KEYNOTE: GLOBAL SURVEILLANCE OF FOOT-AND-MOUTH DISEASE: CONCEPTS, CONSIDERATIONS, AND REQUIREMENTS

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ABSTRACT

Introduction
Prerequisite for global control and eradication of foot-and-mouth disease (FMD) is development of a global FMD surveillance program, the main mission of which would be to provide high quality, accurate, real-time FMD surveillance service on a global scale. The objective of this paper is to provoke discussions that hopefully will lead to formalizing steps leading to development of such a program.

Materials and Methods
A global FMD surveillance system should integrate international, regional, and country-specific efforts, all of which can be incorporated in an overarching global framework. In addition to high quality information and data, a functional real-time global surveillance system will require a) an information technology (IT) system with the ability to visualize and analyze data, and b) formal and efficient administration of the system in real time. Data should include, at a minimum, typical data available for incident cases, molecular changes in the virus, animal and human movement, international marketing and currency, and political and social changes, all of which could be surrogates for FMD risk. An IT system would map, graph, visualize, and analyze data. Analytical techniques would include regressive and auto-regressive models, geospatial analysis techniques, phylogenetic analysis, and time-space clustering techniques. Time-space Bayesian models could be applied to assess progress at a local or global scale.

Results and Discussion
The system should identify high risk areas that could be targeted to prevent disease spread, and to monitor evolving risk for FMD virus exposure. Ongoing analysis of risk factors would provide feedback for surveillance sampling by providing estimates of sample sizes and frequency, and targeted areas or time periods for sampling. A goal of such an integrated surveillance system is to have real-time quantitative estimates of changing and projected risks for FMD throughout the world.

1. INTRODUCTION

Current FMD information systems are quite limited because they only provide access to passively collected data that can be considerably generally outdated, and because they do not necessarily provide information that can be used to prevent or control FMD spread. For example, questions that are not addressed by current information systems include: Where is FMD expected to be found today? Where will it be this time next year? What conditions are necessary for the disease to move into another country? Which emerging strains of virus might not be protected by current vaccine strains or might not be detected by current diagnostic assays? What increases the risk of a country acquiring the disease? Which countries or regions should be targeted actively for sampling and information collection? Which specific actions could be taken to control the disease and to minimize risk of FMD transmission and spread?

During the last decade, there has been considerable discussion about the needs for global FMD surveillance. Activities aimed at developing, organizing, and establishing such a system, however, have not taken hold and fundamental decisions regarding the system organization and functionality have not yet been addressed on an international scale. For example, it will be necessary to 1)
identify how and by whom the system should be operated, maintained, and administered; 2) specify operational attributes required by the system; 3) identify which sources of information should be routinely collected; 4) identify which analytical tools to incorporate; and 5) determine how local decision making will be supported by, and incorporated into, the system.

The objectives of this paper are to:

a) Offer ideas, definitions, concepts, and considerations for a global FMD surveillance program, the main mission of which would be to provide high quality, accurate, real-time FMD surveillance service on a global scale;
b) Encourage surveillance research, the results of which promotes and provokes dialogue required to move forward toward formalizing an efficient international surveillance effort;
c) Propose the creation and operation of a global FMD surveillance system developed and operated through a neutral and independent international consortium;
d) Discuss the architecture of a surveillance system, with emphasis on the description of analytical components that allow prediction and assessment of disease risk and virus evolution.

2. MATERIAL AND METHODS

Disease surveillance has been defined as an active, ongoing, formal, and systematic process aimed at early detection of a specific disease or agent in a population or at early prediction of elevated risk of a population acquiring an infectious disease, with a pre-specified action that would follow detection of the disease, agent, or elevated risk [12]. An effective surveillance system necessarily must collect and process information rapidly, which minimizes the time between information capture and sharing the information with decision makers and stakeholders, who can act quickly to control or prevent the spread of disease [12].

A global FMD surveillance system should take advantage of the international, regional, and country-specific FMD surveillance or reporting systems that are currently in place to build the foundations for a global system. The global system should integrate formal and informal sources of information, which would be incorporated in an overarching global surveillance framework.

A global surveillance system should function to identify 'hotspots' of risk, e.g., countries or regions that are at high risk for the disease or where strains that might not be protected by current vaccines or detected by diagnostic assays are likely to emerge. ‘Hotspots’ could be targeted to mitigate the risk for predicted outbreaks and disease spread, and monitored to assess evolving risk for FMD virus exposure. Ongoing analysis of ‘hotspot’ data could feed back into the surveillance system and provide estimates of disease frequency and trends. These estimates could be incorporated into the global system to update risk estimates at local and global levels. The ultimate goals of global surveillance system that incorporates local and regional programs would include to 1) have real-time quantitative estimates of changing and projected risks for FMD throughout the world; 2) obtain data upon which to base recommendations for where, when, and how to intervene in specific regions and how to evaluate the consequences of such interventions; and 3) use results of evaluations to improve and update projected risk estimates. Thus, the system would operate to improve its 'intelligence' through a process of re-evaluation, assessment of new information, and re-estimation that result in updated estimates of risk.

The architecture of a functional real-time global surveillance will require:

a) An information technology (IT) system that can collect, analyze, and communicate disparate sources of data in real, or near real, time;
b) The ability to visualize and analyze data for the purpose of identifying, predicting and anticipating changes in disease risk; and

c) A plan for formal administration of the system.

3. RESULTS AND DISCUSSION

3.1 Information technology system

Current FMD reporting systems are not designed specifically to facilitate communication and data sharing among different laboratories, field veterinarians, farmers and decision makers. Surveillance
IT systems should be designed to permit this kind of communication while being able to selectively restrict confidential or sensitive information, as necessary. A real-time, web-based system, such as the FMD BioPortal (http://fmd.ucdavis.edu/bioportal/), is an example of an IT system that has been developed to retrieve and visualize publicly available data on FMD. The FMD BioPortal became operational in January 2006, and currently provides temporal and spatial visualization of FMD-related data and supports a system for capturing and disseminating FMD-related news items.

An IT system like the FMD BioPortal, would link disparate sources of formal and informal data, such as ReLaIS, WAHID, ProMed, and GLEWS. It also would be able to visualize and analyze data, including estimates of spatial and temporal variation in risk, and other measures of risk. Data handled by the system would include typical incident data, as they are reported and collected now, and also data about molecular changes in the virus, animal and human movement, international marketing and currency changes, political and social changes that could be surrogates for FMD risk, and measures of disease incidence and virus circulation collected actively as part of local or regional surveillance efforts.

3.2 Techniques for data analysis

A variety of analytical techniques should be included as part of an IT system in order to permit estimation of FMD risk, identification of ‘hotspots’, and prediction of virus evolution and spread. Analytical techniques should include, but not be limited to, regressive and auto-regressive models, geospatial analysis techniques, network analysis, risk analysis, time series analysis, phylogenetic analysis, and time-space clustering techniques.

The space- and time-space scan statistics are among the most common analytical techniques for detection of clusters of infectious disease. The scan statistic has been used to detect areas and times of the year at high risk for FMD outbreaks in Argentina [6], Iran [8], Peru [2], and Mongolia [11]. The Knox test K-Ripley’s test have been used to identify the association of time and space with clustering of FMD outbreaks in, respectively, Peru [6] and Argentina [7].

Time-space Bayesian models have been used to predict FMD risk at a global scale, using data on political, social, demographic, and climatic variables, and other surrogate information [4]. Similar models could be useful within the context of a global surveillance system for identifying areas of the world expected to be at high risk for the disease. Such areas could be targeted selectively for sample and data collection and as part of an active disease prevention program. Time-space Bayesian models were also used to assess the relation between epidemiological factors and changes in the FMD virus [10].

Autoregressive Bayesian models also could be applied to assessing disease control progress. Autoregressive Bayesian methods, such as those used to predict FMD risk in Turkey [1], could be used to monitor trends in FMD at a local or broader level, to forecast the risk of the disease and to monitor the impact of control and intervention programs.

Other techniques also could be useful for predicting and assessing disease risk and evolution. Time-series analysis has been used to assess seasonality, secular effects, trend, and influence of different intervention strategies for FMD in Colombia [3]. Geospatial analysis techniques, such as the probability co-kriging, have been used to predict risk for FMD in Pakistan using imperfect incidence data and surrogate information on herd and population demographics [9]. Quantitative models to assess the risk for FMD spread into free countries have been applied in countries such as Spain [5].

3.3 System administration

Support for the operation and development of the system requires both formal administration, which would be responsible for operation and development of the system, and an international funding mechanism. Considerable multilateral input, including broad international guidance and support for collaboration among countries, organizations, and agencies, will be required to develop the funding base and to meet the needs of participating groups. Input from various national and international agencies and organizations will be necessary to develop a conceptual plan for long-term administration, management, and funding. Possible sources of funding and indirect support (e.g., resources, personnel) from countries and agencies interested in participating in the program will need to be identified.

4. AUTHORS CONCLUSIONS
A global FMD surveillance system that provides high quality, accurate, and real-time information on FMD risk is needed to support FMD control and eradication on a global scale.

Epidemiological models should be applied to identify key areas of the world to be targeted for active collection of samples and information, and for monitoring the evolution of the disease as part of the global FMD surveillance system.

A prerequisite for such a global surveillance system is the creation of an international partnership of agencies, countries, organizations, and individuals to initiate conceptual development of global surveillance.

5. AUTHORS RECOMMENDATIONS

- Develop an infrastructure for a global surveillance network for FMD capture, sample collection, reporting, and modelling.
- An international, neutral and independent consortium should explore formally the interest in, and funding for, developing a formal global FMD surveillance system and organization.
- Formulate specific steps necessary for exploration, design, and implementation, as necessary to move the process forward.

6. ACKNOWLEDGEMENTS

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7. REFERENCES


