Circulation

1. **PCP Stage 2: outcome expected - reduced FMDV impact**
   - Focus is on reduced consequence if animal infected
   - National strategies can describe different targets for the subpopulations (risk classifications)

3. **PCP Stage 3: outcome expected – control over virus circulation**

- Additional Focus is to achieve reduced probability of transmission

PCP Stage	Outcome measure	Vaccination programme design objectives	Examples
2	DISEASE burden	Reduced consequence of infection	Dairy/private sector schemes Public funded cattle-only vaccination
3	Virus circulation	Reduced transmission rate	Programmes that require vaccination as a condition for movement.
4	Evidence for non-circulation	Complete interruption to virus circulation	Programmes that aim at CONTINUAL herd immunity levels SUFFICIENT TO PREVENT virus

Tactical Options -1

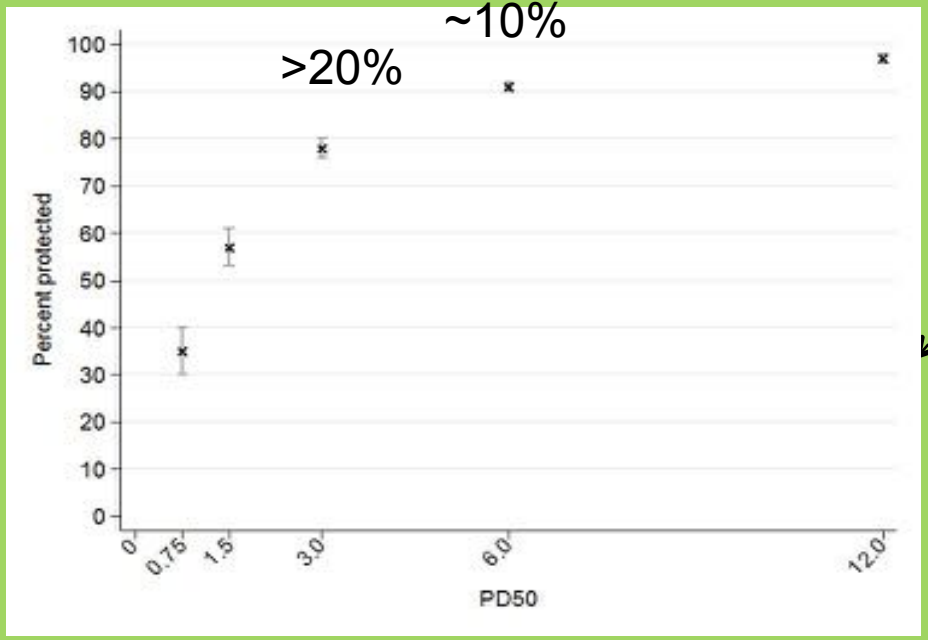
	Objective	Success requires:	Weakness
Buffer Zone vaccination	Separate two populations of different FMD status	• Control over entry and exit to zone. • Targetting of high risk livestock	Insufficient control over borders – livestock pass across zone
Pre-movement vaccination	Reduce risk of non-immune animals spreading infection when moved.	• Regulation of movement across internal borders. • Passport/ID systems to prove immunised.	• Epidemic strains not matched by vaccine. • Effective immunity needs a booster vaccination
International pre-movement vaccination	Reduce risk of animals entering the country with infection	Co-operation with neighbouring countries (formal) or traders (informal)	• Risks of inadequate immunisation schedules. • Problems with ID of vaccinates

Tactical Options - 2

	Objective	Success requires:	Weakness
Emergency re-vaccination (Ring, Zone, Risk Group)	Address problems in Disease reduction or to control circulation	• Capacity for safe imlementation . • Protocols to avoid spreading infection • Existing baseline immunity OR Vaccines capable of high potency or booster 21 days after first. • At least 5 days between vaccination and challenge	• High potential wastage where vaccine used too late. • For new strains, booster vaccination required.
Special vaccination programmes for high trasmission risk groups	Reduce risk of non-immune animals spreading infection.	Political and Administrative capacity to target risk groups.	• Targets hard to reach. • Impact hard to measure. • Owners may not co-operate

Vaccination against DISEASE: vaccine potency matters

Expect 20% cases of clinical disease on challenge with a 3 PD50 vaccine and HIGHER when not well antigenically matched



Infectio us (I)

Data taken from Vianna Filho et al, 2003

Vaccination against disease: potential failure issues

Recipent-related

- Immunodeficiency
- Immature immune system (i.e. age)
- Poor health
- Waning immunity
- Immunological interference (e.g maternal immunity)

Vaccine-related

- Low potency
- Poor match to field strain
- Interference from other vaccines
- Manufacturer problems (i.e. poor quality batch)

VACCINE FAILURE

Incorrect usage

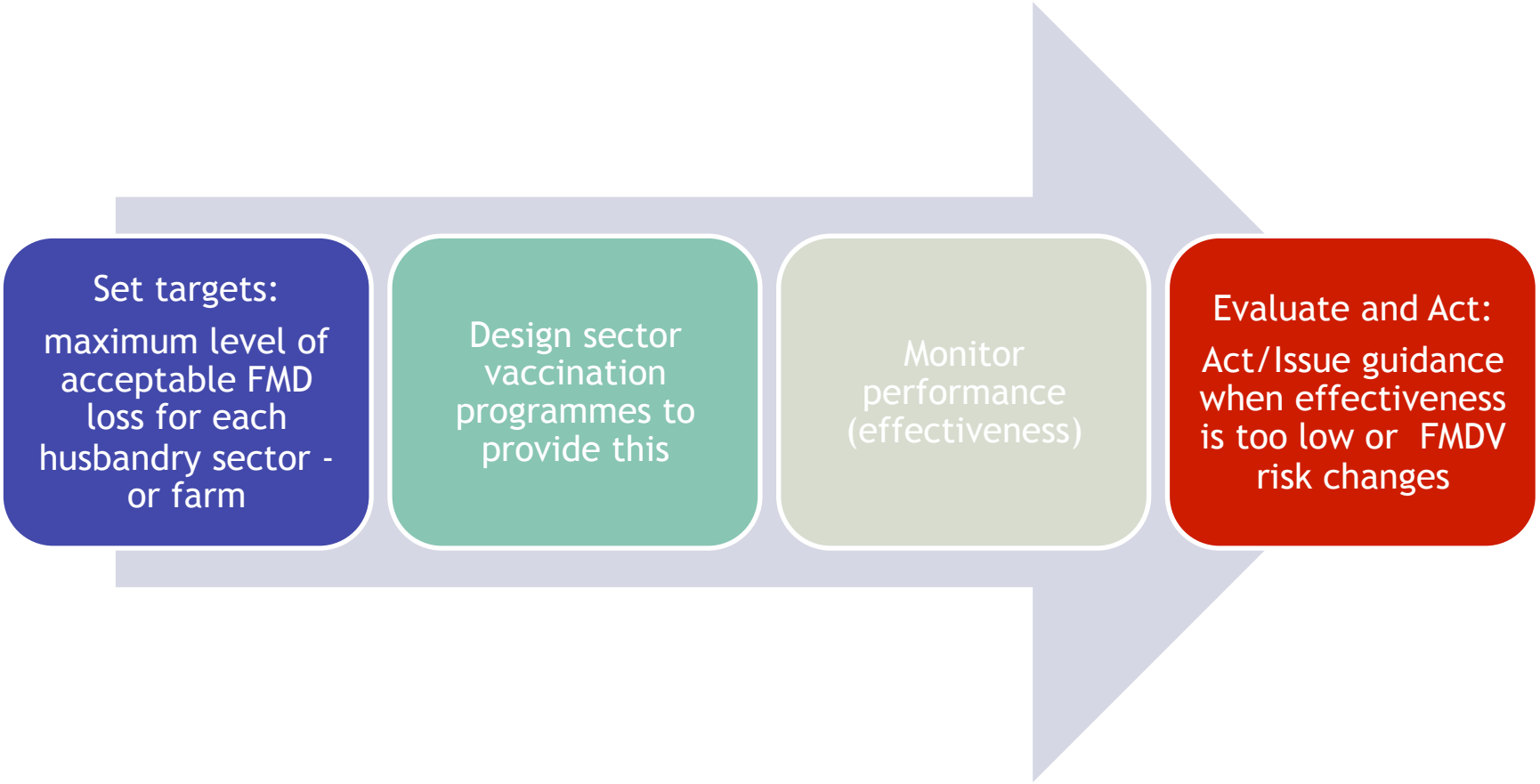
- Administration error (wrong dose)
- Incorrect schedule (e.g. no booster)
- Poor storage (e.g. cold chain issues)
- Beyond expiry date of product

Programme problems

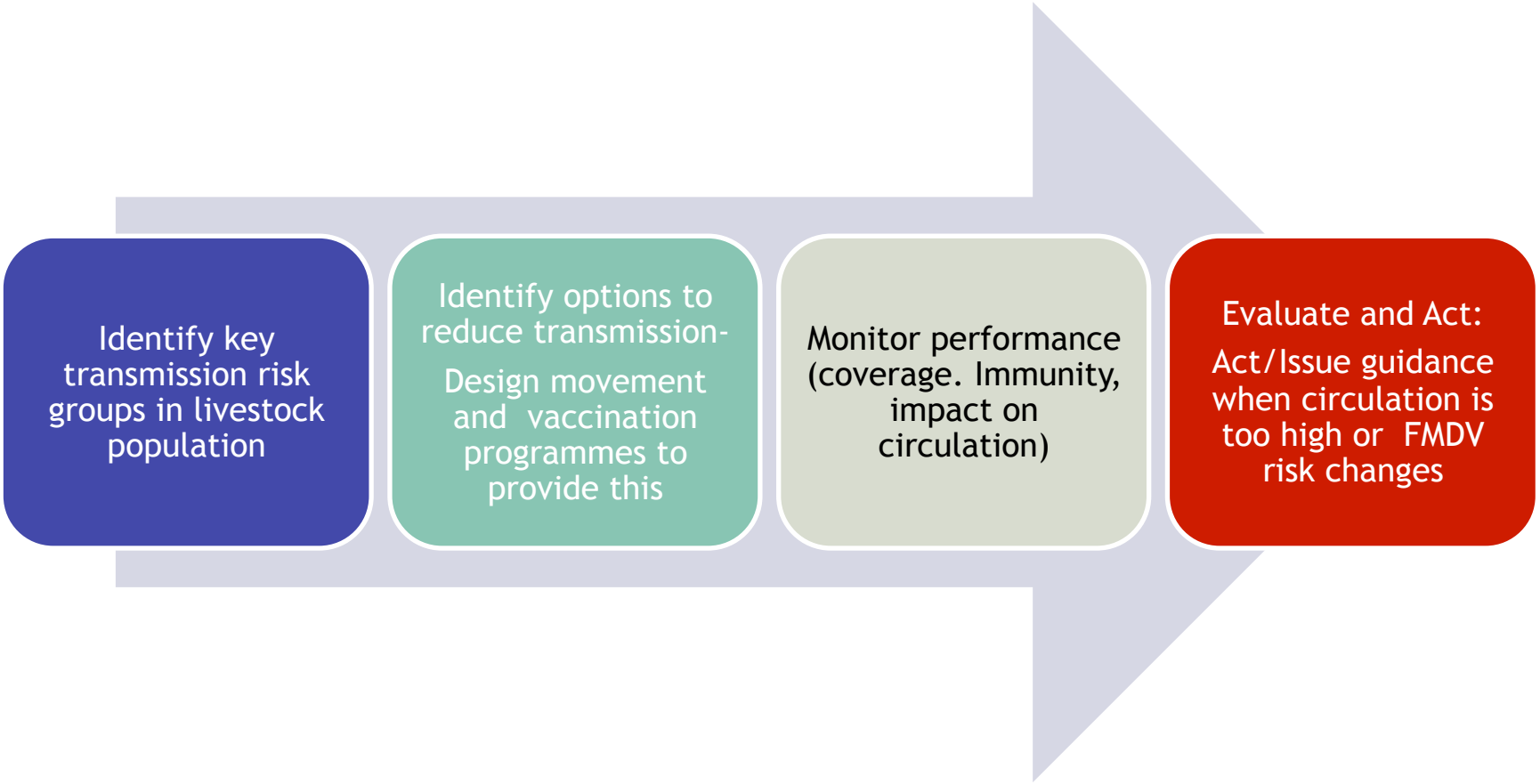
- Vaccine availability
- Incorrect timing or schdeules

FAILURE TO VACCINATE

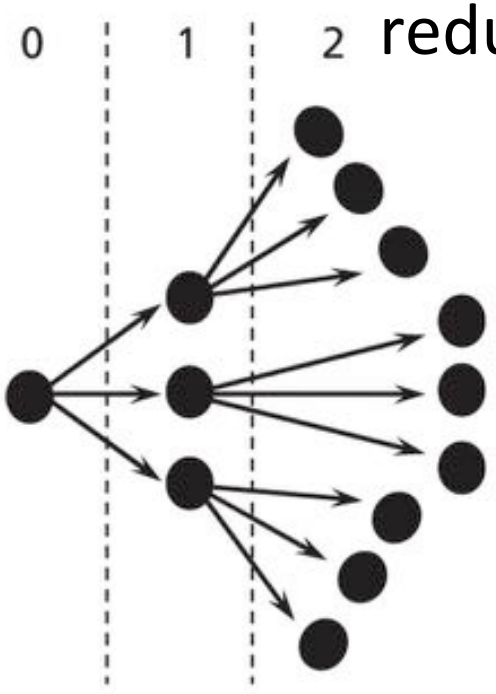
Reducing disease: management process



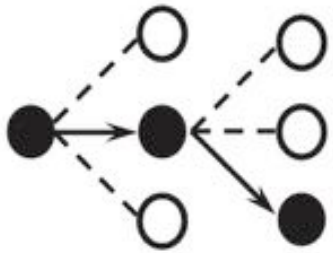
Reducing virus circulation: management process



Vaccination to prevent virus circulation: aim is to reduce Ro to < 1



$R_0 = 3$



$R_n = 1$

Net reproduction number (R_n)

- immune population

<1 = outbreak will die out

Basic reproduction number (R_0) – average number of secondary cases for each primary case of disease in a naïve population

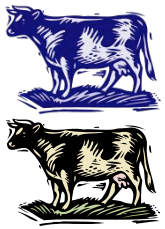
What is the Herd immunity required to prevent circulation?

To have a critical proportion protected such that infection will no longer lead to a major outbreak as the proportion of susceptibles becomes too small: R0 < 1)

That critical proportion is defined by $=1-1/R0$

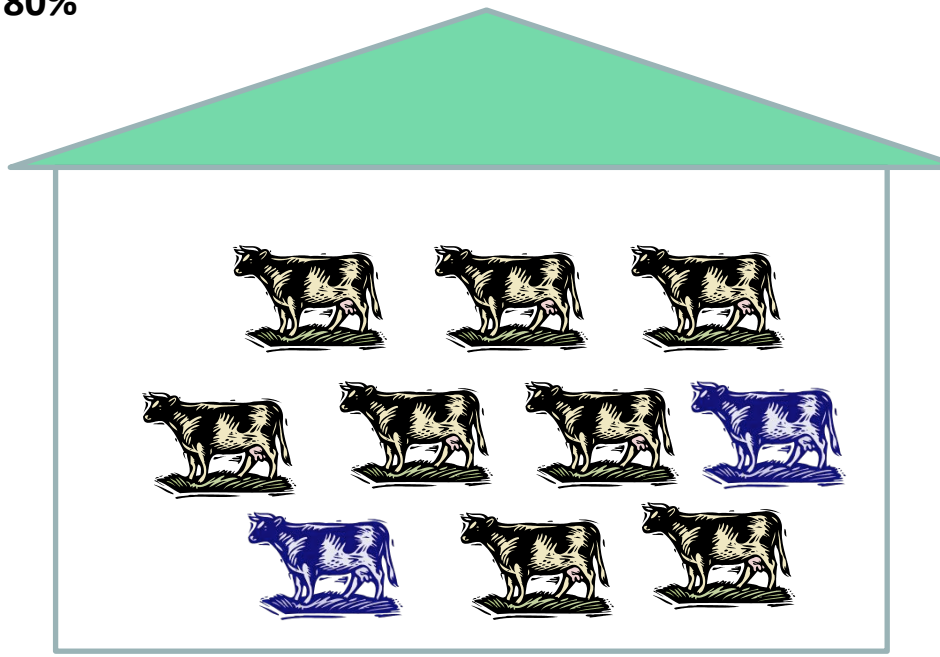
If R0 more than 5: critical proportion > 80%

Critical proportion to be protected

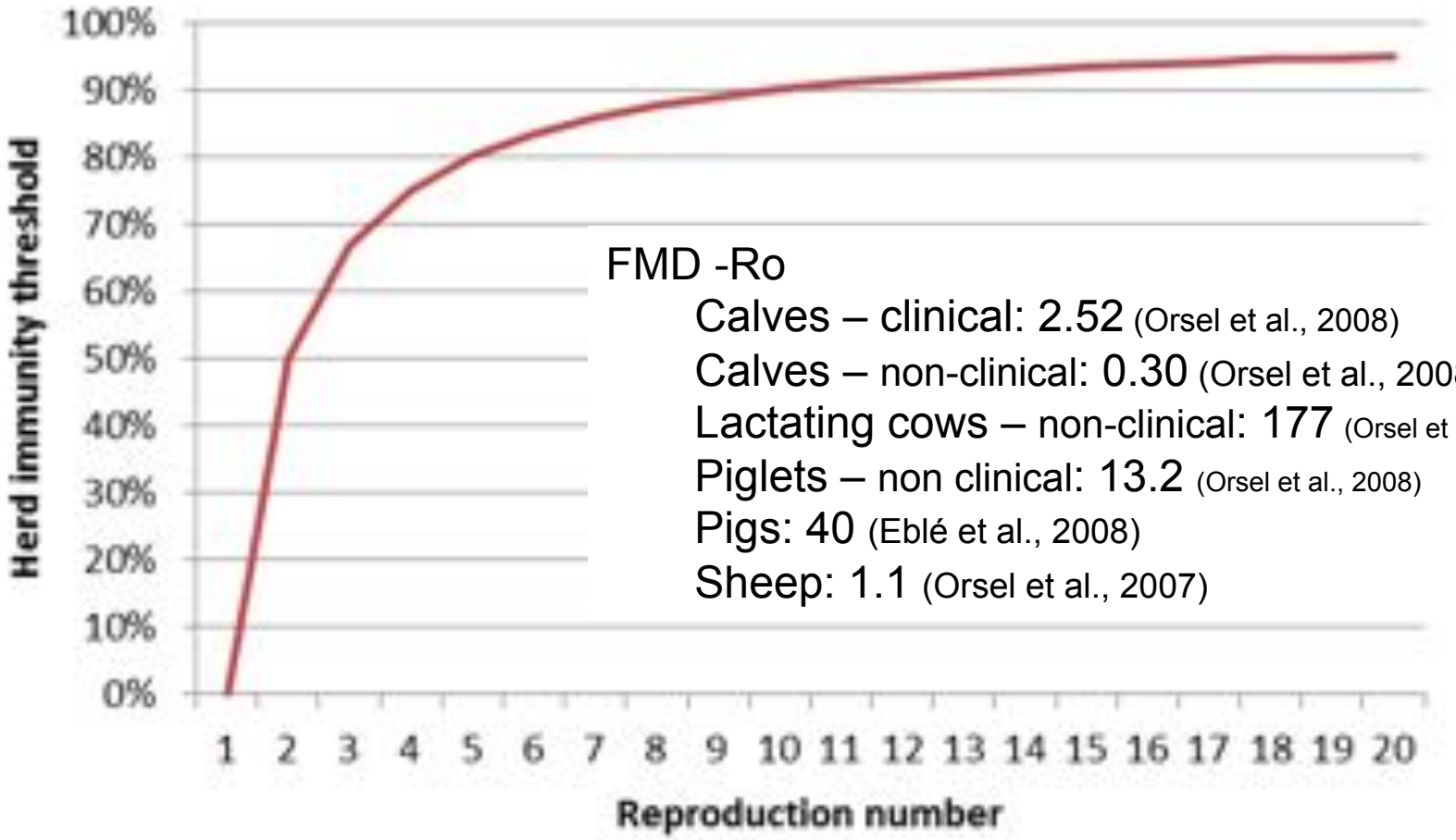


Not vaccinated

Vaccinated



What herd immunity is required to prevent circulation of a disease?



FMD -Ro

- Calves – clinical: 2.52 (Orsel et al., 2008)
- Calves – non-clinical: 0.30 (Orsel et al., 2008)
- Lactating cows – non-clinical: 177 (Orsel et al., 2008)
- Piglets – non clinical: 13.2 (Orsel et al., 2008)
- Pigs: 40 (Eblé et al., 2008)
- Sheep: 1.1 (Orsel et al., 2007)

Which species to vaccinate? Ro and mixed cattle and sheep systems

- R = 5.3 — **100% cattle**
- R = 4.4 — **78% cattle (NL)**
- R = 3.7 — **61% cattle (Uruguay)**
- R = 2.1 — **24% cattle (New Zealand)**
- R = 1.1 — **0% cattle i.e. 100% sheep**

The higher the proportion of cattle in a mixed cattle-sheep population, the higher the R for the mixed population

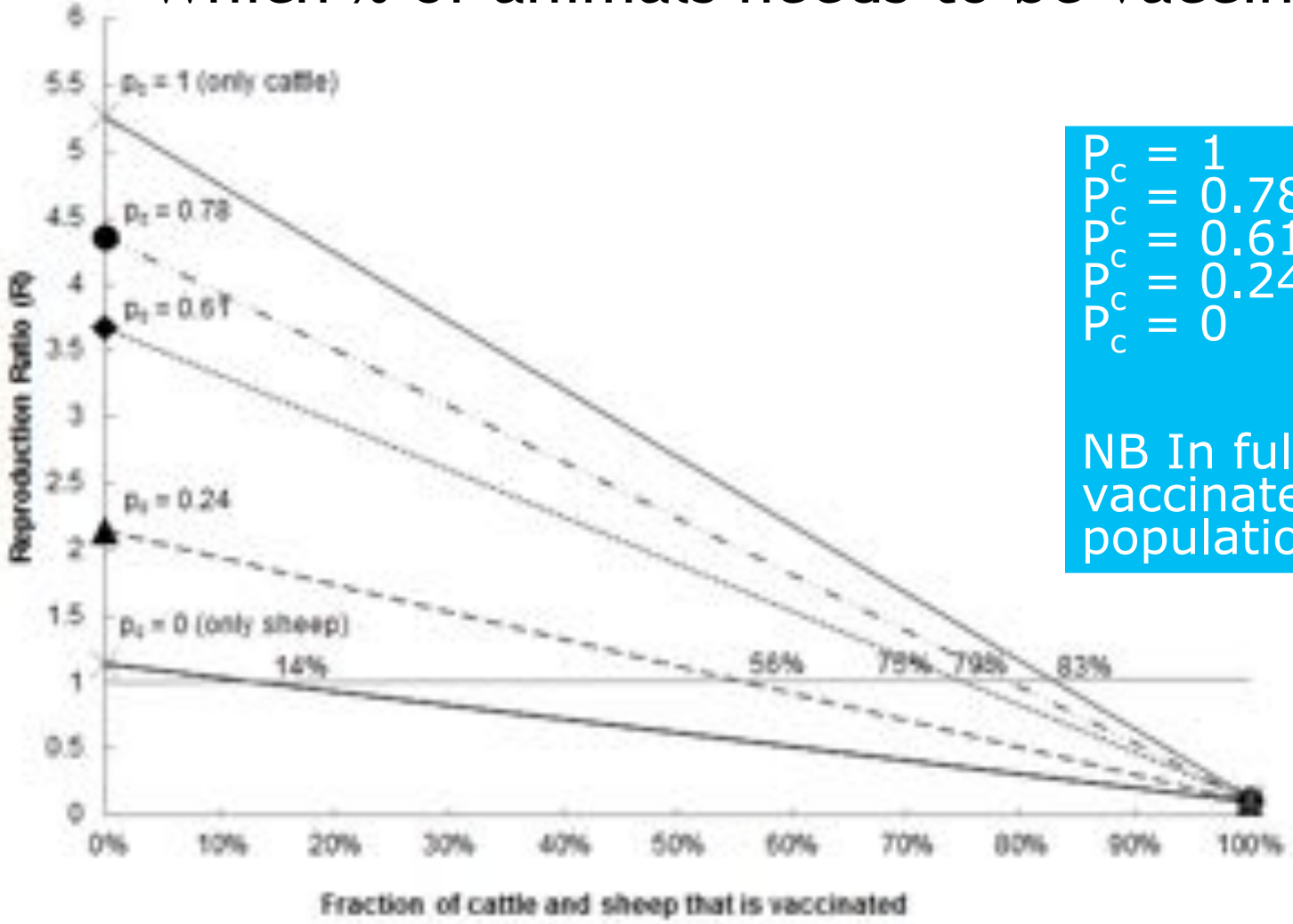
Source: Carla Bravo de Rueda

Vaccination of cattle only will be sufficient to stop transmission in mixed populations of cattle and sheep

C. Bravo de Rueda, A. Dekker, P.L. Eblé, M.C.M. de Jong

Vaccination of both cattle and sheep

Which % of animals needs to be vaccinated



$P_c = 1 \rightarrow 83\%$
$P_c = 0.78 \rightarrow 79\%$
$P_c = 0.61 \rightarrow 75\%$
$P_c = 0.24 \rightarrow 56\%$
$P_c = 0 \rightarrow 14\%$

NB In fully vaccinated populations $R<1$

Modelling predictions for mixed sheep and cattle populations:

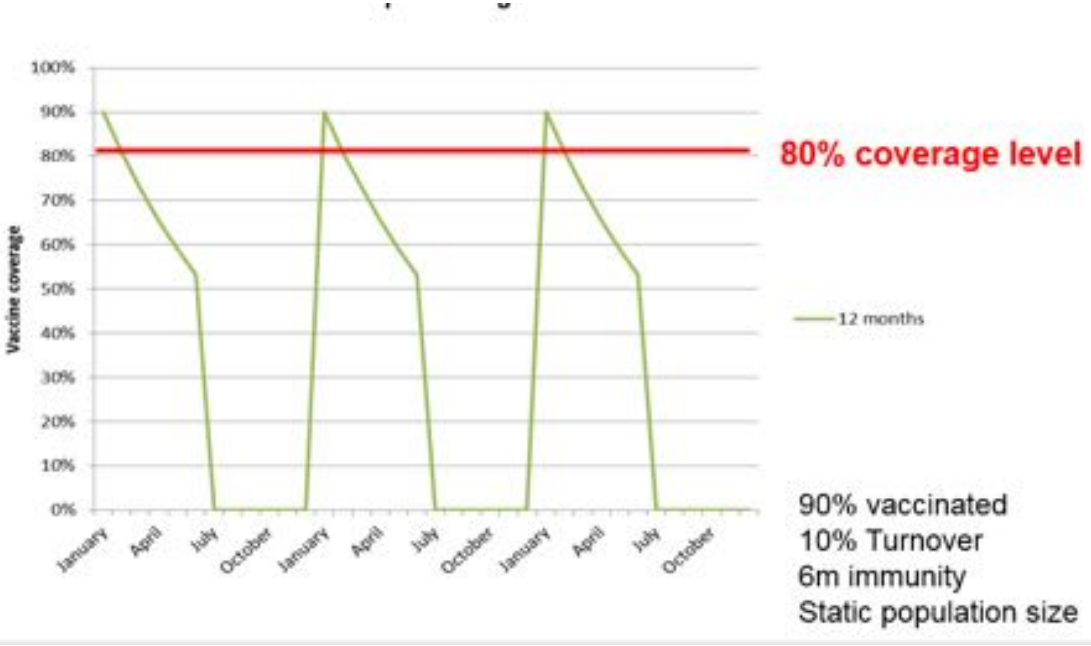
In mixed cattle-sheep populations with at least 14% of cattle, vaccination of cattle only seems to be sufficient to reduce $R<1$

Acknowledgements:
Dutch Ministry of Economic Affairs
European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 226556 (FMD-DISCONVAC)

Herd immunity is NOT the same as vaccination coverage

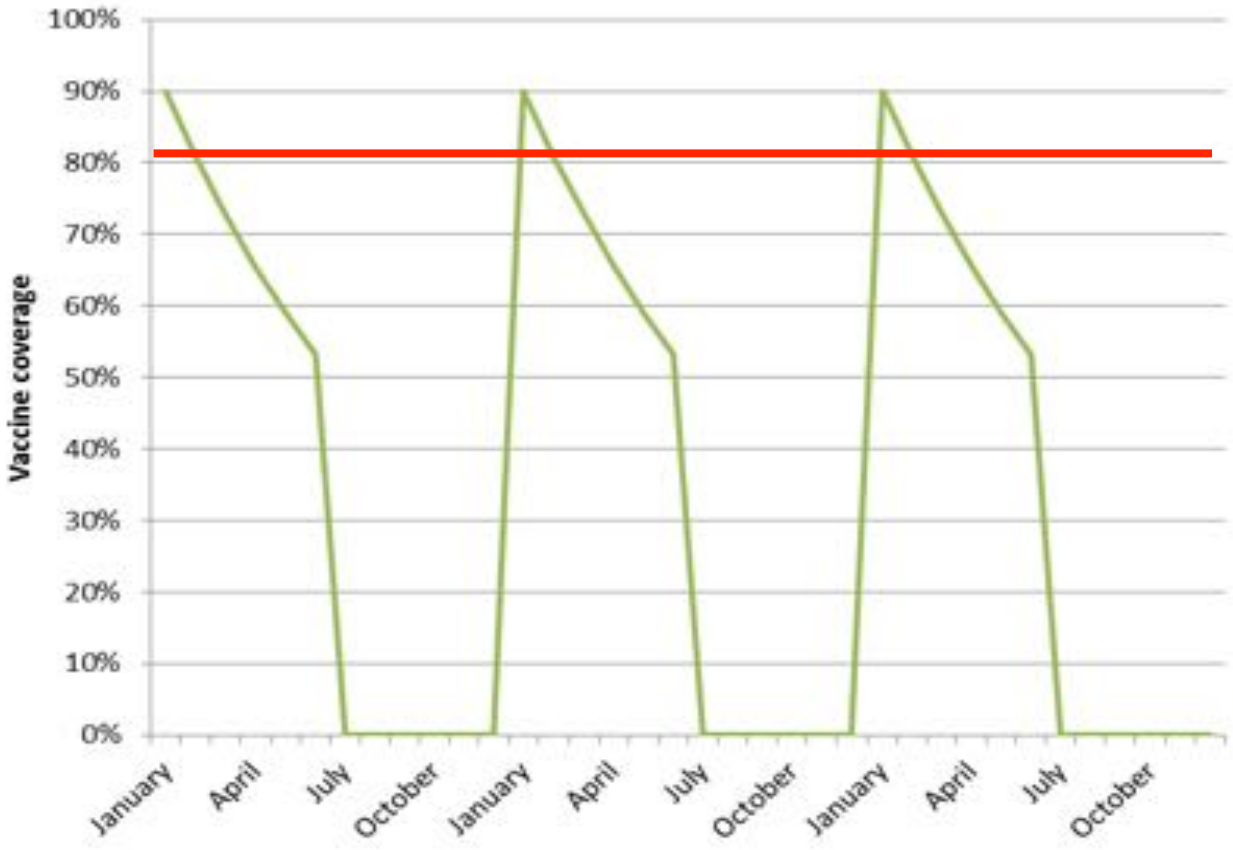
Herd Immunity wanes after each vaccination

Re-vaccination intervals matter



Why is it difficult to maintain high coverage levels for FMD?

Simple coverage model in Excel



80% coverage level

90% vaccinated
10% Turnover
6m immunity
Static population size

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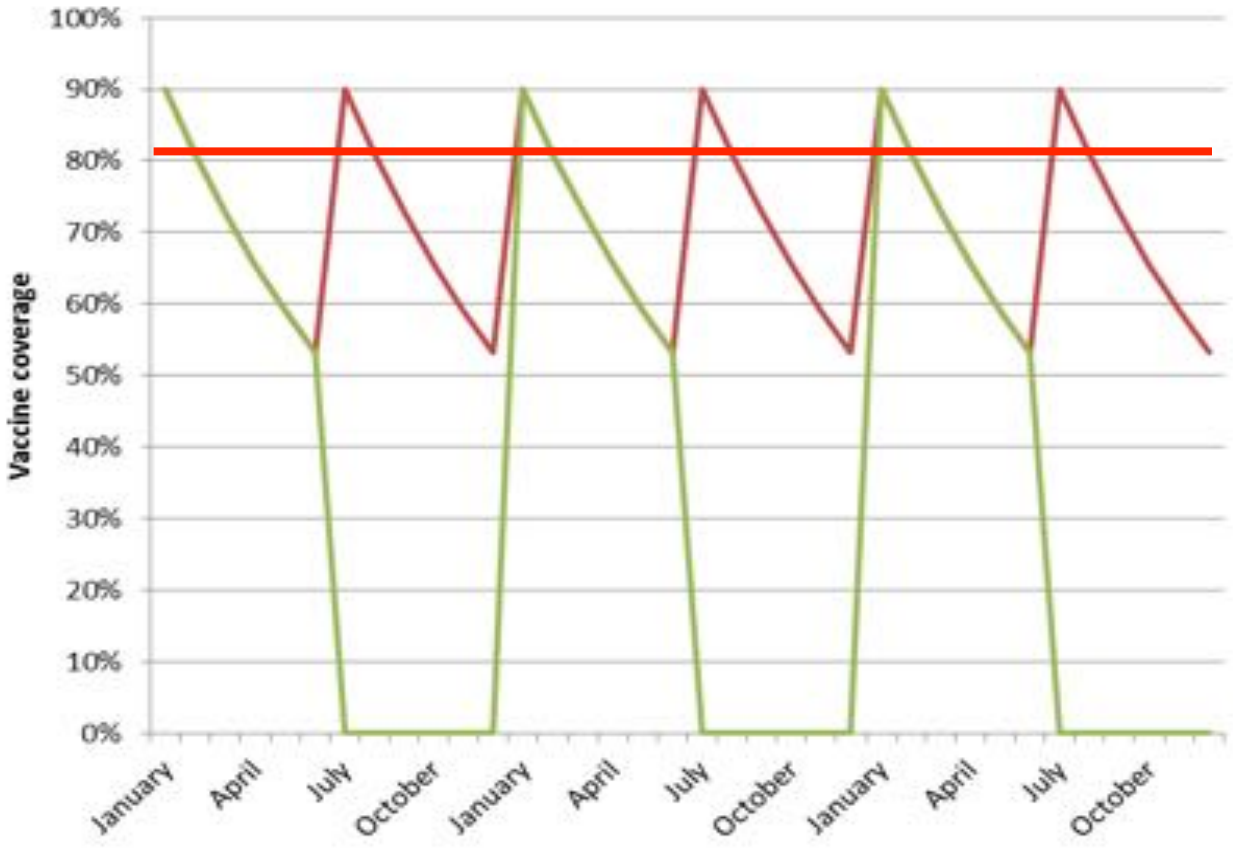

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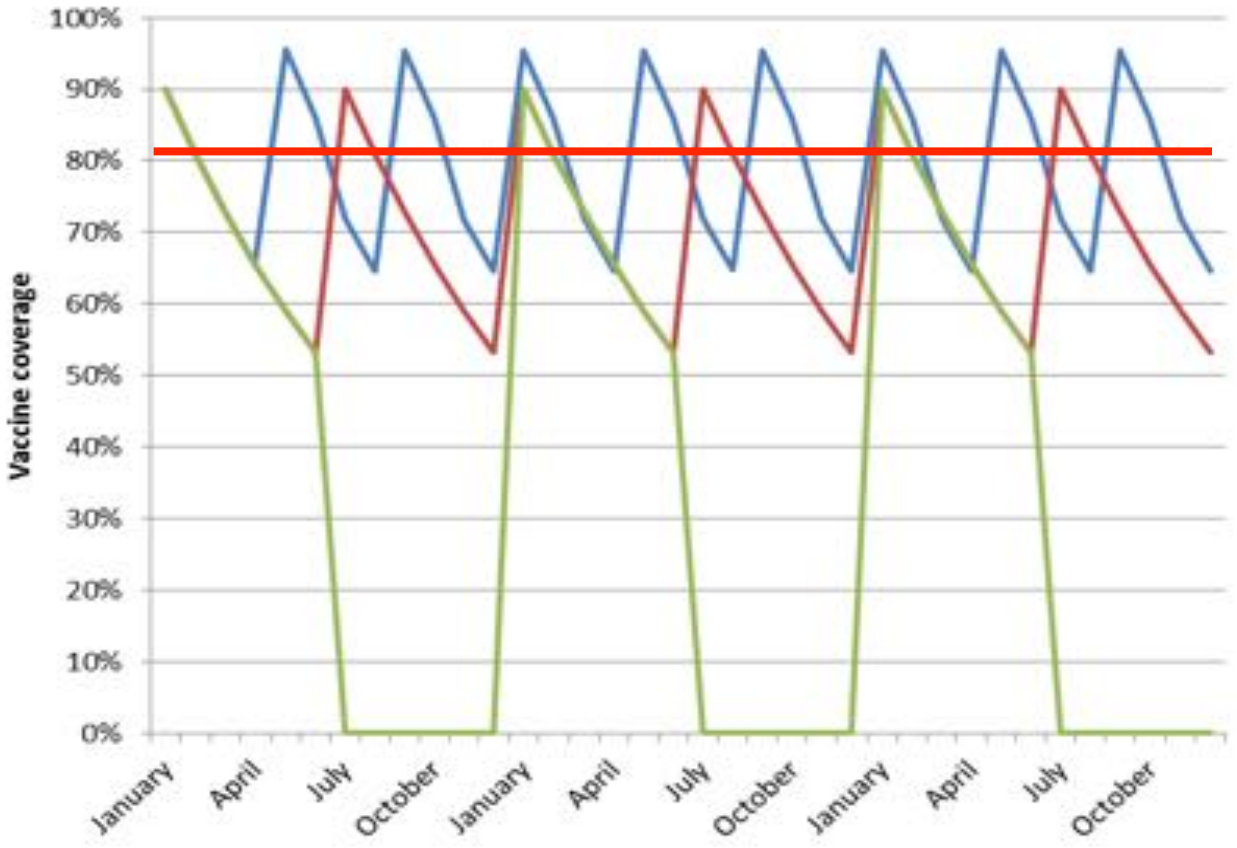

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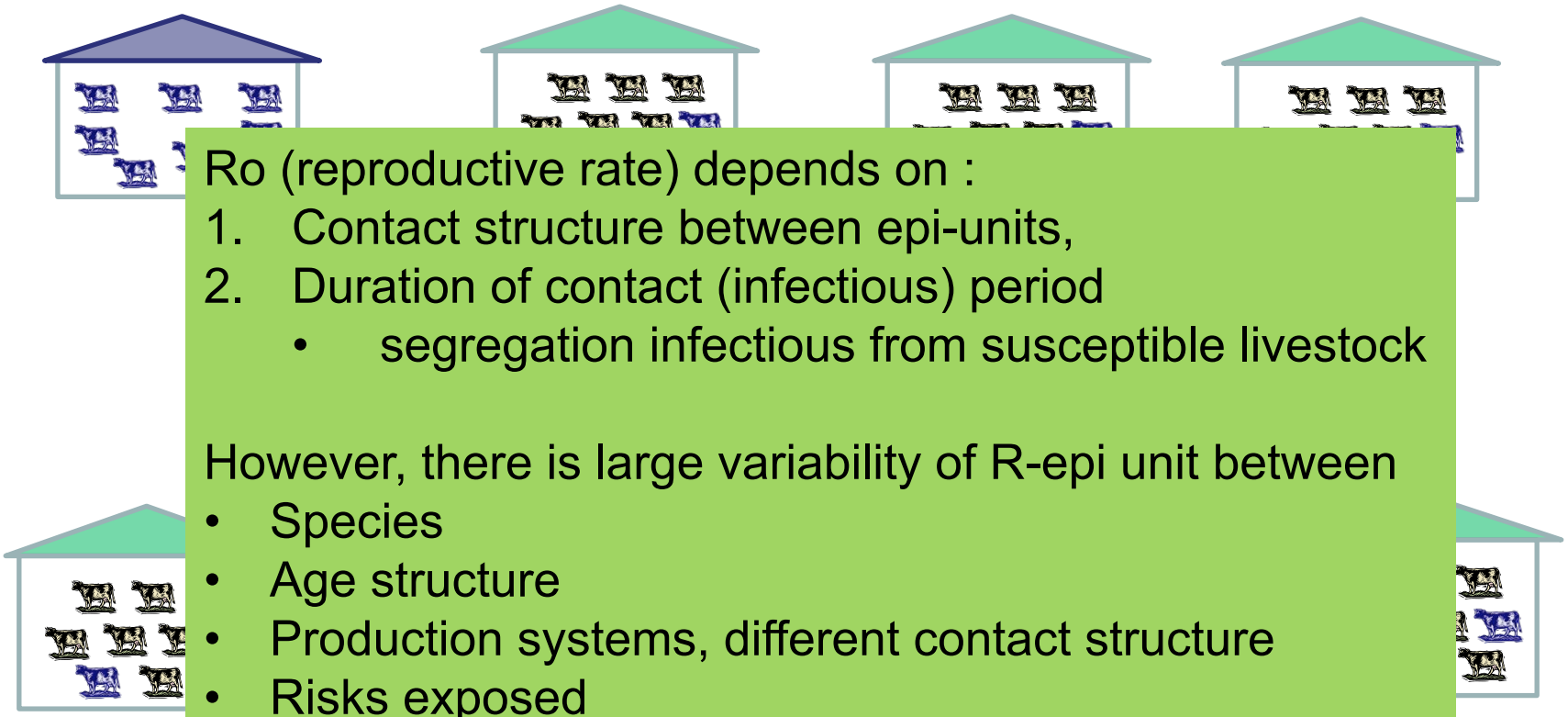
As animals are kept in groups, we must consider inter-herd transmission



Ro (reproductive rate) depends on :

1. Contact structure between epi-units,
2. Duration of contact (infectious) period
   - segregation infectious from susceptible livestock

However, there is large variability of R-epi unit between

- Species
- Age structure
- Production systems, different contact structure
- Risks exposed

What can be done? How can we use vaccination to prevent circulation?

Either:

Reduce inter-herd transmission (Ro)

- **Movement management rules**

OR

Target vaccination to risk populations

- **Greater effect of limited resources**
- **% Herd immunity targets differ**

OR DO BOTH

Mass vaccination strategies frequently fail if they are not risk based

FMDV is highly contagious (high Ro) - the Herd immunity is insufficient to prevent circulation

The herd immunity required relates to risk of transmission (Ro)

Risk of transmission relates to intra-herd contact (density) and inter-herd contact rate

Argues for

Risk based vaccination strategies

Risk-based vaccination - Principles

- Risk-based or “targeted” vaccination
- Certain animals may be at a higher risk of disease (management, age, breed, location)
- In some animals the disease may be more severe with a greater economic impact (dairy cows, young animals)
- Focussing on these animals may be a much more *efficient* and *cost-effective* way of using limited resources

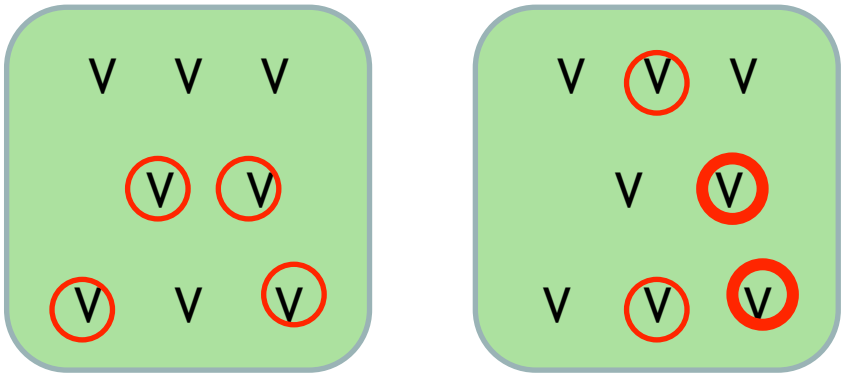
Risk is defined by

Probability

x

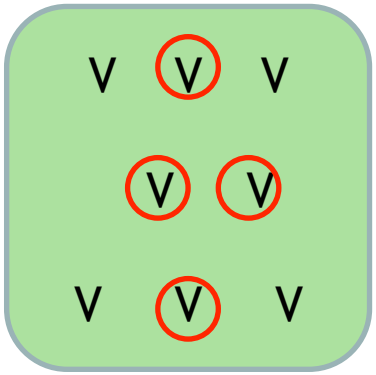
Consequence

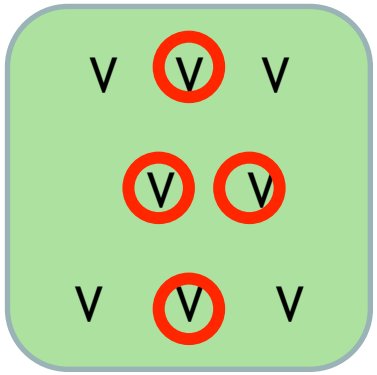
Random (mass) compared to Risk based vaccination :



1st campaign

2nd campaign

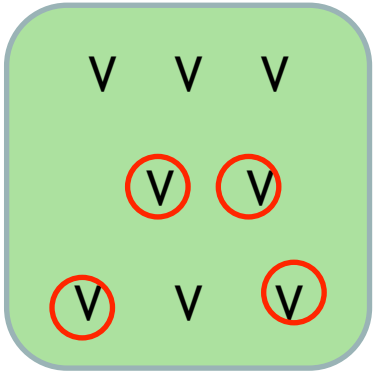




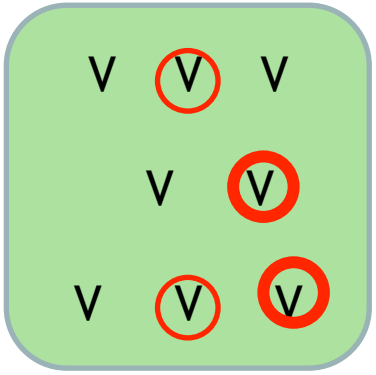
Random application of vaccine

Risk-based application of vaccine

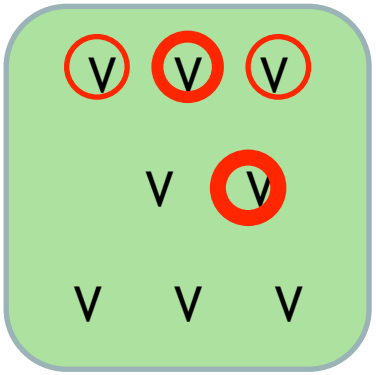
- Animal markets
- Borders
- Intensive production system



1st campaign



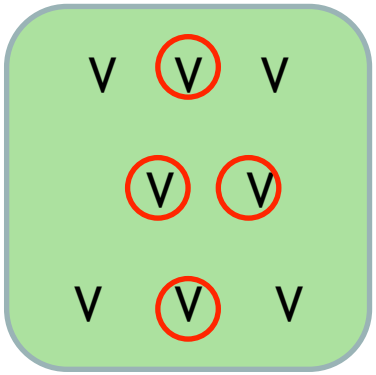
2nd campaign

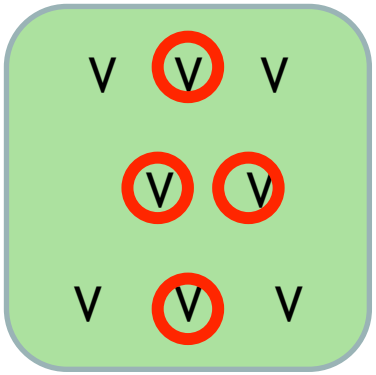


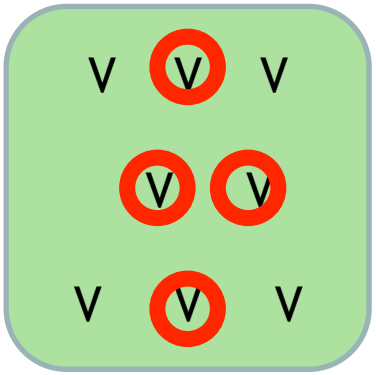
3rd campaign

Could be anywhere

Where is the virus?

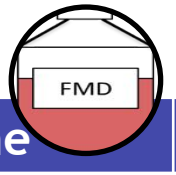






Unlikely in the vaccinated epi-units

Issues to address in the vaccination plan



Animal	Vaccine	Delivery	Programme
Contact structure Within epi-unit and between epi-units	Potency	Biosecurity applied by vaccinators	Planning - Season - Production systems
Livestock turn-over	Self-life	Correct application	Risk assessment
Species difference	Matching	Coverage within and between epi-units	Stakeholder consultation
Age differences - Maternal Ab - Risks		Making farmers understand	
Risk exposure: - Production systems - Management - Region			

Implementation of the strategy

✓Role and responsibilities

✓Stakeholder participation

✓Training and Standard Operational Procedures

✓Evaluation and selection of suppliers

✓Legislation and enforcement

✓Data collection and analysis

✓Other control measures: Movement restrictions, Biosecurity, Informing livestock owners

Role and responsibility

Vaccine attributes

- Safety
- Shelf life
- Match with field virus
- Potency
- Duration of protection

➔ Quality assessment

- ❖ Complete
- ❖ Accurate
- ❖ Regular
- ❖ Independent

Distribution

- Cold chain
- Planning
- Coverage

➔ Central supervision

- ❖ Data format
- ❖ Collection
- ❖ Analysis
- ❖ Reporting

Application

- Injection and dose
- Age category
- Biosecurity

➔ Local supervision

- ❖ Training
- ❖ Evaluation
- ❖ Vaccination card
- ❖ Data recording

Immune protection

- Health status

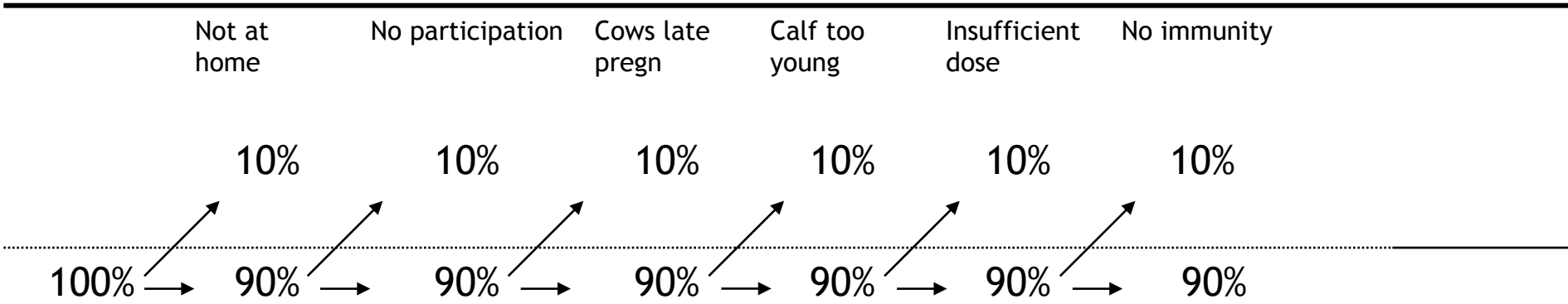
➔ Vaccinator's assessment

Implementation of the strategy

- ✓**Legislation framework:**
  Regulatory requirements
- ✓**Training and Standard Operational Procedures**:
  Biosecurity, vaccination, cold chain, safety
- ✓**Definition of responsibilities:**
  Authority and responsibility
- ✓**Analysis of other simultaneous programmes:**
  Optimization of the efforts
- ✓**Analysis of problems occurred in the past:**
  Root cause analysis
- ✓**Data collection and analysis:**
  Monitoring system

Why is it difficult to achieve high coverage levels for FMD?

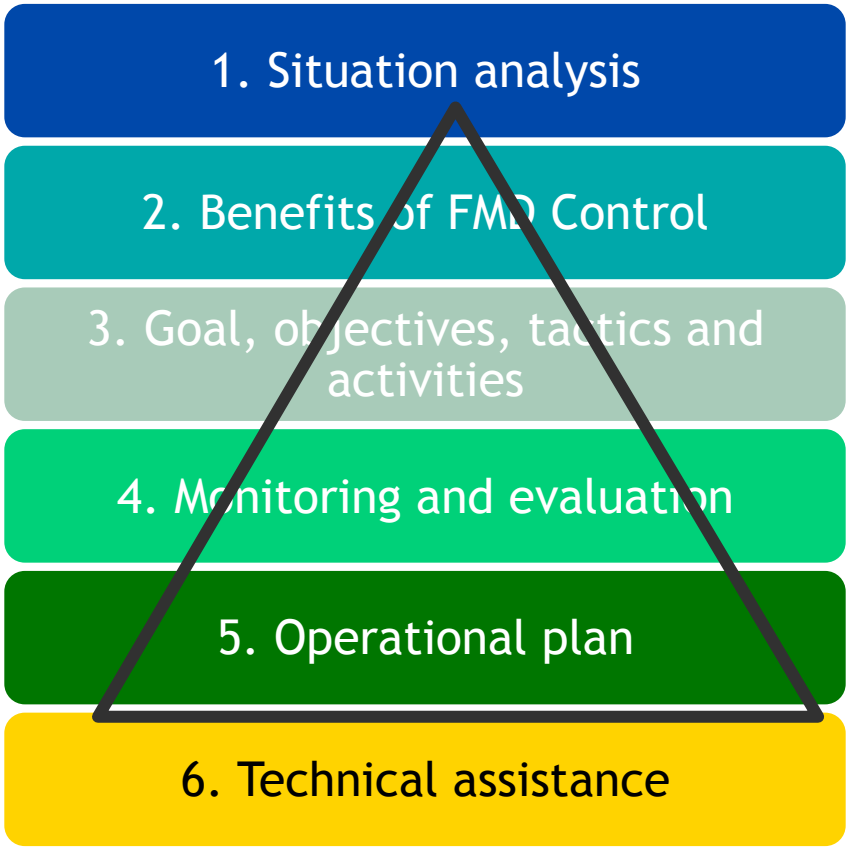
You start with the target of 100% coverage…



Total effect	90%	81%	73%	66%	59%	**47%**

And no vaccine is perfectly effective….

Chapter 5 of the Risk Based Strategic Plan



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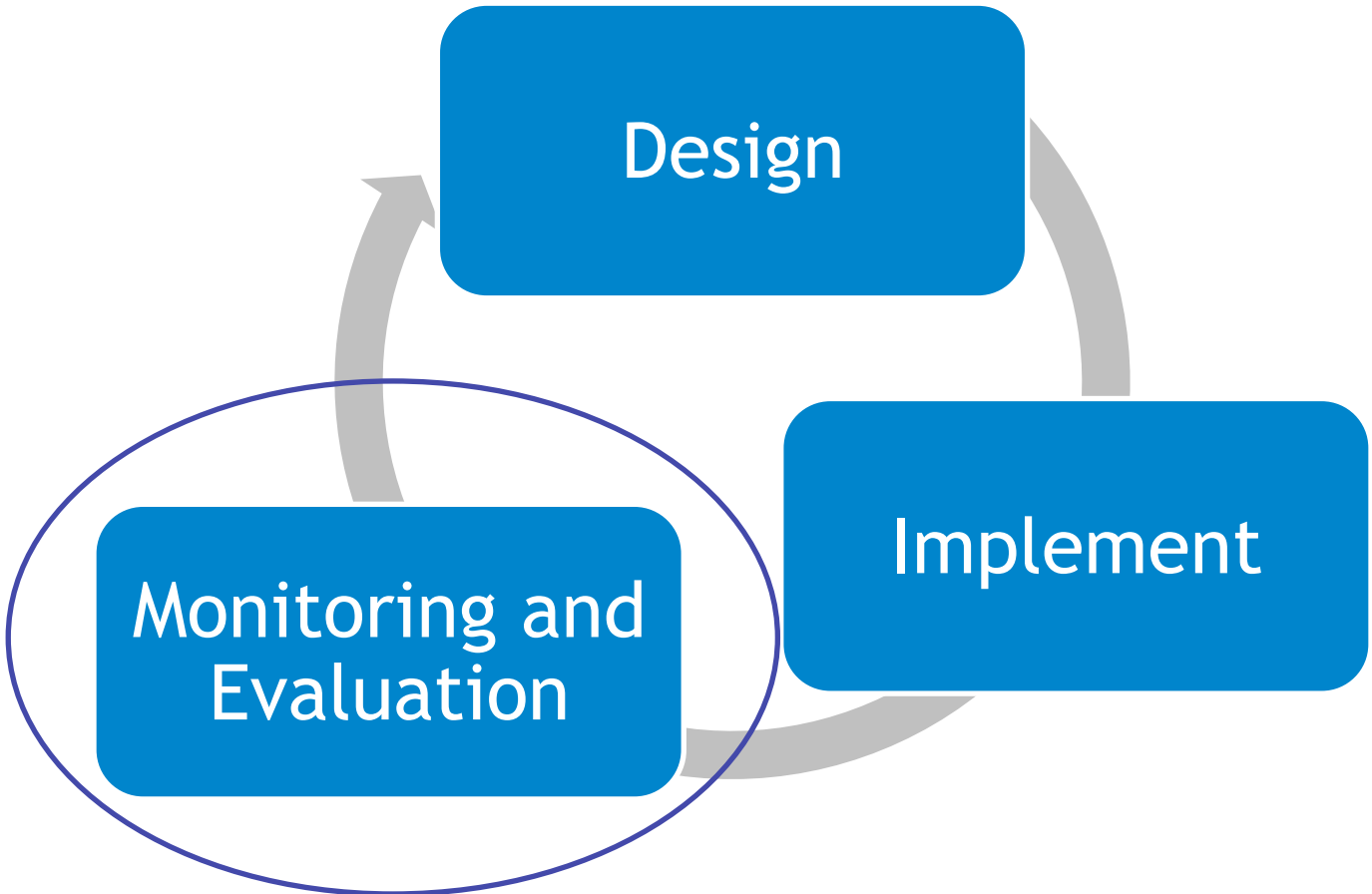
Phases of a vaccination programme

- equally important -



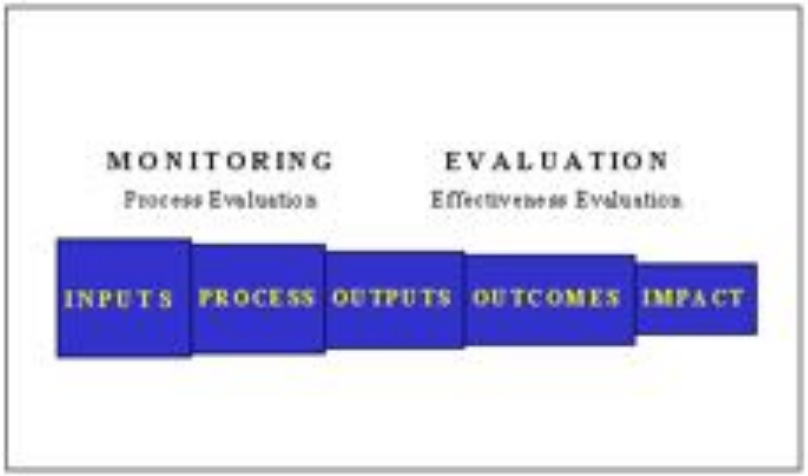
Monitoring is different from Evaluation

Monitoring:

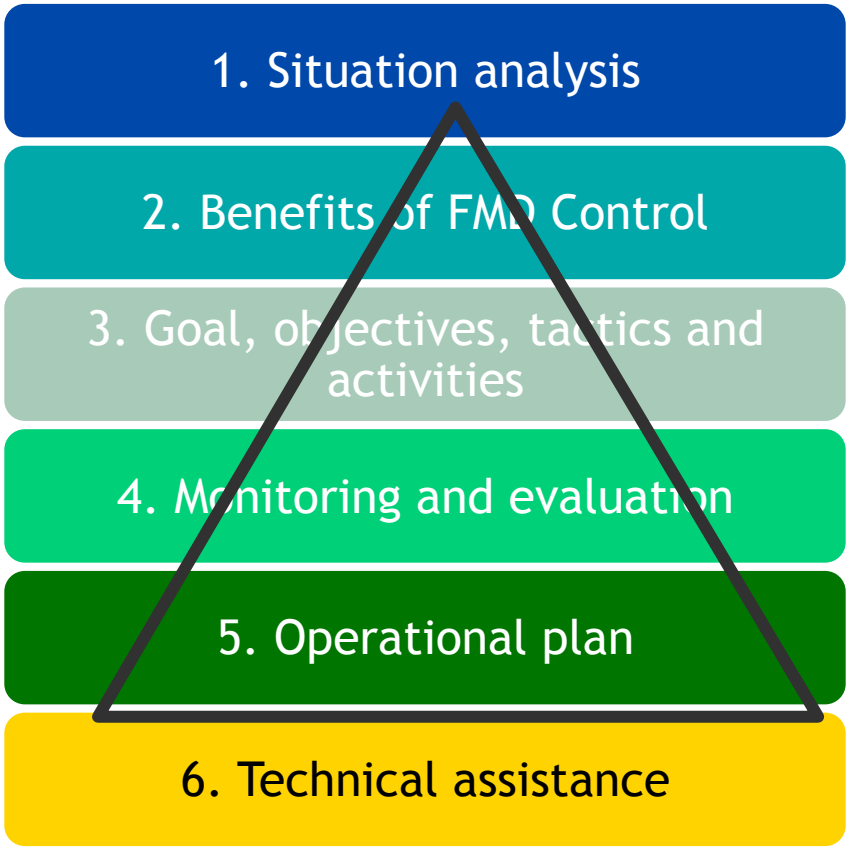
- A continuing function providing management with indications of progress
- Routine data collection and reporting to management
- Triggers actions if performance indicators not achieved e.g. in vaccination coverage or excessive disease

Evaluation

- Periodic event
- Objective assessment of ongoing or completed programme
- Assesses impact and efficiency
- Provides basis for major changes to programmes
- Reports to funding body/stakeholders



Chapter 4 of the Risk Based Strategic Plan



→Focus of EuFMD support is to assist VS to establish capacity for Monitoring and Evaluation (PCP Stage 2-3)

Monitoring principles

1. Identify indicators for measures that are critical to success
2. Identify targets to reach and levels that are not acceptable (triggers)
3. Programme the routine collection of data required and routine reporting of the achievement of indicators
4. Monitoring vaccination programmes:
    1. Coverage : monitoring for evidence targets reached - did animals receive intended level of vaccines?
    2. Immunity: monitoring for herd immunity following vaccination
    3. Impact: monitor for evidence that disease or circulation of virus is within acceptable limits
    4. Include Other critical issues such as cold -chain if critical to success

Why Monitor more than coverage?

- **Because good coverage does not always result in immunity or protection against disease**
- **Because the management and stakeholders increasingly want evidence that vaccination leads to less disease or less circulation**

- **Guidelines: OIE/FAO (2016, expected release mid year). Training can be provided**

Types of impact indicator	How measured
Disease	Herd or village studies: Vaccine Effectiveness (VE) at preventing cases
Virus Circulation	Surveys: Sero-conversion (NSP antibodies), usually 6-12 month age cohort

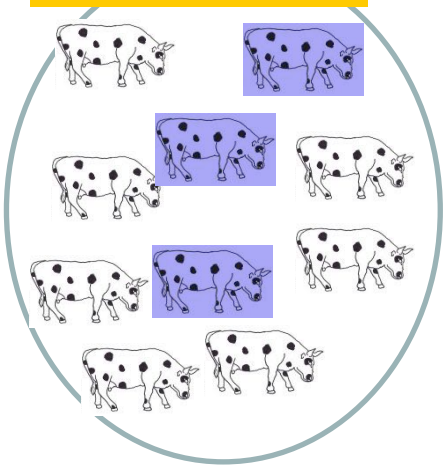
Monitoring impact on disease: field vaccination effectiveness studied in herds recently affected

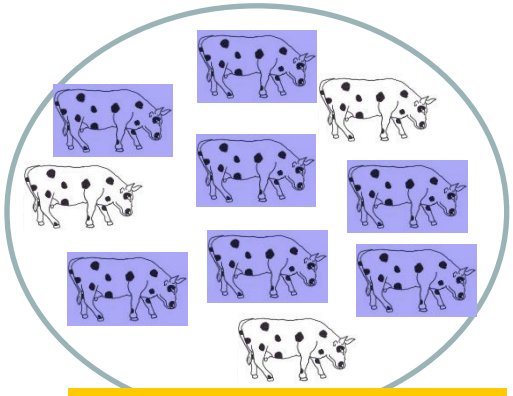
Vaccination effectiveness (VE)

- Level of protection after vaccination

$$VE = \frac{\text{incidence of disease in Vx}}{\text{incidence of disease in non Vx}}$$

Vx population





Non-Vx population

	Clinical FMD	No clinical FMD	
Vaccinated	3 30%	7	10
Non vaccinated	7 70%	3	10

VE = 1 – 0.3/0.7 = 57%

Outbreak after vaccination?

Evaluation of the strategy

✓ **Animal and epi-population immunity induced**

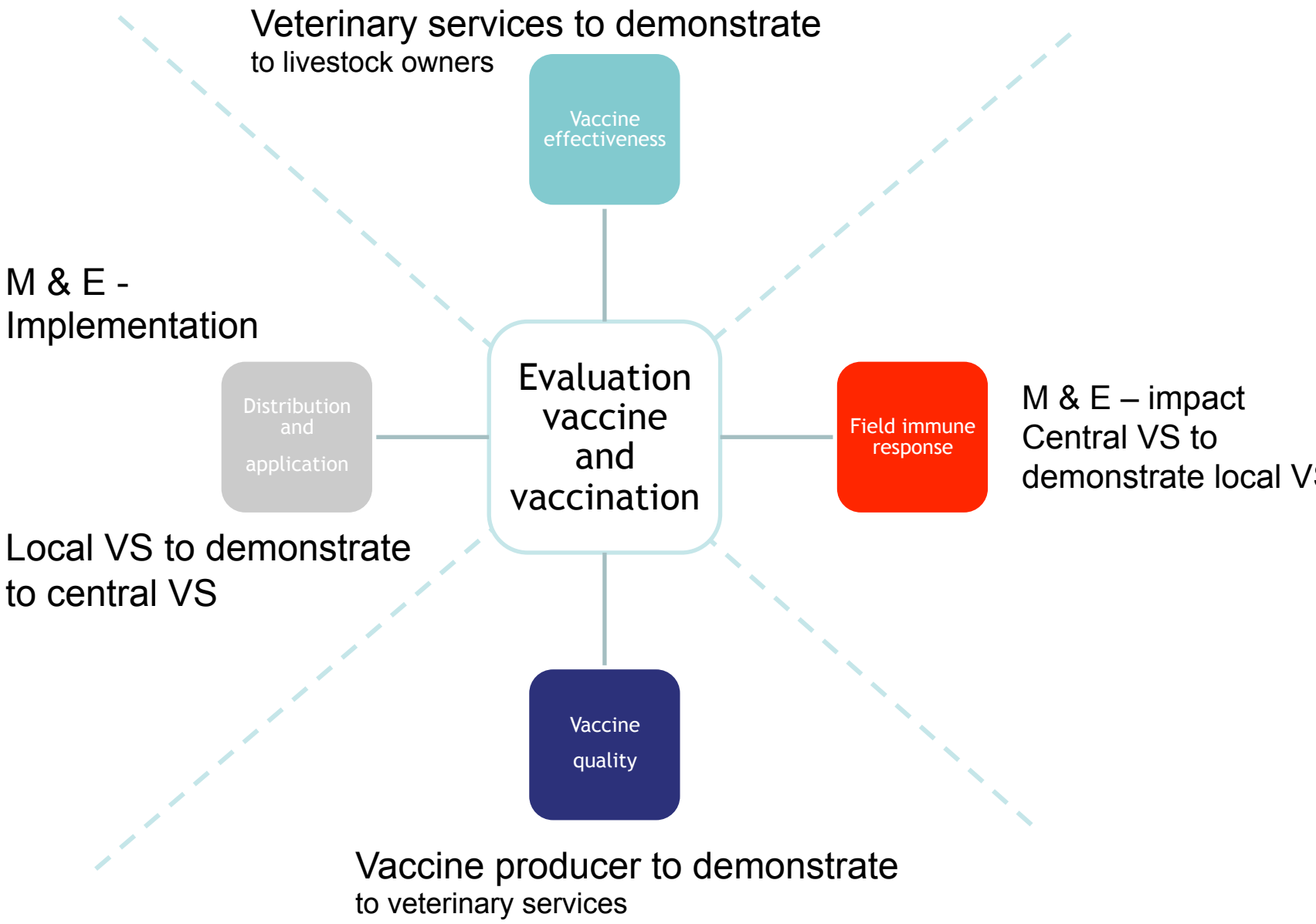
✓**Consistency of the results**

✓**Effective protection**
Comparison of clinical FMD in Vx and Non-Vx

✓ **Duration of immunity**

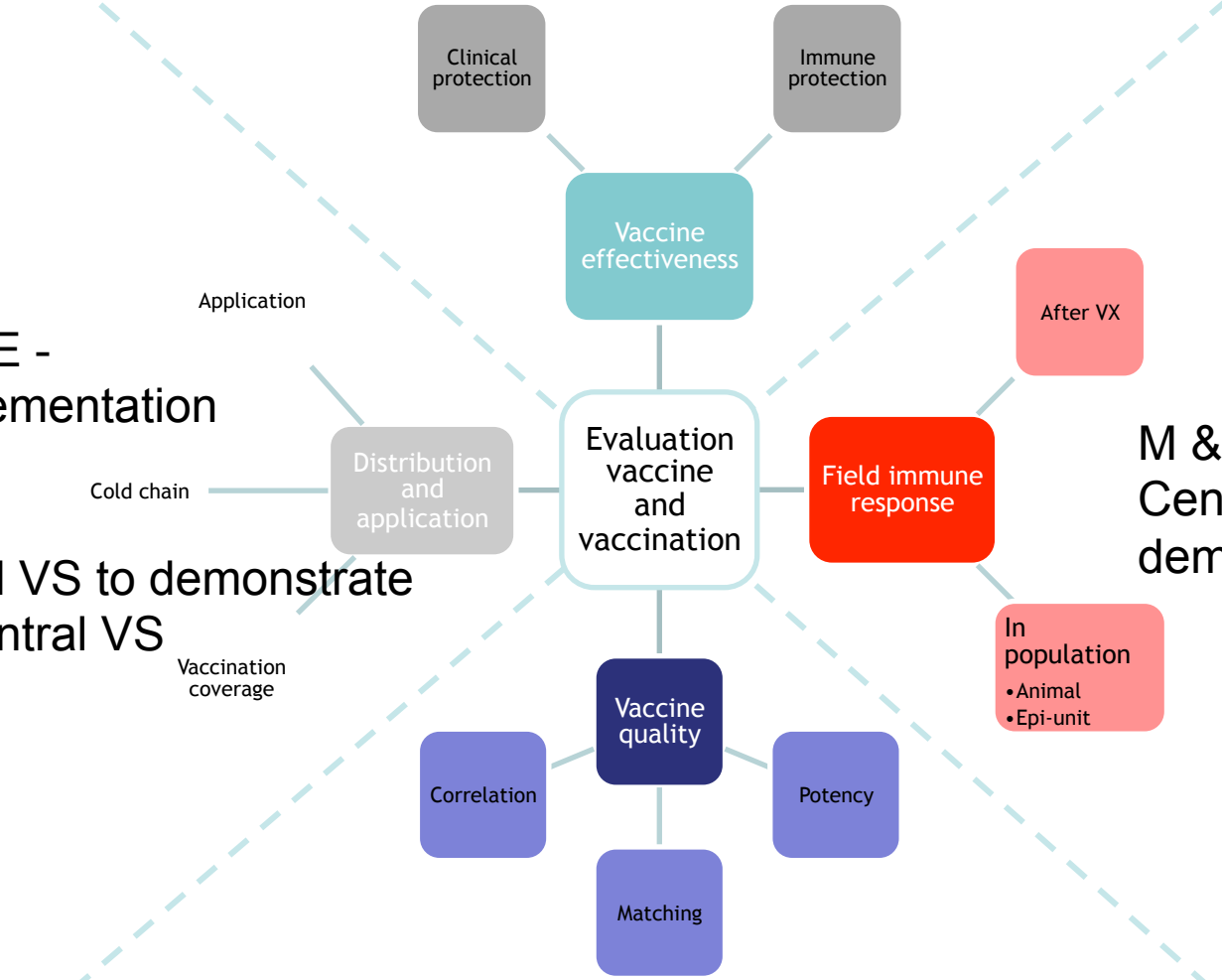
✓**Customer satisfaction**

Overview of evaluation



Overview of evaluation

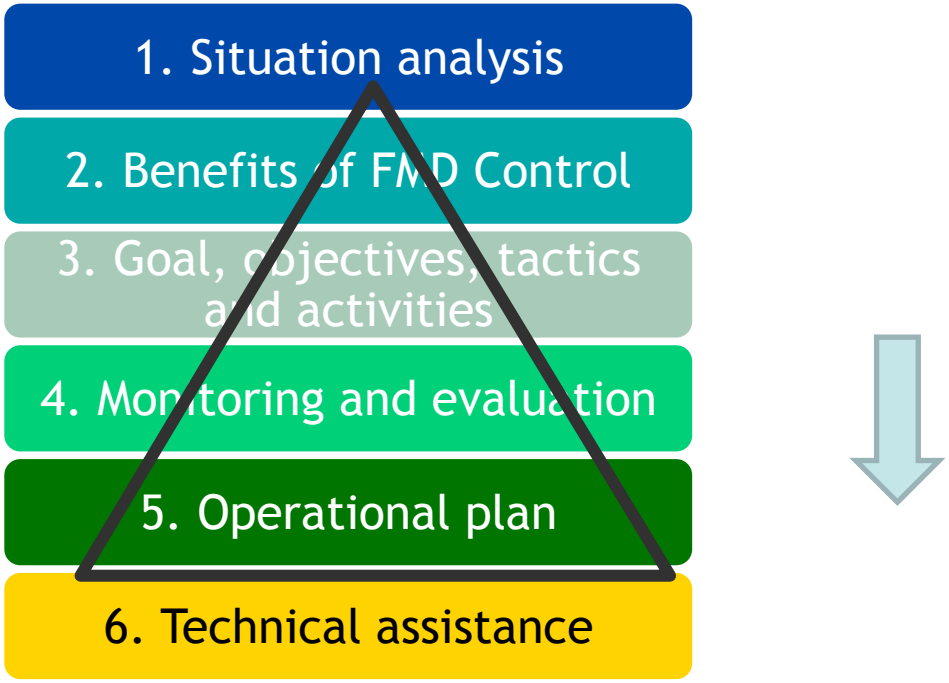
Veterinary services to demonstrate
to livestock owners



Vaccine producer to demonstrate
to veterinary services

National Risk Based Strategic Plans (RBSP)

Excellent Basis for effective, sustainable national control plans



Control of FMD by vaccination is complex: every situation is different

Its not baking a cake…

No recipe book

Ingredients change frequently

So no standard formula works

FMDV: Every new epidemic strain will differ from the previous

Its more like managing a vegetable garden in a desert

Failure is likely..so Identify the key risks

Monitor the key indicators as often as needed to detect problems early

Evaluate every season

Thank you

Merci beaucoup