Current Vaccinology Considerations in North American Foreign Animal Disease Events – Implications for Foot and Mouth Disease (FMD) Preparedness and Response

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Current Vaccinology Considerations in North American Foreign Animal Disease Events – Implications for Foot and Mouth Disease (FMD) Preparedness and Response

Summary of what I'll share with you today:

Vaccination –	Basic considerations
Aspects of FMD –	Where are we in vaccination?
Newer literature -	What does it tell us?
Implications -	Preparedness and Response

CHAPTER

22

Foot-and-Mouth Disease

Peter W. Mason[1,2] and Marvin J. Grubman[3]

Vaccines for Biodefense and Emerging and Neglected Diseases

CHAPTER

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Foot-and-Mouth Disease

Peter W. Mason[1,2] and Marvin J. Grubman[3]

Vaccines for Biodefense and Emerging and Neglected Diseases

"… It's importance to mankind is confirmed by the fact that FMD virus (FMDV) was the first animal virus discovered…"

CHAPTER

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Foot-and-Mouth Disease

Peter W. Mason[1,2] and Marvin J. Grubman[3]

Vaccines for Biodefense and Emerging and Neglected Diseases

"… vaccines are very useful as part of an eradication campaign in countries where FMDV is enzootic… these vaccines are not ideally suited to control outbreaks in disease-free countries… need for new vaccines…"

Expert Reviews

Development of vaccines toward the global control and eradication of foot-and-mouth disease

Expert Rev. Vaccines 10(3), 377–387 (2011)

Luis L Rodriguez[†1] and Cyril G Gay[2]

Foot-and-mouth disease (FMD) is one of the most economically and socially devastating diseas
affecting animal agriculture throughout the world. Although mortality is usually low in adu

EXPERT REVIEWS

Development of vaccines

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Luis L Rodriguez[†1] and Cyril G Gay[2]

Table 1. Current and ideal profile of foot-and-mouth disease vaccines for global eradication.

Characteristic	Current status	Ideal	Ref.
Prevents infection	No	Yes	[5,6,24]
Onset of protective immunity (dpv)	7[†]	1	[6,19,25]
Broad cross-protection	Only within some serotypes	Across all 7 serotypes	[2]
Duration of immunity	4–12 months[‡]	Lifelong	[11,21,22]
Shelf life (years)	1	>4[§]	[32]
Requirement for high biosafety containment	Yes, growth of large amounts of infectious virus	No, noninfectious or attenuated vaccine virus production platform	[32]
DIVA compatible	Requires antigen purification	Negative marker engineered into vaccine platform	[105]
Ability to rapidly incorporate emerging viral strains	Requires adaptation of field strains	Allows rapid production of new antigens	[32]
Short withdrawal period for food consumption (days)	21–60[¶]	≤21	[32]
Thermal stability	Requires refrigeration	No refrigeration required	[32]
Cost	Moderate	Low	[32]

[†]Vaccines containing high antigen loads can induce partial protection at 4 dpv.
[‡]Dependent on vaccine formulation and species.
[§]Recommendation from Global Roadmap for Improving Tools to control FMD, Agra, India 2006 [106].
[¶]Varies from country to country.
DIVA: Differentiating infected from vaccinated animals; dpv: Days post-vaccination.

Key considerations for vaccines

- USDA for emergency use vaccines is to administer high quality, high potency (6PD50) vaccines which provide a wider spectrum of immunity and also rapid onset of protection
- Vaccines only effective once administered.
- We can withdraw from the 'Bank' only what we deposit in the Bank.
- A stockpile (the NVS) suggests there is 'plenty'; we are not in the land of plenty for the NAFMDVB.

Rev. sci. tech. Off. int. Epiz., 2012, 31 (3), 777-787

Probability of introducing foot and mouth disease into the United States via live animal importation

G.Y. Miller [(1)*], J. Ming [(2)], I. Williams [(1)] & R. Gorvett [(2)]

Summary

Foot and mouth disease (FMD) continues to be a disease of major concern for the United States Department of Agriculture (USDA) and livestock industries. Foot and mouth disease virus is a high-consequence pathogen for the United States (USA). Live animal trade is a major risk factor for introduction of FMD into a country. This research estimates the probability of FMD being introduced into the USA via the legal importation of livestock. This probability is calculated by considering the potential introduction of FMD from each country from which the USA imports live animals. The total probability of introduction into the USA of FMD from imported livestock is estimated to be 0.415% per year, which is equivalent to one introduction every 241 years. In addition, to provide a basis for evaluating the significance of risk management techniques and expenditures, the sensitivity of the above result to changes in various risk parameter assumptions is determined.

Rev. sci. tech. Off. int. Epiz., 2012, 31 (3), 777-787

Probability of introducing foot and mouth disease into the United States via live animal importation

G.Y. Miller [1]*, J. Ming [2], I. Williams [1] & R. Gorvett [2]

Conclusions

The probability of introduction of FMD from live animal importation is only 0.415% per year, which is equivalent to one introduction every 241 years. It may be difficult for governments to appropriately allocate funding for such low probability events. Nonetheless, the potential economic consequences of an FMD introduction are quite large. Thus, a full risk assessment which incorporates the economic considerations along with the probabilities associated in these analyses is warranted. This is beyond

Key considerations for vaccines

USDA for emergency use vaccines is to administer high quality, high potency (6PD50) vaccines which provide a wider spectrum of immunity and also rapid onset of protection

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A stockpile (the NVS) suggests there is ‘plenty’; we are not in the land of plenty for the NAFMDVB.

Consider the contrast of the FMD outbreak in Korea with the potential of an outbreak in IA

There is no magic spigot

Impact of Emergency Vaccination in a Foot-and-Mouth Disease Outbreak in Minnesota, USA

GY Miller, SB Gale, SJ Wells, CE Eshelman

prepare FMD response plans. The objective of the current study was to evaluate emergency vaccination control strategies for a simulated FMD outbreak in Minnesota. The North American Animal Disease Spread Model (NAADSM) was used to develop and compare

Results – application of large scale emergency vaccination can diminish the duration and severity of an FMD outbreak.

ISVEE – The Netherlands, 2012.

CONCLUSIONS

- Models that began in a Dairy Index herd showed greater response to vaccination effect across all measured outputs.
- The application of a large scale, rapidly administered, emergency vaccination program (1500 herds vaccinated per day) greatly diminished the duration and severity of an FMD outbreak, assuming a Dairy Index Herd.
- It appeared that any effect related to delays to deliver vaccine and time to develop immunity was muted when vaccination capacity was 1500 herds per day. This suggests that the importance of more massive scale of vaccination once it begins is more relevant than delays associated with vaccine delivery.

Rev. sci. tech. Off. int. Epiz., 2011, 30 (3), 789-796

Triggers for foot and mouth disease vaccination in the United States

K.B. Parent [1], G.Y. Miller [1, 2] & P.J. Hullinger [3]

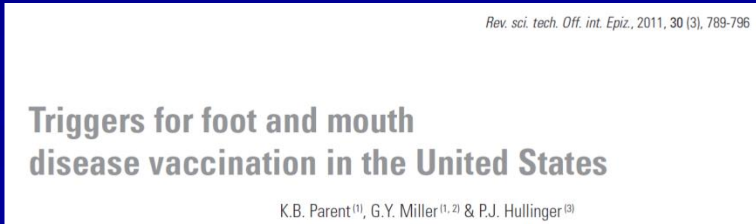
Summary

In the United States, the national policy for foot and mouth disease (FMD) vaccination lacks clarity. To better understand what potential Incident

with an FMD outbreak scenario that started in north-western Illinois and spread across state lines by the end of the fifth week. The scenario had four infected premises at the end of week one, 13 at the end of week two, and 60 (including

Potential Incident Commanders requesting FMD vaccination by week of outbreak scenario

Week	very or somewhat likely	very or somewhat unlikely
1	2 (28%)	5 (71%)
2	4 (57%)	3 (43%)
3	5 (71%)	2 (28%)
4	5 (71%)	2 (28%)
5	6 (86%)	1 (14%)


Rev. sci. tech. Off. int. Epiz., 2011, **30** (3), 789-796

Triggers for foot and mouth disease vaccination in the United States

K.B. Parent [1], G.Y. Miller [1, 2] & P.J. Hullinger [3]

What does other recent research tell us with regard to FMD vaccination

Vaccine 30 (2012) 3106–3111

Contents lists available at SciVerse ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

An alternate delivery system improves vaccine performance against foot-and-mouth disease virus (FMDV)

Mital Pandya[a], Juan M. Pacheco[a], Elizabeth Bishop[a], Mary Kenney[a], Francis Milward[b], Timothy Doel[c], William T. Golde[a,*]

[a] *Plum Island Animal Disease Center, Agricultural Research Service, United States Department of Agriculture, Greenport, NY, United States*
[b] *Merial Animal Health, Athens, GA, United States*
[c] *Merial Animal Health, Pirbright, Surrey, UK*

Vaccine 30 (2012) 3106–3111

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ABSTRACT

Foot-and-mouth disease virus (FMDV) causes vesicular disease of cloven-hoofed animals with severe agricultural and economic implications. One of the most highly infectious and contagious livestock pathogens known, the disease spreads rapidly in naïve populations making it critical to have rapidly acting vaccines. Needle inoculation of killed virus vaccine is an efficient method of swiftly vaccinating large numbers of animals, either in eradication efforts or in outbreak situations in disease free countries, although, to be efficient, this requires utilizing the same needle with multiple animals. Here we present studies using a needle free system for vaccination with killed virus vaccine, FMDV strain O1 Manisa, as a rapid and consistent delivery platform. Cattle were vaccinated using a commercially available vaccine formulation at the manufacturer's recommended dose as well as four and sixteen fold less antigen load per dose. Animals were challenged intradermalingually (IDL) with live, virulent virus, homologous strain O1 Manisa, at various times following vaccination. All non-vaccinated control cattle exhibited clinical disease, including fever, viremia and lesions, specifically vesicle formation. Cattle vaccinated with the 1/16× and 1/4× doses using the needle free device were protected when challenged at both 7 and 28 days after vaccination. These data suggest that effective protection against disease can be achieved with 1/16 of the recommended vaccine dose when delivered using the needle free, intradermal delivery system, indicating the current vaccine stockpile that can be extended by many fold using this system.

Vaccine (2008) 26, 1681—1687

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journal homepage: www.elsevier.com/locate/vaccine

High potency vaccines induce protection against heterologous challenge with foot-and-mouth disease virus

K.E. Brehm[a], N. Kumar[a], H.-H. Thulke[b], B. Haas[a,*]

Vaccine (2008) 26, 1681—1687

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High po heterol disease

K.E. Brehn

ble. Annual vaccination of cattle, which had contributed to the eradication of the disease in many European countries, was ceased in EU member states in 1991 and replaced by a new control strategy [1,2]. This strategy consists mainly of stamping out and movement controls and in appropriate cases, emergency vaccination. For obvious ethical reasons, there is a strong desire to reduce reliance on large-scale culling of animals to control future outbreaks of FMD. Since the storage time of formulated vaccines is limited, several countries and groups of countries have established FMD vaccine banks in the form of concentrated viral antigens stored over liquid nitrogen. It is neither economically or logistically

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the likeliest perceived risk. Because it would take several months to produce a new vaccine from a field isolate contingencies must be based on the use of existing vaccines. While it should be attempted to match the vaccine strains as closely as possible to the field strains against which protection is required, often new variants arise against which no such vaccine is readily available. The most accurate

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High potency vaccines induce protection against heterologous challenge with foot-and-mouth disease virus

K.E. Brehm[a], N

sic potency of different vaccines [7]. Since there is a lack of experimental cross protection studies [8] we investigated the capability of high potency vaccines to induce protection against heterologous challenge and the correlation of protection and neutralization titre of post vaccination sera.

Vaccine (2008) 26, 1681—1687

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dose also the level of protection decreased. Furthermore, in vitro neutralization titres were correlated with protection in vivo. Three vaccines with homologous PD50 values of at least 32 showed significant protection even against heterologous challenge with viruses showing *r*-values below 0.3. In six out of the eight heterologous challenge experiments, the high potency vaccines still conferred a protection of at least six PD50. For comparison, it should be mentioned that vac-

What happened in the 2010 FMD outbreak in Japan?

REVIEW *Virology*

The 2010 Foot-and-Mouth Disease Epidemic in Japan

Norihiko MUROGA[1)], Yoko HAYAMA[1)], Takehisa YAMAMOTO[2)], Akihiro KUROGI[3)], Tomoyuki TSUDA[4)] and Toshiyuki TSUTSUI[1)]*

ABSTRACT. Foot-and-mouth disease (FMD) occurred recently for the first time in a decade in Japan. The index case was detected on a beef-breeding farm in Miyazaki Prefecture, Southern Japan, on April 20, 2010. After confirmation of this first case, control measures such as stamping out, movement restriction and disinfection were implemented. However, these strategies proved insufficient to prevent the spread of FMD and emergency vaccination was adopted. Up until the last outbreak on July 4, 2010, a total of 292 outbreaks had been confirmed, with about 290,000 animals having been culled. The epidemic occurred in an area with a high density of cattle and pigs, making disease control difficult. Invasion of the disease into a high-density area aided its rapid spread and led to difficulties in locating suitable burial sites. Epidemiological investigations indicated that the disease was introduced into Japan approximately one month before detection. This delay in initial detection is considered to have allowed an increased number of outbreaks in the early stage of the epidemic. Nevertheless, the epidemic was contained within a localized area in Miyazaki Prefecture and was eradicated within three months because of intensive control efforts including emergency vaccination. Although this epidemic devastated the livestock industry in Japan, many lessons can be learnt for the future prevention and control of infectious diseases in animals.

KEY WORDS: epidemic, foot-and-mouth disease, Japan, vaccination.

doi: 10.1292/jvms.11-0271; *J. Vet. Med. Sci.* 74(4): 399–404, 2012

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Rapid increase in numbers of infected farms caused destruction delays. Over 100 farms awaiting destruction by mid-May

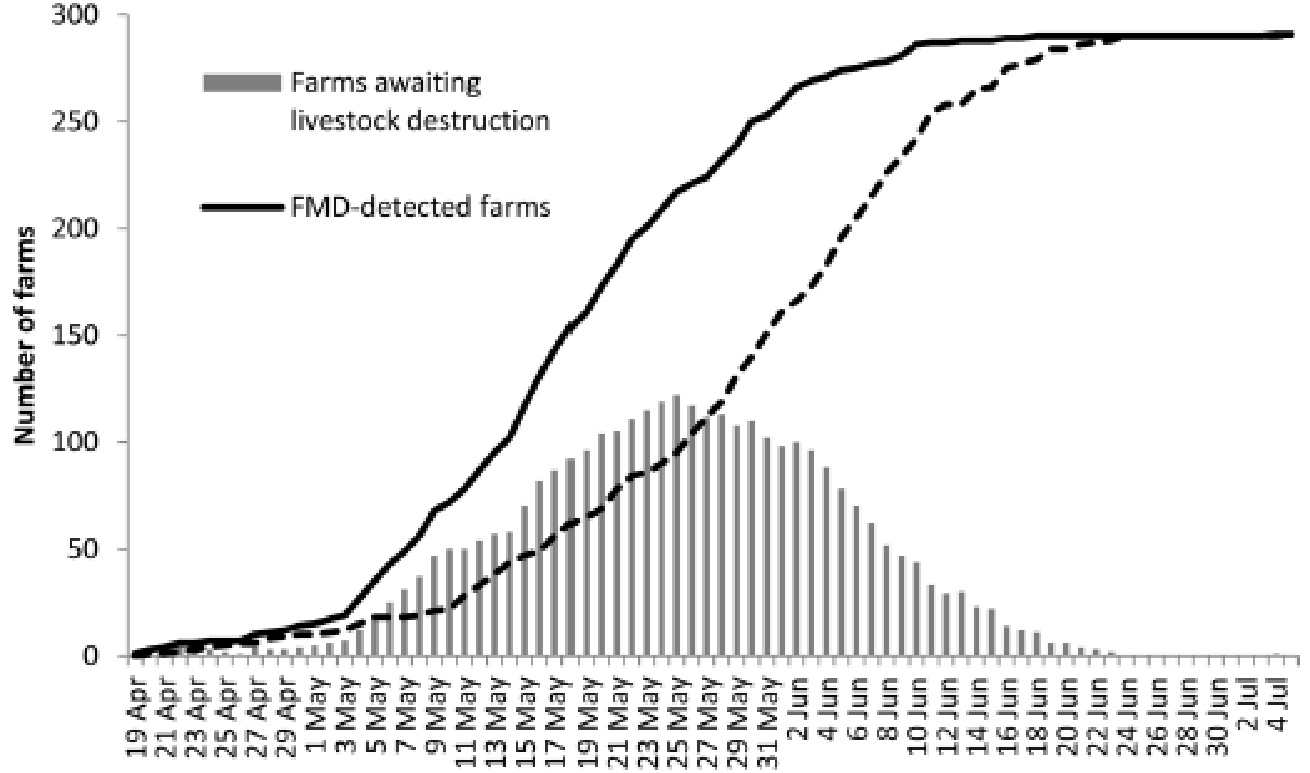

Fig. 2. Livestock destruction at infected farms by date.

J. Vet. Med. Sci. 74(4): 399–404, 2012

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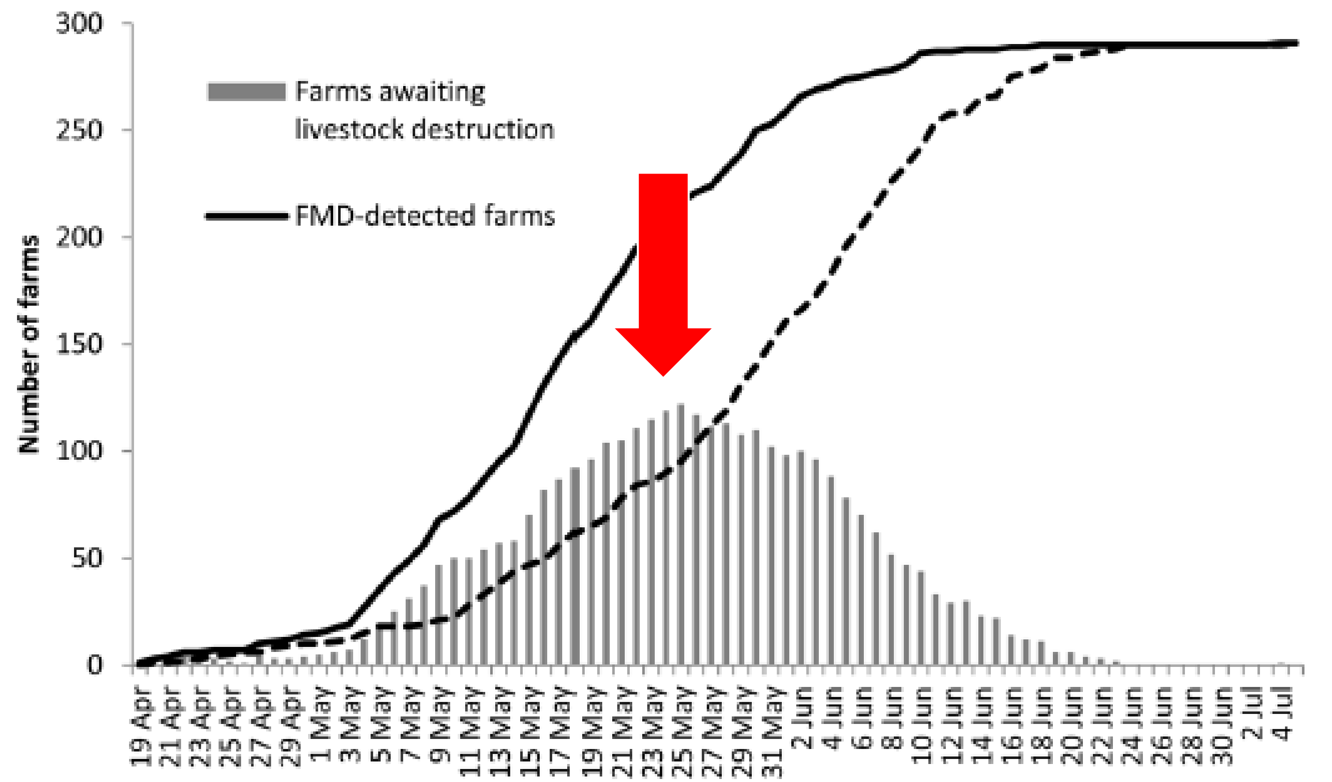
Number of farms exceeded abilities to depopulate. At that point, vaccination was implemented.



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- Primary eradication strategy for FMD in Japan is stamping out and movement restrictions.
- Once emergency vaccination began, all cloven-hoofed animals were targeted.
- Pigs had higher priority than cattle for vaccination.
- All vaccinated animals were subsequently culled and buried.
- Full government compensation paid for all infected, culled and vaccinated animals; COST = US$550 million. Other economic aid also provided.
- Compensation based on market value of the animals.

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Important issues identified from this outbreak:

- First use of Emergency vaccination for Japan
- Vaccination contributed to disease containment
- Disease control difficult in the most densely populated livestock areas
- Finding appropriate burial sites for culled animals difficult
- Burial was challenging – needed also to include incineration and rendering
- Vaccination implemented mainly due to delay from culling known infected premises
- Decision to adopt emergency vaccination at the appropriate time is crucial to minimize losses, although this is difficult to judge
- Various factors important in successful disease containment

J. Vet. Med. Sci. 74(4): 399–404, 2012

Economic impacts of FMD outbreaks high

The economic impacts of foot and mouth disease – What are they, how big are they and where do they occur?

T.J.D. Knight-Jones[a,b,*], J. Rushton[b]

A B S T R A C T

Although a disease of low mortality, the global impact of foot and mouth disease (FMD) is colossal due to the huge numbers of animals affected. This impact can be separated into two components: (1) direct losses due to reduced production and changes in herd structure; and (2) indirect losses caused by costs of FMD control, poor access to markets and limited use of improved production technologies. This paper estimates that annual impact of FMD in terms of visible production losses and vaccination in endemic regions alone amount to between US$6.5 and 21 billion. In addition, outbreaks in FMD free countries and zones cause losses of >US$1.5 billion a year.

Preventive Veterinary Medicine xxx (2013) xxx–xxx

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A B S T R A C T

FMD is highly contagious and the actions of one farmer affect the risk of FMD occurring on other holdings; thus sizeable externalities are generated. Control therefore requires coordination within and between countries. These externalities imply that FMD control produces a significant amount of public goods, justifying the need for national and international public investment.

Preventive Veterinary Medicine xxx (2013) xxx–xxx

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Table 1
Estimated FMD vaccinations by country per year [based on the number of vaccine doses produced, as estimated by leading FMD vaccine manufacturers using expert opinion and industry data (Hamond, 2011)] and the population targeted (based on author's consultations and Wint and Robinson (2007)).

Region	Vaccinations		Population targeted		
	Doses (millions)	%	Species	Population (millions)	% vaccinated[a]
China	1600	68.1	Cattle, shoats, pigs and buffalo	833	192.2
India	150	6.4	Cattle and buffalo	280	53.6
Rest of Asia	50	2.1	Cattle, pigs and buffalo	283	17.7
Africa	15	0.6	Cattle	272	5.5
Europe and Turkey	15	0.6	Cattle	140	10.7
Middle East	20	0.9	Cattle and shoats	167	12.0
South America	500	21.3	Cattle	342	146.1
Total	2350	100.0		2036	115.4

[a] Calculated as the number of vaccine doses × 100/population size; values >100% imply that on average animals were vaccinated more than once a year.

Preventive Veterinary Medicine xxx (2013) xxx–xxx

Economic impacts of FMD outbreaks high

The economic impacts of foot and mouth disease – What are they, how big are they and where do they occur?

T.J.D. Knight-Jones[a,b,*], J. Rushton[b]

Table 5
Estimated impact of FMD outbreaks in free countries (S.O. = stamping out).

Location Year	Taiwan[a] 1997	Uruguay[b] 2001	UK[a] 2001	Japan[c] 2010	Rep. Korea[d] 2010–2011
Costs (US$ millions)					
Direct costs	254	–	3558	550	2780
Indirect costs	6363	–	5646	N/A	N/A
Total cost	6617	700	9204	>550	>2780
Adjusted to value of the US$ in 2011[e]	9450	880	11,600	>568	>2870
As percentage of GDP	−0.64%	N/A	−0.20%	N/A	N/A
Duration (months)	4.5	4	7.5	4	5
Control method	S.O. + Vacc	S.O. + Vacc	S.O.	S.O. + Vacc	S.O. + Vacc
Slaughtered animals	4 million	20,000	6.24 m	2,90,000	3.47 m

Direct losses – e.g. production losses, invisible losses (decreased fertility)
Indirect losses – e.g. control costs, loss of markets, movement controls

Preventive Veterinary Medicine xxx (2013) xxx–xxx

FMD Outbreaks in UK & Uruguay: Compelling argument for vaccination

	UK	Uruguay
Cattle population	>10 million	>10 million
Sheep population	>35 million	>12 million
Pig population	> 5 million	>0.3 million
No. of Infected herds	2,026	2,057
Animals (FMD +) slaughtered	1,227,900	6,937
Total slaughtered	6,600,000	6,937
Duration of outbreak	7 months	4 months
No. of vaccine doses used	0	24 million
Direct cost	US$ 4.6 B	US$ 13 M
Total economic impact	> US$ 10 B	<US$ 400 M

Slide shared by Alfonso Torres, Cornell University; it is important to recognize that these economic impacts do not consider Trade embargoes.

Journal of Reviews on Global Economics, 2012, 1, 47-61

The Economic Impact of High Consequence Zoonotic Pathogens: Why Preparing for these is a Wicked Problem

Gay Y. Miller[1,2,*] and Katie Parent[1]

IMPLICATIONS OF THE ECONOMIC IMPACTS OF FADs AND ZPDs AND WHY PREPAREDNESS IS A WICKED PROBLEM

How much to invest and what to procure for FAD preparedness and response is difficult to determine.

outbreaks. Distributions of estimated impacts are often markedly skewed with a long tail for low probability high economic impacts. However, an actual outbreak, which

The disease involved, the virulence and characteristics of the disease agent, the spread of disease, the species involved, the geographic origin of disease, and the density of the animals in and around outbreak areas, are among many other factors that all influence the manner in which an outbreak unfolds and this varies markedly between outbreaks. It is

Transboundary and Emerging Diseases

Transboundary and Emerging Diseases

ORIGINAL ARTICLE

Factors Associated With Within-Herd Transmission of Serotype A Foot-and-Mouth Disease Virus in Cattle, During the 2001 Outbreak in Argentina: A Protective Effect of Vaccination

B. P. Brito[1,2], A. M. Perez[1,2], B. Cosentino[3], L. L. Rodriguez[4] and G. A. König[5]

Summary

Argentina suffered an extensive foot-and-mouth disease (FMD) epidemic between July 2000 and January 2002, 3 months after obtaining the official FMD-free without vaccination status conferred by the World Organization for Animal Health. This is one of the largest FMD epidemics controlled by implementation of a systematic mass vaccination campaign in an FMD-free country. In 2000, 124 herds were reported as FMD positive, 2394 herds in 2001 and one in January 2002; the total number of cattle herds in the country at that time was approximately 230 000. Estimates of FMD transmission are important to

 • Transboundary and Emerging Diseases. **58** (2011) 387–393

Transboundary and Emerging Diseases

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ORIGINAL ARTICLE

Factors Associated With Within-Herd Transmission of Serotype A Foot-and-Mouth Disease Virus in Cattle, During the 2001 Outbreak in Argentina: A Protective Effect of Vaccination

B. P. Brito[1,2], A. M. Perez[1,2], B. Cosentino[3], L. L. Rodriguez[4] and G. A. König[5]

In this study, the protective effect of the vaccine was evidenced by the association between vaccination and low rate of within-herd transmission. These results are in agreement with early studies, suggesting that emergency vaccination has a protective impact on disease transmission and that there is a decreased transmission rate within the herd even if the vaccine is applied soon before or even few days after initial infection in the herd.(Cox and

 • Transboundary and Emerging Diseases. **58** (2011) 387–393

Economic impacts of control strategies

From Vaccination against FMD I: Epidemiological Consequences, Backer, et al, Prev Vet Med 107 (2012): 27-40.

And From: Vaccination against FMD – Differentiating strategies and their epi and economic consequences. Backer, J, Bergevoiet, R, Hagenaars' T, et al. LEI report 2009-042.

Conclusions regarding economic consequences

- What is the optimal strategy: culling, 2-km or 5-km vaccination? Culling strategy is the economically preferred strategy in SPLAs. Vaccination is the economically preferred strategy in DPLAs.
- In DPLAs with vey high densities of livestock vaccination within a radius of 5km around detected farms results in the lowest costs whereas in other DPLAs vaccination of 2km around detected farms results in the lowest costs.

All models are wrong.
Some models are useful.

Economic impacts – trade considerations

Implications of FMD for the swine/pork industry:

For the first 11 months of 2012: exports were at 27% of total production! Export value at $56.12/head.

Scientific Trade Barriers with FMD will likely be severe

- Sources:
http://www.pork.org/filelibrary/Pork%20Leader/August262010PorkLeader.pdf
http://www.usmef.org/news-statistics/press-releases/u-s-beef-pork-exports-dip-slightly-lamb-rebounds/

OIE

Bottom line related to vaccination:

- **This is quite complex**
- **Unclear of time importers would bar US exports – could easily exceed OIE guidance**
- **Unclear if vaccination would really change the time exports are barred**

Critical response to post-outbreak vaccination against foot-and-mouth disease

G. Chowell, A. L. Rivas, N. W. Hengartner, J. M. Hyman, and C. Castillo-Chavez

1991 *Mathematics Subject Classification.* Primary 92D25, 92D30; Secondary 92B05, 92B15.

ABSTRACT. The effectiveness of vaccinations initiated after the onset of an infectious epidemic (post-outbreak vaccinations or POV) was retrospectively explored by modeling: 1) the days required by the infective agent to reproduce (replication cycle or RC), 2) the time required by the susceptible population to become protected after POV 3) the number, time and location of cases,

Findings support the hypothesis that the time available to achieve effective POV against FMD is brief. Reductions in epidemic size were marginal when POV began at or after the third RC. Because, in this scenario, the earliest time protective antibody levels could be achieved was either 8 days (high-potency vaccine) or 12 days post-outbreak (regular vaccine), the earliest time

third replication cycle of FMDV ($\sim$ epidemic days 9-12)

Risk Analysis, Vol. 30, No. 4, 2010 DOI: 10.1111/j.1539-6924.2009.01327.x

Probability of Exporting Infected Carcasses from Vaccinated Pigs Following a Foot-and-Mouth Disease Epidemic

Clazien J. de Vos,[1,*] Mirjam Nielen,[2] Emelinda Lopez,[2,3] Armin R.W. Elbers,[1] and Aldo Dekker[1]

Emergency vaccination is an effective control strategy for foot-and-mouth disease (FMD) epidemics in densely populated livestock areas, but results in a six-month waiting period before exports can be resumed, incurring severe economic consequences for pig exporting countries. In the European Union, a one-month waiting period has been discussed based on negative test results in a final screening. The objective of this study was to analyze the risk of exporting FMD-infected pig carcasses from a vaccinated area: (1) directly after final screening and (2) after a six-month waiting period. A risk model has been developed to estimate the probability that a processed carcass was derived from an FMD-infected pig (P_{carc}).

Risk Analysis, Vol. 30, No. 4, 2010 DOI: 10.1111/j.1539-6924.2009.01327.x

Probability of Exporting Infected Carcasses from Vaccinated Pigs Following a Foot-and-Mouth Disease Epidemic

Clazien J. de Vos,[1,*] Mirjam Nielen,[2] Emelinda Lopez,[2,3] Armin R.W. Elbers,[1] and Aldo Dekker[1]

calculations indicated that P_{carc} was on average 2.0×10^{-5} directly after final screening, and 1.7×10^{-5} after a six-month waiting period. Therefore, the additional waiting time did not substantially reduce P_{carc}. The estimated values were worst-case scenarios because only viraemic pigs pose a risk for disease transmission, while seropositive pigs do not. The risk of

was declared free incorrectly. Model results indicate that resuming export after a six-month waiting period does not substantially reduce this probability relative to a one-month (or three-month) waiting period.

All models are wrong.
Some models are useful.

The foot-and-mouth disease epidemic in The Netherlands in 2001

A. Bouma[a,*], A.R.W. Elbers[b], A. Dekker[c], A. de Koeijer[a],

outbreaks of FMD occurred. Most of the virus infections on those farms were "neighborhood infections". Because the situation seemed out of control locally and the destruction capacity became insufficient, it was decided to implement an emergency vaccination strategy for all biungulates in a large area around Oene to stop further spread of the virus. All susceptible animals on approximately 1800 farms in this area were vaccinated. All farms subsequently were depopulated, starting from 2

Preventive Veterinary Medicine 57 (2003) 155–166

The foot-and-mouth disease epidemic in The Netherlands in 2001

A. Bouma[a,*], A.R.W. Elbers[b], A. Dekker[c], A. de Koeijer[a],

The transmission of FMDV between herds was quantified for two different periods. The first period (PI) was the interval between report of the first case in the UK and the first outbreak in The Netherlands. The second period (PII) was the interval after the first outbreak in The Netherlands (21 March 2001) and the last outbreak (22 April 2001). The control measures in PI were the standstill of animal transport and the prohibition of livestock markets; the control measures in the second interval were the addition of: depopulation of infected herds; pre-emptive culling of farms within a zone of 1 km around an outbreak; screening and tracing; and emergency vaccination. Because the different

PI = Period One – movement controls and no livestock markets
PII = Period Two – included everything else

Preventive Veterinary Medicine 57 (2003) 155–166

The foot-and-mouth disease epidemic in The Netherlands in 2001

A. Bouma[a,*], A.R.W. Elbers[b], A. Dekker[c], A. de Koeijer[a],

($P = 0.008$). The estimate of β_{I} was 0.13, and of β_{II} was 0.10. The R_{h} of period I ($R_{\mathrm{h,I}}$) was estimated to be 2.6 and R_{h} of period II ($R_{\mathrm{h,II}}$) was 0.71. Thus, the prohibition of transport and markets was not sufficient to reduce the transmission to a level such that R_{h} would become <1. The expected number of secondary cases when $R < 1$, is approximated by

4. Concluding remarks

Culling of infected herds was not a problem, but the capacity to depopulate all herds within an area of 1 km around a case became a problem quickly after the first outbreaks were detected (major infected area was a farm-dense area). Therefore, emergency vaccination was implemented. This has the same effect as pre-emptive culling: reduction of the infectivity of farms already infected but not yet detected, and reduction of the density of susceptible animals and herds within the area. This combination reduces the reproduc-

Preventive Veterinary Medicine 57 (2003) 155–166

Implications for Preparedness and Response

Approaches to Post Vaccination Monitoring

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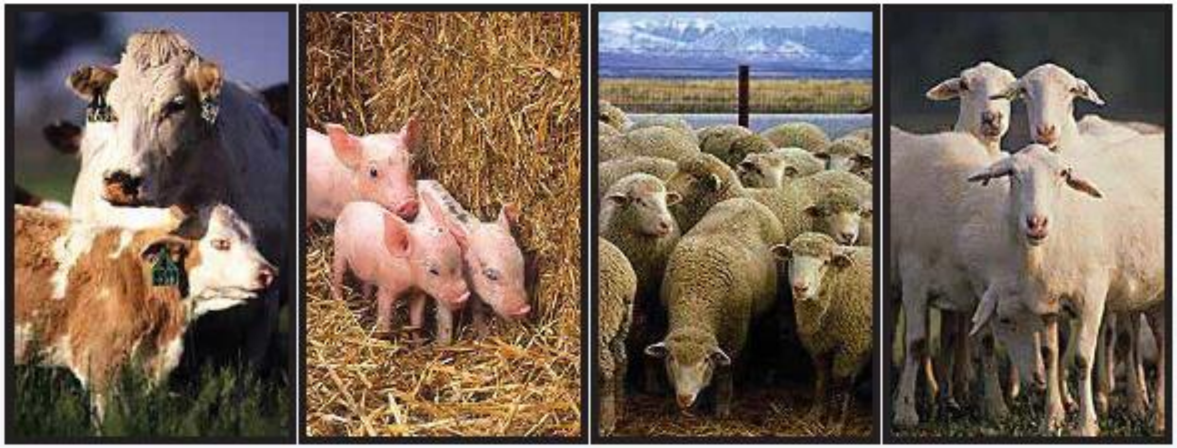

Summary

- **Needs:**
  - Develop PVM to become part of vaccination program
- **Challenges:**
  - Vaccine quality, availability and storage at optimum temp
  - Animal identification
- **Uncertainty:**
  - Country acceptance to implement
  - Transparency!!
- **Gaps:**
  - Vaccine quality control centers
  - Validated PVM screening tools
  - Producers awareness and incentives
- **Recommendation:**
  - Let's do it

US plan for vaccine distribution, and administration.

Granularity in the plan is critical

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Journal of Wildlife Diseases, 49(4), 2013, pp. 759–785

FOOT AND MOUTH DISEASE: A LOOK FROM THE WILD SIDE

Genevieve V. Weaver,[1] Joseph Domenech,[2] Alex R. Thiermann,[2] and William B. Karesh[1,3,4,5]

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ABSTRACT: We review the literature and discuss control options regarding foot and mouth disease (FMD) in wildlife around the world. There are more than 100 species of wild, feral, laboratory, or domesticated animals that have been infected naturally or experimentally with FMD virus. Apart from the African buffalo (*Syncerus caffer*) in sub-Saharan Africa, wildlife has not been demonstrated to play a significant role in the maintenance of FMD. More often, wildlife are passively infected when outbreaks of FMD occur in domestic livestock, and, in some wild ungulates, infection results in severe disease. Efforts to control FMD in wildlife may not be successful when the disease is endemic in livestock and may cause more harm to wildlife, human livelihoods, and domestic animals. Currently in sub-Saharan Africa, the complete eradication of FMD on a subcontinental scale in the near term is not possible, given the presence of FMD-infected African buffalo and the existence of weak veterinary infrastructures in some FMD-endemic countries. Therefore efforts to control the disease should be aimed at improved vaccines and improved use of vaccines, improved livestock management practices, and utilization of programs that can help in disease control such as the FMD Progressive Control Program and regulatory frameworks that facilitate trade such zonation, compartmentalization, and commodity-based trade. Though not meeting the definition of wildlife used in this review, feral domestic

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FOOT AND MOUTH DISEASE: A LOOK FROM THE WILD SIDE

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[5] Corresponding author (email: Karesh@EcoHealthAlliance.org)

Despite conjecture on the role of South American wildlife as a possible reservoir for FMDV, there is no evidence to date supporting that claim.

- World eradication for FMD may not be possible in the near term
- Maybe FMD eradication from the America's is possible?

THANK YOU FOR YOUR ATTENTION!

QUESTIONS?

Drooling more dominant feature in cattle

Lameness a more dominant feature in swine; drooling is rare.

Pictures: http://www.aphis.usda.gov/emergency_response/downloads/nahems/fad.pdf

The Veterinary Journal 188 (2011) 18–23

Contents lists available at ScienceDirect

The Veterinary Journal

journal homepage: www.elsevier.com/locate/tvjl

Review

Foot-and-mouth disease: The question of implementing vaccinal control during an epidemic

A.M. Hutber[a,*], R.P. Kitching[b], J.C. Fishwick[c], J. Bires[d]

Culling and vaccination

With respect to culling (used with or without vaccination) it is noteworthy that the administration of vaccines (1 day) and subsequent immunological boost to immunity (3–4 days) can typically take up to 5 days to achieve: serotyping and matching the vaccine to the challenge strain may add a further day. With effective management, culling can be achieved within 48 h. Vaccination may however reduce the levels of excreted and circulating virus, and the usefulness of vaccination is often impacted by the virulence of a challenge strain against any given species. In turn, the viru-

Economic impacts of FMD outbreaks high

Korea (South and North) 2010-11 Outbreak

- March 8, 2011

"The recent FMD outbreak in South Korea has caused one third of the country's pig herd to be destroyed…"

"3.40 million pigs culled… Before the outbreak, pig numbers in South Korea … 9.9 million. In addition, 151,000 cattle had to be culled".

Full text: http://tinyurl.com/62bwa7g

By any measure, this outbreak was poorly managed.

2010 FMD Outbreak in Korea-Government's Response to this Emergency and Important Lessons Learned

Department of Animal Bio-systems Science
Chungnam National University

Heekwon Ahn

History of FMD outbreak in S. Korea

April - May 2010
Serotype O

4 pig farms and 7 cattle farm in 4 provinces
(50,000 heads of animal within in 500m radius of the affected farms had been culled)

Ending of movement restriction in July 2010

Acquired FMD free status in Sept. 2010

Nov.2010 - March2011
Serotype O

More than 3.5 million heads of animal had been culled

Why has quarantine zone collapsed and FMD spread so quickly ?

- Slack monitoring and belated quarantine measures were the main factors

About 6 days delayed until the laboratory confirmation . Although a suspicious FMD case has been reported on Nov. 23, the authorities took lukewarm action because of the false-negative results from simple FMD test kit.

- Unlike US, Korean farms are gathered in small regions. So the disease spreads quickly and the damage is huge.

Why has quarantine zone collapsed and FMD spread so quickly ?

-Cold weather made disinfectants ineffective because they freeze up antiseptic solutions .

Why has quarantine zone collapsed and FMD spread so quickly ?

Suspected sources of contamination	Contaminated case (270 cases)
Vehicles - Feed delivery	113
Vehicles - Transportation to slaughter house	24
Neighbor farm-sharing road	23
Vehicles- Animal medicine delivery	17
Farm owner-visit to FMD outbreak farms	17
Semen delivery personnel	14
Trucks-Animal manure transportation	11
Visitor	10
Vehicles-Bedding material transportation	9
veterinarian	8
Farm owner-attend the local meeting	6
Artificial inseminator	4
Trucks-Milk collection	4
Infectious disease prevention team	4
Farm owner- visit livestock market	3
Vehicles-Infected animal transportation	3

Vehicles : 181 (67%)
Farm owner : 26 (10%)
Veterinarian, disease prevention team : 30(11%)

US Team members

Dr. Gay Miller, Univ of IL, and adjunct UMN, (Summer appt 2007-2010; USDA, APHIS, VS, EM&D, NCAHEM, NVS)

Dr. Scott Wells, University of Minnesota

Dr. Diego Fridmann, USDA, APHIS, VS, EM&D, NCAHEM

Mr. Richard Nolan, USDA, APHIS, VS, , EM&D, NCAHEM, NVS

Mr. Michael Gallagher, USDA, APHIS, VS, EM&D, NCAHEM, NVS

Dr. Tim Goldsmith, University of Minnesota

Dr. Shelley Mehlenbacher, University of Minnesota

Mr. Steven Downs, 3D Responder and Videographer**,** Clean Harbors Environmental Services

Dr. Harry Snelson, American Association of Swine Veterinarians

Dr. Elizabeth Parker, National Cattlemen's Beef Association

Dr. Jamie Jonker, National Milk Producers Federation

Dr. Marvin Meinders, Department of Homeland Security

Uruguay and Argentina

So when vaccination is practiced - requires an additional 12 months with no FMD outbreaks to receive OIE FMD free status.

FMD free country where vaccination is not practised

2) send a declaration to the OIE stating that:

a) there has been no *outbreak* of FMD during the past 12 months;

b) no evidence of FMDV *infection* has been found during the past 12 months;

c) no *vaccination* against FMD has been carried out during the past 12 months;

FMD free country where vaccination is practised

2) send a declaration to the OIE stating that:

a) there has been no *outbreak* of FMD during the past two years;

b) no evidence of FMDV circulation has been found during the past 12 months;

Recovery of FMD Free Status Vaccination NOT practiced

Article 8.5.9.

Recovery of free status

1) When an FMD *outbreak* or FMDV *infection* occurs in an FMD free country or *zone* where *vaccination* is not practised, one of the following waiting periods is required to regain the status of FMD free country or *zone* where *vaccination* is not practised:

   a) three months after the last *case* where a *stamping-out policy* and serological *surveillance* are applied in accordance with Articles 8.5.42. to 8.5.49.; or

   b) three months after the *slaughter* of all vaccinated *animals* where a *stamping-out policy*, emergency *vaccination* and serological *surveillance* are applied in accordance with Articles 8.5.42. to 8.5.47. and Article 8.5.49.; or

   c) six months after the last *case* or the last *vaccination* (according to the event that occurs the latest), where a *stamping-out policy*, emergency *vaccination* not followed by the slaughtering of all vaccinated *animals*, and serological *surveillance* are applied in accordance with Articles 8.5.42. to 8.5.47. and Article 8.5.49., provided that a serological survey based on the detection of antibodies to nonstructural proteins of FMDV demonstrates the absence of *infection* in the remaining vaccinated population.

   Where a *stamping-out policy* is not practised, the above waiting periods do not apply, and Article 8.5.2. or 8.5.4. applies.

Article 8.5.47. of the OIE Terrestrial Animal Code taken from http://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_1.8.5.htm on 4-3-13.

Four strategies are recognised by the OIE in a programme to eradicate FMDV *infection* following an *outbreak*:

1) *slaughter* of all clinically affected and in-contact susceptible *animals*;

2) *slaughter* of all clinically affected and in-contact susceptible *animals* and *vaccination* of at-risk *animals*, with subsequent *slaughter* of vaccinated *animals*;

3) *slaughter* of all clinically affected and in-contact susceptible *animals* and *vaccination* of at-risk *animals*, without subsequent *slaughter* of vaccinated *animals*;

4) *vaccination* used without *slaughter* of affected *animals* or subsequent *slaughter* of vaccinated *animals*.

The time periods before which an application can be made for re-instatement of freedom from FMD depends on which of these alternatives is followed. The time periods are prescribed in Article 8.5.9.

OIE

Bottom line related to vaccination:

- **Decision to vaccinate is important and will not be made lightly/easily.**
- **OIE recommendations for member countries will be followed.**
- **Trade impacts will be large whether or not vaccination is used.**

Risk and Consequence Management

Risk transfer **is not** risk management.

Consequence transfer **is not** consequence management.

All models are wrong.
Some models are useful.

Use of expert opinion for animal disease decisions: An example of foot-and-mouth disease status designation

R.B. Garabed[a,*], A.M. Perez[b,c], W.O. Johnson[d], M.C. Thurmond[b]

A B S T R A C T

When data representing a preferred measurement of risk cannot be obtained, as is often the case for global animal diseases, decisions that affect millions of people and their animals are typically made based on expert opinion. Expert opinion can be and has been used to address the critical lack of data existing for prevalence and incidence of many global diseases, including foot-and-mouth disease (FMD). However, when a conclusion based on expert opinion applies to a topic as sensitive as FMD, which has tremendous economic, political, and social implications, care should be taken to understand the accuracy of and differences in the opinion data. The differences in experts' opinions and the relative accuracy of an expert opinion elicitation for "diagnosing" country-level FMD presence were examined for the years 1997–2003 using Bayesian methods. A formal survey of eight international FMD experts revealed that individual experts had different opinions as to the probability of finding FMD in a country. However, a weighted average of the experts' responses was relatively accurate (91% sensitivity and 85% specificity) at identifying the FMD status of a country, compared to using a method that employed

Preventive Veterinary Medicine 92 (2009) 20–30

Considerations and Details for US FMD Preparedness and Response

- DIVA (Differentiating Infected from Vaccinated Animals) very important – VAC Bank vs other
- Not all vaccines are DIVA compatible
- Vaccinated animals may become carriers of the virus – field occurrence unknown, but may not occur in a way that is affects transmission risk
- Multivalent vaccines are used in SA – US VAC Bank can specifically target outbreak serotype

Considerations and Details for US FMD Preparedness and Response

- Identification of premises – no mandated ID
- Identification of animals – no mandated ID
- Communication with owners/managers
- Details of vaccine implementation – sketchy
- Personnel, time and other resources – not known

US Consumers lack knowledge about FMD
Confuse FMD with other diseases

Research indicates:

- 72% of consumers think FMD affects humans
- 69% of consumers think people can get FMD from infected meat
- 42% of consumers say they would stop drinking milk if there is an FMD outbreak

Consumers' care most about how FMD will impact them and their family's health. Consumers want guarantees the food they are eating is safe.

From: FMD Cross-Species Communications team 2012 (includes Beef and Pork checkoff, and Dairy Management, Inc.)

Uruguay Mass FMD Vaccination Study

Uruguay Emergency Vaccination Plan

Option 1: ‘Stamping out’ within the affected area and compensation for animals and goods destroyed; resources from the permanent compensation fund.

Option 2: ‘Stamping out’ within the affected area and their contacts within the focal area, ring vaccination around the focal area with further disposal of vaccinated animals.

Uruguay Mass FMD Vaccination Study

Uruguay Emergency Vaccination Plan

Option 3: Ring vaccination within a 10km radius of outbreak, discontinuation of ‘stamping out’ and emergency vaccination in a predetermined area, but not general vaccination of the national herd.

Option 4: Option 3 is evaluated by authorities. If the result is not as expected, then the entire cattle population (national herd) will be vaccinated.

Uruguay Mass FMD Vaccination Study

FMD 2001 Outbreak highlights

End of Outbreak Declared by Uruguay 9-30-01

Uruguay Declared free by OIE 5-22-03

MGAP estimated 95% vaccine protection after 2nd vaccination

24 million doses used in 69 days; ~10 million animals

Vaccine administered mainly by producers

Indemnity paid based on replacement not slaughter value

Uruguay Mass FMD Vaccination Study

February 2010 National Survey Estimated % of Protection

- 56% immunity in cattle under 1
- 84% immunity in cattle 1-2 years
- 94% immunity in cattle over 2

Consider age distribution of cattle in the US.

Question: Would this vaccine used in Uruguay, even with repeated doses (this vaccine efficacy also declines fairly quickly after ~ 2.5 months), provide protection to stop a US epidemic?

Uruguay Mass FMD Vaccination Study

February 2010 National Survey Estimated % of Protection suggests:

Given US cattle age distribution suggests:

Endemic vaccines (such as those used in South America) likely do not provide the protection desired for emergency use.

Human food impacts of FMD

- Impacts will depend directly on response to outbreak
- USDA - initial response could be quarantines and stop movement orders in areas of infection and beyond.
- If it became apparent the US were becoming endemic, would US officials consider allowing recovery in place? Would this occur de facto?
- Would officials allow consideration for vaccination of premises in the face of an outbreak?
- When do we pull the trigger to vaccinate?

Applied Economic Perspectives and Policy (2012) volume 34, number 1, pp. 119–146.
doi:10.1093/aepp/ppr039

Submitted Article

Emergency Vaccination to Control Foot-and-mouth Disease: Implications of its Inclusion as a U.S. Policy Option

Amy D. Hagerman*, Bruce A. McCarl, Tim E. Carpenter, Michael P. Ward, and Joshua O'Brien

Abstract *Emergency animal vaccination has been used in recent international foot-and-mouth disease outbreaks, but current USDA policy favors emergency vaccination use only if standard culling practices alone may not be enough to control spread of the disease. Using simulation modeling, we examine implications of standard culling plus emergency ring vaccination strategies on animal loss and economic welfare loss compared to a standard culling base. Additionally, breakeven risk aversion coefficient analysis is used to examine emergency vaccination as a risk management strategy. Results indicate that response enhanced with emergency vaccination is inferior to standard culling under short diagnostic delays because it causes, on average, greater animal and national economic welfare losses. We find that emergency vaccination does have merit as a risk management strategy, as it can reduce the likelihood of an "extreme" outbreak.*

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Submitted Article

Emergency Vaccination to Control Foot-and-mouth Disease: Implications of its Inclusion as a U.S. Policy Option

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nearby herd disease spread probability is reduced. However, to avoid the trade consequences of being categorized as "FMD free with vaccination" as opposed to "FMD free without vaccination", the vaccinated animals are culled along with infected and direct contact animals.

permits the analysis of trade restrictions and regional level production. In terms of trade, no regionalization[3] is assumed in this study; as a consequence, it is assumed that the United States loses its non-pasteurized dairy and meat export markets. This could occur due to the time neces-

herd. It was assumed that all infected livestock are culled and that some additional exposed animals considered dangerous contacts are also culled.

All models are wrong.
Some models are useful.

Recovery of FMD Free Status
Vaccination NOT practiced

Article 8.5.9.

Recovery of free status

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   a) three months after the last *case* where a *stamping-out policy* and serological *surveillance* are applied in accordance with Articles 8.5.42. to 8.5.49.; or

   b) three months after the *slaughter* of all vaccinated *animals* where a *stamping-out policy*, emergency *vaccination* and serological *surveillance* are applied in accordance with Articles 8.5.42. to 8.5.47. and Article 8.5.49.; or

   c) six months after the last *case* or the last *vaccination* (according to the event that occurs the latest), where a *stamping-out policy*, emergency *vaccination* not followed by the slaughtering of all vaccinated *animals*, and serological *surveillance* are applied in accordance with Articles 8.5.42. to 8.5.47. and Article 8.5.49., provided that a serological survey based on the detection of antibodies to nonstructural proteins of FMDV demonstrates the absence of *infection* in the remaining vaccinated population.

   Where a *stamping-out policy* is not practised, the above waiting periods do not apply, and Article 8.5.2. or 8.5.4. applies.

Recovery of FMD Free Status
Vaccination practiced

2) When an FMD *outbreak* or FMDV *infection* occurs in an FMD free country or *zone* where *vaccination* is practised, one of the following waiting periods is required to regain the status of FMD free country or *zone* where *vaccination* is practised:

a) 6 months after the last *case* where a *stamping-out policy*, emergency *vaccination* and serological *surveillance* in accordance with Articles 8.5.42. to 8.5.47. and Article 8.5.49. are applied, provided that the serological *surveillance* based on the detection of antibodies to nonstructural proteins of FMDV demonstrates the absence of virus circulation; or

b) 18 months after the last *case* where a *stamping-out policy* is not applied, but emergency *vaccination* and serological *surveillance* in accordance with Articles 8.5.42. to 8.5.47. and Article 8.5.49. are applied, provided that the serological *surveillance* based on the detection of antibodies to nonstructural proteins of FMDV demonstrates the absence of virus circulation.

Summary:

- If using ONLY Stamping-out – 3 mo waiting after last case
- If using Stamping-out and vaccination – 6 mo waiting after last case; may ↑ recovery time by 3 mo depending
- If using only emergency vaccination and NO Stamping-out – 18 mo waiting after last case; may ↑ recovery time by 15 mo

Epidemic and economic impacts of delayed detection of foot-and-mouth disease: a case study of a simulated outbreak in California

Tim E. Carpenter,[1] Joshua M. O'Brien, Amy D. Hagerman, Bruce A. McCarl

Abstract. The epidemic and economic impacts of *Foot-and-mouth disease virus* (FMDV) spread and control were examined by using epidemic simulation and economic (epinomic) optimization models. The simulated index herd was a ≥2,000 cow dairy located in California. Simulated disease spread was limited to California; however, economic impact was assessed throughout the United States and included international

national agriculture welfare losses of $2.3–$69.0 billion

median number of infected premises (IP) ranged from approximately 15 to 745, increasing as the detection delay increased from 7 to 22 days. Similarly, the median number of herds under quarantine increased from approximately 680 to 6,200, whereas animals slaughtered went from approximately 8,700 to 260,400 for detection delays of 7–22 days, respectively. The median economic impact of an FMD outbreak in California was estimated to result in national agriculture welfare losses of $2.3–$69.0 billion as detection delay increased from 7 to 22 days, respectively. If assuming a detection delay of 21 days, it was estimated that, for every additional hr of delay, the impact would be an additional approximately 2,000 animals slaughtered and an additional economic loss of $565 million. These findings underline the critical importance that the United States has an effective early detection system in place before an introduction of FMDV if it hopes to avoid dramatic losses to both livestock and the economy.

J Vet Diagn Invest 23:26–33 (2011)

Economic impacts of FMD outbreaks high

The economic impacts of foot and mouth disease – What are they, how big are they and where do they occur?

T.J.D. Knight-Jones[a,b,*], J. Rushton[b]

6. Conclusion

Wealthy countries that have eradicated FMD face ongoing costs from periodic outbreaks and the costs of maintaining preparedness. Many countries reduce the impact of the disease with extensive ongoing vaccination programmes. The global scale and costs associated with these programmes is vast with billions of doses adminis-tered annually. Restricted access to international markets

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ELSEVIER

Virus Research 91 (2003) 101–144

www.elsevier.com/locate/virusres

Review

Control and eradication of foot-and-mouth disease

Paul Sutmoller [a,1,*], Simon S. Barteling [b,2], Raul Casas Olascoaga [c,3], Keith J. Sumption [d]

recovered animals were probably carriers. The introduction of vaccination drastically reduced the incidence and morbidity rates and the amount of virus circulating in the livestock population. In countries in which FMD was controlled by the use of systematic vaccination of the cattle population only, transmission of disease from carrier cattle to non-vaccinated or other susceptible species has not been observed. Also, in situations in which, after a period of 'freedom of FMD', vaccination was discontinued there has been no case of FMD linked to the existence of carriers.