FMD VACCINES AND THEIR USE IN VACCINATION PROGRAMMES: THEORY AND PRACTICE

Chris Bartels, Melissa McLaws, Naser Rasouli, Theodore Knight-Jones, Keith Sumption
Context

- Endemic FMD region
- EUFMD project activities in Egypt, Iran, Turkey
- PCP-FMD Stage 1 and 2

- Mass vaccination is necessary but not just that!
- Target vaccination programmes using field data
  - Value chain, sero-survey, sequencing etc.
- Learn from what is done and its effect
  - define parameters for implementation and impact
- Support strategy development - decision-making process and its implementation
S - I - R compartmental model

Susceptible (S) → Force of infection → Infectious (I) → Recovery rate → Immune (Recovered)

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Contact structure

Susceptible (S) → Infectious (I)

Effective contact rate between S and I

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Intensity times frequency

High risk

Medium risk

Lower risk

Materials
People
Animal

Probability to transmit infection

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R₀: basic reproduction number

R₀ is the average number of cases that arise from one infected individual when the entire population is susceptible. The critical value is R₀ = 1.
Effect of vaccination

- Susceptible (S)
- Infectious (I)
- Immune (R)

Reduce susceptibility by increasing R
Effect of vaccination

Decrease in transmission of infection as virus load is reduced

Susceptible (S) → Infectious (I)

Reduce susceptibility by increasing R

Immune (R)

Shortening duration of infectious period

Reproduction number will decrease. However, it may not be smaller than 1
Quality of vaccine

Jamal et al., 2008

Infectious (I)
Vaccination implementation

- Susceptible (S)
- Immune (R)
- Infectious (I)

- Herd immunity
- Vaccination coverage
- Cold chain

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Herd immunity

- 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: $R_0 < 1$)

Critical proportion to be protected

- Not vaccinated
- Vaccinated
Epi-unit immunity

However, there is large variability of R-epi unit between
- Species
- Production systems
- Regions/areas
<table>
<thead>
<tr>
<th>Setting a target for vaccination coverage?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at home</td>
</tr>
<tr>
<td>10%</td>
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<tr>
<td>100% → 90%</td>
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<tr>
<td>Home</td>
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<tr>
<td>Total effect 90%</td>
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Setting a target for vaccination coverage?

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100% → 90% → 90%

Home Participation

Total effect 90% 81%

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Setting a target for vaccination coverage?

<table>
<thead>
<tr>
<th>Setting</th>
<th>Not at home</th>
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<th>Cows late pregn</th>
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<tbody>
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<td>100%</td>
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<td>90%</td>
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Total effect: 90% 81% 73%

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## Setting a target for vaccination coverage?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Home</th>
<th>Participation</th>
<th>Cows not late preg</th>
<th>Calves</th>
<th>Sufficient dose</th>
<th>Proportion protected</th>
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</thead>
<tbody>
<tr>
<td>Not at home</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>No participation</td>
<td>100%</td>
<td>90%</td>
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<td>80%</td>
</tr>
<tr>
<td>Cows late pregn</td>
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<td>90%</td>
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<td>90%</td>
<td>90%</td>
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</tr>
<tr>
<td>Calf too young</td>
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<td>90%</td>
<td>90%</td>
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<td>90%</td>
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</tr>
<tr>
<td>Insuff dose</td>
<td>100%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>No immunity build up</td>
<td>100%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
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</tr>
</tbody>
</table>

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

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Time component: Animal turn-over and relative short protection after vaccination

- Susceptible
- Immune (R)
- Infectious (I)

Protective effect of vaccination disappears quickly
It requires more than just vaccination
How best to target vaccination when vaccination is taken as one of the components of FMD control?
Input for revising a vaccination strategy

- Value chain analysis
  - important drivers for animal (and animal product) movements
    - people - stakeholders - are involved

- Level of FMD infection and putative risk factors
  - Sero survey in different husbandry systems, regions, species

- Defining risk hotspots of FMD transmission
  - Need for prioritization of routes of spread

- Cost-benefit analysis of control strategies
Differences between production systems

High impact of FMD

Dairy farms

Common villages

Low risk of getting FMD infection

Low impact of FMD

Beef farms

Trading villages

High risk of getting FMD infection

Differences between production systems

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High risk of getting FMD infection
High impact of FMD

Dairy farms (15%)

Low risk of getting FMD infection

Low impact of FMD

Common Villages (60%)

Trading Villages (10%)

Beef farms (15%)

High risk of getting FMD infection
High impact of FMD

Low risk of getting FMD infection

Low impact of FMD

Primarily young bull calves are transported

Dairy farms (15%) → Beef farms (15%)

Common Villages (60%)→ Trading Villages (10%)
High impact of FMD

Dairy farms (15%) → Beef farms (15%)

Common Villages (60%) → Trading Villages (10%)

Low risk of getting FMD infection

Focus on bull calves for fattening
High impact of FMD

Low impact of FMD

Vaccination of calves before trading + mass vaccination 3x/year

Mass vaccination 3+x/year,

Dairy farms (15%) → Beef farms (15%)

Common Villages (60%)

Vaccination of calves (before trading)

Trading Villages (10%)

Mass vaccination 3x/year

Low risk of getting FMD infection

High risk of getting FMD infection
High impact of FMD

Low impact of FMD

Common Villages (60%)
Vaccination of calves (before trading)

Dairy farms (15%)
Vaccination of calves before trading + mass vaccination 3x/year

Mass vaccination 3+x/year, Beef farms (15%)

Trading Villages (10%)
Mass vaccination 3x/year

Low risk of getting FMD infection

High risk of getting FMD infection

Animal movement restriction
Why and how to monitor vaccination programs?
Vaccine quality
- Proportion protected
- Duration of protection
- Early detection of new strains and serotypes and check for vaccine matching

Vaccination implementation
- Farmer’s compliance
- Motivation of vaccinators
- Correct administration

Animal turn over
- Vaccine availability
- Registration of vaccinations
- Cold chain from vaccine producer to animal

Susceptible (S)

Infectious (I)

Immune (R)

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Key performance indicators

• Implementation
  - KAP for farmers - how do farmers perceive FMD and control against FMD?
    - Knowledge, attitude and practice
  - Cold chain check: use of temperature tags
  - Vaccination coverage: within and between epi-units over one year period

• Impact
  - Vaccine quality assessment
  - Vaccine effectiveness
  - Repeated sero-surveys
  - Number of FMD outbreaks reported
  - Cost benefit analysis

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Vaccine quality assessment

- SAARC Regional Roadmap meeting on FMD:
  - Whatever the origin of the vaccine used in a FMD control programme, the veterinary authority is responsible for vaccine quality (primary vaccine failure).
Vaccine effectiveness - VE

• Reduction in risk of disease experienced by vaccinated compared with unvaccinated individuals in the field (Halloran et al., 1977)

\[
VE = (1 - \frac{Risk_{\text{vac}}}{Risk_{\text{non-vac}}}) \times 100
\]

• ‘Easy’ to study - provides field information
  - Combination of vaccine efficacy and effectiveness
    • Effect of refrigeration, storage, transport, administration in animals → observational results

• Requires good documentation on vaccination and FMD disease history

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Preliminary results from Turkish studies

- Investigation of new Asia-1 *Group I* vaccine
  - Turkish 2011 field strain vaccine
  - Village FMD Asia-1 outbreak investigation in Turkey

  *Cattle from affected barns only*

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>FMD cases</th>
<th>Relative risk [95%CI]</th>
<th>Vaccine effectiveness [95%CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Asia-1 vaccine</td>
<td>No</td>
<td>101</td>
<td>53 (52%)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>63</td>
<td>9 (14%)</td>
<td>RR=0.27 [0.16-0.46]</td>
<td>73% [54%-84%]</td>
</tr>
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Vaccine effectiveness increased after adjusting for confounding (age and sex)

**Vaccine effect**

*But 44% village coverage*
FMD control is risk management requiring tools and conditions

- Legislation
- Knowledge about FMD transmission
- Veterinary Services competence
- Finances
- Stakeholder participation
- Communication
- Mass vaccination
- Biosecurity measures
- Animal movement restriction
- Quarantine
- Identification and registration
FMD control is risk management

support to strategy development, decision-making, implementation and M&E

EUFMD/FAO has a role here

Legislation
Stakeholder participation
Communication
Identification and registration

Knowledge about FMD transmission
Veterinary Services competence
Finances
Plenty of work ahead