Animal Disease Outbreak

An unintentional introduction of the foot-and-mouth disease (FMD) virus into the domestic livestock population in a U.S. state.

Data Summary

In the following table, note that the low and high likelihoods do not correspond to the low and high impacts. In addition, low and high impacts are not necessarily correlated with each other between different impact categories.

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities	0[1]		
	Injuries and Illnesses	Number of Injuries or Illnesses			
Economic	Direct Economic Loss	U.S. Dollars (2011)	$2.3 Billion	$15.2 Billion	$69.0 Billion
Social	Social Displacement[2]	People Displaced from Home ≥ 2 Days	0	1,000	N/A[3]
Psychological	Psychological Distress	Qualitative Bins	See text		
Environmental	Environmental Impact	Qualitative Bins[4]	Moderate[5]		
LIKELIHOOD	Frequency of Events	Number of Events per Year[6]	0.04	0.1	0.1

Event Background

Foot and mouth disease (FMD) is one of the most devastating diseases affecting cloven-hoof animals such as cattle, swine, sheep and deer. The viral disease is highly contagious, with 7 types and more than 80 sub-types, and vaccination for one type does not confer immunity to the others. Additionally, the FMD virus can survive freezing temperatures but not temperatures above 50 degrees Celsius.[7] Thus far, a pan-viral vaccination that would protect against all types has not been developed. FMD is easily transmitted and spreads rapidly through respiration and through contact with milk, semen, blood, saliva and feces. Pigs are particularly efficient amplifiers of the disease as they shed large amounts of virus into the air, while cattle are highly susceptible to the airborne-transmitted virus, owing to the large lung capacity and high volumes of air these animals respire. The FMD virus remains viable for long periods of time in both animate and inanimate objects and can be spread by contact with:

[1] There are no significant human health implications resulting from a foot and mouth disease outbreak.
[2] See discussion.
[3] A high estimate was not determined.
[4] The United States Environmental Protection Agency (EPA) convened an ad hoc group of environmental experts representing the fields of environmental science, ecological risk, toxicology, and disaster field operations management to estimate environmental impacts for this event. The comments and rankings presented in this Risk Summary Sheet have not undergone review by the EPA and only represent the opinions of the group. Estimates pertain to the potential for adverse effects on living organisms associated with pollution of the environment; they are grouped into high, moderate, low, and de minimus (none) categories.
[5] Floods were given a best estimate of "Low." Experts indicated that the impacts could be higher depending on the acreage required for disposal of infected carcasses. Additionally, there is some potential for contamination to spread into wild animal populations.
[6] Estimates provided by subject matter experts from the Office of Health Affairs (OHA), DHS.
[7] United States General Accounting Office, July 2002; Foot and Mouth Disease: To Protect U.S. Livestock, USDA Must Remain Vigilant and Resolve Outstanding Issues; GAO-02-808; at http://www.gao.gov/new.items/d02808.pdf (accessed 10 March 2013).

- Animals
- Animal products, such as meat, milk, hides, skins and manure
- Transport vehicles and equipment
- Clothes and shoes
- Hay, feed and other veterinary biologics
- Human nasal passages and skin

While there are no significant human health implications of FMD, an outbreak of the disease can have important economic impacts. FMD is found in 60 percent of the world's countries and is endemic in many countries in South America, Africa, Asia and the Middle East. The international community values products that come from FMD-free countries and typically restricts trade in FMD-susceptible products from endemic countries or those affected by an ongoing outbreak. The Office International des Epizooties (OIE), an intergovernmental organization comprised of 158 member countries, was established in 1924 to guarantee the sanitary safety of world trade by developing rules for international trade in animals and animal products. OIE classifies member countries, or zones within countries, as being FMD-free with or without vaccination; the U.S. currently does not vaccinate for FMD and maintains an FMD-free without vaccination status. When an outbreak of FMD occurs in an FMD-free without vaccination country, OIE standards require that country wait 3 months after the last reported case of FMD when a "stamping out" approach has been used for eradication to apply for reinstatement of FMD-free status. If vaccination is used in the eradication process, the country cannot apply for reinstatement of FMD-free status until 3 months after the last vaccinated animal is slaughtered, or 6 months if the animal(s) are vaccinated and not slaughtered. In all cases, serological surveillance evidence must be submitted to prove the disease has been eradicated.

Given the value placed on FMD-free status, a confirmed case of FMD in the U.S. would result in an immediate restriction of exports. The current control strategy (9 CFR 53.4 Destruction of Animals with FMD) in USDA Animal and Plant Health Inspection Service (APHIS) regulations to regain FMD-free status is to stamp out, or cull all infected and susceptible animals.[8] The APHIS Administrator has discretion to examine other options based on the size and/or extent of an outbreak.

Assumptions

Economic Impact

For this scenario, a potential introduction of the disease in California is considered. Although limited to one state, a single case of FMD can be considered a national-level event with repercussions across the country.

Carpenter et al[9] studied epidemic and economic impacts of FMD virus spread and control using epidemic simulation and economic optimization models. The simulated index herd was a single 2,000 cow dairy herd located in California. Although the initial infection was presumed to come from an FMD infected feral swine, similar results would come from any single infected animal introduced to the herd. Disease spread was limited to California, but economic impacts,

[8] United States General Accounting Office, July 2002; Foot and Mouth Disease: To Protect U.S. Livestock, USDA Must Remain Vigilant and Resolve Outstanding Issues; GAO-02-808; at http://www.gao.gov/new.items/d02808.pdf (accessed 10 March 2013).
[9] Carpenter, T.E. O'Brien, J.M. Hagerman, A.D. McCarl, B.A. Epidemic and economic impacts of delayed detection of foot-and-mouth disease: a case study of an outbreak in California. *Journal of Veterinary Diagnostic Investigation*, 23, 26-33 (2011); at http://www.ncbi.nlm.nih.gov/pubmed/21217024, http://vdi.sagepub.com/content/23/1/26.long (accessed 10 March 2013).

including international trade effects, were felt throughout the U.S. There were five separate index detection delays examined, ranging from 7 to 22 days, with 100 iterations each. This led to a median economic impact estimated at $2.3-$69.0 billion, depending on the number of days delay until detection of disease. The "Low" and "High" estimates on economic burden are extrapolated from these numbers. Similarly direct costs and indirect costs are calculated from these totals. The indirect costs may be significantly higher given the variability in the potential costs listed above. The best case estimate is based on a detection delay of 14 days. This number is extremely difficult to estimate since the actual time from infection to diagnosis is impossible to ascertain.

The direct economic impact of an FMD outbreak will come from an immediate reduction in lost international trade as well as disease control and eradication efforts, which include the cost of:

- Maintenance of animal movement controls
- Control areas
- Intensified border inspections
- Vaccines
- Depopulation
- Carcass disposal
- Indemnification to farmers for losses
- Disinfection and decontamination efforts

Indirect costs can include:

- Impacts on local economies
- Loss in upstream/downstream industries
- Reduction in visitorship and tourism loss
- Treatment of groundwater or other environmental remediation necessitated by carcass disposal or burning
- Land value implications on animal disposal property
- Changes in livestock and meat industry structure
- Short term adjustments in meat consumption based on real or uncertain information[10]

Social Displacement

For the purposes of the SNRA, social displacement was defined as the number of people forced to leave home for a period of two days or longer. Note that there are limitations to this measure of social displacement, as the significant differences between temporary evacuations and permanent displacement due to property destruction are not captured.

- For the Animal Disease national-level event, the SNRA project team assumed a low estimate for social displacement of zero.[11]
- The best estimate of 1,000 was provided by subject matter experts from National Consortium for the Study of Terrorism and Responses to Terrorism (START).[12] Experts noted that those working on or near farms may be asked to relocate to reduce the chance of transmitting foot-and-mouth disease to other livestock.

[10] Hagerman, USDA Office of Economic Research Services, unpublished.
[11] Farm animals removed for euthanization as part of control efforts are not included in the SNRA's measure of social displacement.
[12] START is a Department of Homeland Security University Center of Excellence that focuses on social and behavioral aspects of terrorism, natural disasters, and technological accidents, and the social, behavioral, cultural and economic factors influencing responses to and recovery from catastrophes.

- A high estimate for social displacement was not determined for this event.

Psychological Distress

Psychological impacts for the SNRA focus on significant distress and prolonged distress, which can encompass a variety of outcomes serious enough to impair daily role functioning and quality of life. An index for significant distress was created that reflected empirical findings that the scope and severity of an event is more important than the type of event. The equation for this index uses the fatalities, injuries, and displacement associated with an event as primary inputs; a factor elicited from subject matter experts weights the index for differing psychological impact based on the type of event, but as a secondary input.[13] The numerical outputs of this index formula were used to assign events to bins of a risk matrix for a semi-quantitative analysis of psychological risk in the SNRA.

Environmental Impact

The United States Environmental Protection Agency (EPA) convened an ad hoc group of environmental experts representing the fields of environmental science, ecological risk, toxicology, and disaster field operations management to estimate environmental impacts for this event. Estimates are based on the following assumptions:

- Experts were elicited to provide estimates in the environmental impact category based on assumptions. Actual environmental/ecological harm that occurs as a result of the events described in a given scenario may vary considerably, and will depend on numerous variables (e.g., chemical or biological agent, contamination extent, persistence, toxicity—both chronic and acute toxicity—and infectivity).
- EPA defined environmental consequence (impact)[14] as the potential for adverse effects on living organisms associated with pollution of the environment by effluents, emissions, wastes, or accidental chemical releases; energy use; or the depletion of natural resources.
- Experts identified the best estimate for environmental impacts as "Low." Experts indicated that the consequences could be higher depending on the acreage required for disposal of infected carcasses. Additionally, there is some potential for contamination to spread into wild animal populations.

Potential Mitigating Factors

In the event that an FMD outbreak does occur in the U.S., there are four possible strategies for control and eradication of FMD in domestic livestock in the event of an outbreak. Each is supported by critical activities that include surveillance, biosecurity, decontamination,

[13] A Significant Distress Index is calculated from these inputs using a formula proposed by subject matter experts consulted for the SNRA project: $N_{SD} = C_{EF} \times (5\ Fat + Inj + \frac{1}{2}\ D)$, where N_{SD} represents the number of persons significantly distressed, C_{EF} is the expert assessed Event Familiarity Factor, *Fat* is the number of fatalities, *Inj* is the number of injuries and/or illnesses, and *D* is the number of persons displaced (Social Displacement). In words, this formula suggests that there are 5 significantly distressed persons for each life lost; 1 for each person injured; and 1 for each 2 people displaced. This formula was constructed to reflect the empirical finding that the most severe stressor of a disaster is losing a loved one, followed by injury, followed by displacement. Uncertainty was captured by applying the index formula to the low, best, and high estimates of these three human impact metrics.

The Event Familiarity Factor is intended to capture the extent to which the event entails an ongoing threat with uncertainty regarding long term effects, is unfamiliar, or that people dread, exacerbating psychological impacts. This factor, ranging from 1.0 for familiar events to 1.3 for unfamiliar events, was provided by subject matter experts for each national-level event included in the SNRA: Animal Disease Outbreak was given a C_{EF} of 1.0.

The numerical estimates calculated from this formula are reported in Appendix G. The semi-quantitative risk matrix is discussed in the Findings (Psychological Distress Risk).

[14] The 2011 SNRA referred to impacts as 'consequences' because of prior usage in quantitative risk assessment (Kaplan and Garrick [1981, March], On the quantitative definition of risk: *Risk Analysis* 1(1) 11-32). Except where it will cause confusion, 'impact' is used synonymously in this document because of pre-existing connotations of the word 'consequence' within FEMA.

epidemiological activities, movement control, and communication. These four strategies are recognized by the OIE in Article 8.5.47 of the Terrestrial Animal Health Code (2010):[15]

- Stamping out or slaughter of all clinically affected and in-contact susceptible animals.
- Stamping out, modified with emergency vaccination-to-slaughter, which includes slaughter of all clinically affected and in-contact susceptible animals and vaccination of at-risk animals, with subsequent slaughter of vaccinated animals.
- Stamping out modified with emergency vaccination-to-live, which includes slaughter of all clinically infected and in-contact susceptible animals and vaccination of at-risk animals, without subsequent slaughter of vaccinated animals.
- Vaccinate-to-live without stamping out. Vaccination used without slaughter of infected animals or subsequent slaughter of vaccinated animals.

Many factors will be considered when determining whether a particular response strategy would be appropriate and advantageous. While no factor will independently dictate a response strategy, or a decision to employ emergency vaccination, there are many factors that will influence the decision of whether to vaccinate or not. Factors will include:[16]

- Disruptions to interstate commerce
- Disruptions to international trade
- Acceptance of response strategy or strategies
- Scale of outbreak
- Rate of outbreak spread
- FMD vaccine availability
- Resources available to implement response strategies

Additional Relevant Information

Similar to estimating the economic implications, establishing the frequency of an occurrence of FMD is difficult. An outbreak of FMD has not occurred in the U.S. since 1929, so any estimate of frequency or impact can only be based on data from other countries where recent outbreaks have occurred, as well as estimates based on models from current U.S. industry information. The United States has experienced nine known outbreaks of FMD from its first occurrence in 1870 to its final eradication in 1929, indicating a low frequency estimate of approximately 0.04, or 9 events in 235 years in the U.S.[17,18] The highest frequency of occurrence is an estimation based on the recent outbreaks during the previous decade in the United Kingdom, Japan and South Korea. DHS Office of Health Affairs experts estimate a high frequency of once per decade, or 0.1 in a

[15] Foreign Animal Disease Preparedness & Response Plan (FAD PReP)/Foot-and-Mouth Disease Response Plan (The Red Book) USDA Animal and Plant Inspection Service (USDA-APHIS). Chapter 5, General FMD Response, November 2010 draft, at http://www.aphis.usda.gov/animal_health/acah/downloads/documents/FMD_Response_Plan_November_2010_FINAL.pdf; Chapter 4, FMD Response Goals and Strategy, updated (June 2012) draft citing 2011 OIE Terrestrial Animal Health Code, at http://www.aphis.usda.gov/animal_health/emergency_management/downloads/fmd_responseplan.pdf.

[16] Ready Reference Guide to Foot and Mouth Disease (FMD) Response and Emergency Vaccination Strategies, USDA APHIS Veterinary Services, 7/27/2011; incorporated as section 4.4.1 (General Factors that Influence the Response Strategy) of Foreign Animal Disease Preparedness & Response Plan (FAD PReP)/Foot-and-Mouth Disease Response Plan (The Red Book) USDA Animal and Plant Inspection Service (USDA-APHIS), June 2010; at http://www.aphis.usda.gov/animal_health/emergency_management/downloads/fmd_responseplan.pdf.

[17] Foot and Mouth Disease Factsheet. American College of Veterinary Pathologists, July 2012; at http://www.acvp.org/media/factsheet/FootMouth.cfm (accessed 10 March 2013).

[18] Foot and Mouth Disease: A threat to U.S. agriculture. Congressional Research Service, RS-20890, April 16, 2001; at http://www.nationalaglawcenter.org/assets/crs/RS20890.pdf (accessed 10 March 2013).

given year. Since FMD is a highly communicable disease that is resilient and easily obtained, the SNRA project team selected 0.1 in a given year as the best estimate for this event.

While there is no historical data from the U.S. from which to estimate the cost of an FMD outbreak, there have been several outbreaks in other countries in the past decade which emphasize the severity of the impact. Examples of outbreaks include the following:

- In 2001, the United Kingdom (UK) suffered one of the largest FMD epidemics to occur in a developed country in several decades. Approximately 7 million animals were culled and their corpses burned on pyres. The outbreak devastated the nation's farming industry and cost the UK an estimated $11.9-$18.4 billion, including $4.8 billion in losses to agriculture, the food industry and the public sector, $4.2-$4.9 billion in lost tourism and $2.9-$3.4 billion in indirect losses.[19]
- The FMD outbreak in South Korea that occurred in late 2010 and ended in April of 2011 is estimated to have cost that country over $2.6 billion U.S. dollars and resulted in the loss of 3.47 million livestock.[20]
- Japan suffered a similar outbreak in 2010, which cost an estimated $3.14 billion U.S. The Japan and South Korea outbreaks are believed to have been caused by the same FMD virus serotype. The source of the Japan outbreak is believed to be contaminated wheat straw imported from China.[21]

[19] Carpenter, T.E. O'Brien, J.M. Hagerman, A.D. McCarl, B.A. Epidemic and economic impacts of delayed detection of foot-and-mouth disease: a case study of an outbreak in California. *Journal of Veterinary Diagnostic Investigation*, 23, 26-33 (2011); full text http://www.ncbi.nlm.nih.gov/pubmed/21217024, http://vdi.sagepub.com/content/23/1/26.long (accessed 10 March 2013).
[20] 'South Korea reports another FMD case'. Xinhua [China Radio International] , April 20, 2011. At http://english.cri.cn/6966/2011/04/20/2821s633266.htm (accessed 10 March 2013).
[21] APHIS Evaluation of the Foot and Mouth Disease Status of Japan. Veterinary Services, Animal and Plant Health Inspection Service, USDA, April 1, 2011. At http://www.r-calfusa.com/Animal_Health/110401APHISJapanFMDEvaluation.pdf (accessed 10 March 2013).