# DOWNLOAD PDF SPATIAL MODELS AND THE CONTROL OF FOOT-AND-MOUTH DISEASE

## Chapter 1 : Project MUSE - The Geographic Spread of Infectious Diseases

*Abstract: This research presents three complementary models of FMD control. The first model is a spatially sensitive epidemiological representation of disease spread. The second model is integrated with the first model to determine the short and long run regional and aggregate costs and benefits of.*

Mathematical modeling is a. We used statistical tools to explore the dynamics of epidemics and to evaluate the consequences of virus reintroduction in France. We developed a stochastic farm-based model adapted to the French farm structure from previous modeling works following the epidemic in the United Kingdom. This model depends upon the distance between the French farms and on species type e. Since data were only available at the town scale, the farm location and the number of animals in each farm were simulated over the surface area of each French town, as well as the number of mixed farms. Based on simulations of the model, our results allowed for the study of local disease transmission, since it begins simulations once limitation of movement is put into place. On average, the same 50 randomly chosen initially infected farms would lead to 1 infected farms ; 1 when two control strategies culling within 0. Regions with high densities of cows and sheep e. Pays-de-la-Loire are high-risk zones, confirming that the epidemic process depends upon the location and the type of initially infected farms size, species type. The results of this model highlight the importance of Geographical Information Systems GIS to obtain more precise data concerning herds. The disease is caused by a virus belonging to the family Picornaviridae, a member of the Aphthovirus genus. The virus is highly resistant in the environment, can persist outside the host or in animal products for over one month and may be dispersed by wind over long distances [14]. It can be transmitted between herds by commercial movements, either by direct or indirect contact [28]. Infected animals excrete the virus before the end of the incubation period until recovery and the virus is mainly Article published by EDP Sciences and available at http: Le Menach et al. The disease affects sheep, cattle, goats, pigs and all wild cloven-hoofed mammals. The incubation period lasts from 3 to 11 days including a 1â€"4 day presymptomatic period during which the animals are already infectious [15]. The animals then show signs of the disease characterized by fever and anorexia and a decrease in milk yield for 2 to 3 days before exhibiting acute signs. There are species heterogeneities in aerosol excretion and clinical signs: As a result, sheep may be responsible for long-range disease spread through commercial movements. Pigs excrete the virus in large quantities but are much less susceptible than sheep or cows [17]. The same situation was observed in the Netherlands [6]. According to French legislation, when a herd is infected, two buffers are put into place: The infected herd is culled and other strategies, such as preemptive culling or ring vaccination may be used in these buffers [22]. Therefore we may consider the French domestic animal population as entirely susceptible for this study. The majority of work on the mathematical modeling of FMD addresses the â€" and UK epidemics. The first studies used a susceptible-exposed-infectious-removed SEIR [2] model of infection dynamics within the animal population. No spatial or species heterogeneity were taken into account [14]. Nevertheless, exposure to a virus has a spatial component that can influence the spatial spread of the disease: The importance of spatial clustering has been emphasized for several diseases including FMD [13]. Following the UK epidemic, Ferguson et al. No species heterogeneity has been implemented but spatial heterogeneity was taken into account. This model incorporates the effect of national movement restriction into disease spread and concluded that the R0 i. Durand and Mahul [8] developed a deterministic state-transition model derived from a Markov chain, where the unit of concern is an average composite herd and the time step is half a week. The model was used to compare the development of FMD epidemics in two very different regions in France and for control strategies implemented by the animalhealth authorities. Species cows and sheep and spatial heterogeneity were taken into account. The goal of this research was to explore the impact of FMD reintroduction into a given area focusing on direct spread from farm to farm. In order to accomplish this, we developed a farm-based mathematical model applying the Keeling et al. We Modeling dynamics of foot-and-mouth disease Figure 1.

Modeling the infection process. Finally they are classified as Removed R after the animals have been culled. If the farms are located within a certain radius containing an infected farm C , the susceptible farms are classified as the Susceptible control Sc , the Latent one as the Latent control Lc and the Subclinical one as the Subclinical control SCc. They are all classified as Removed within 2 days. This model is a useful tool to evaluate the dynamics of epidemics and the impact of various control strategies on a national scale. Model Our model structure was similar to that of Keeling et al. We built a stochastic SEIR model at the farm level with a 1 day time step. It was reasonable to treat the farm as an individual unit because of the rapid transmission of the virus between the animals. This assumption has been used successfully in past research on rapidly transmissible diseases more especially since animals would be kept within holdings if an epidemic occurred [9, 11, 18]. First, each farm was classified as susceptible S. When the animals of the farm became infected, the farm was classified as Latent L. This period lasted for 4 days and then the farm was classified as Subclinical SC for 5 days [18]. This means that the animals excreted the virus but exhibited no signs or only prodromal signs not detected by the authorities. Then the animals exhibited acute symptoms and the farm was classified as symptomatic infectious C. The animals were culled R in a delay varying from 1 to 3 days according to the UK outbreak data [18]. Thus the infectious period was assumed to be 8 days at the beginning of the epidemic and 6 days at the end Fig. We employed the mean values for disease states, since it has been previously shown that ignoring the distributed nature of the true lags did not significantly impact on either the spatial or temporal pattern of the epidemic [19]. The probability that a susceptible farm i is infected by the neighboring infectious farms j was: It represents the multiplicative relative risk of transmission as a function of the distance from an IP. The probability Pei that a susceptible farm i is infected by an infectious farm j first depends upon the number of cows and sheep in each farm respectively N i , k , N j , k: We consider a Transmission Kernel K d ij that varies with the distance between farm i and j, dij. The kernel represents the relative risk of transmission as a function of distance from an Infected Premise IP and is equal to one if farm i was adjacent to an IP Fig. Third, the probability of transmission was different for the two species, through the parameters Suk and Trk. Suk denotes the relative risk for a cow to catch the disease compared to a sheep â€" also known as the susceptibility parameter. Trk denotes the rate of disease spread â€" also known as the transmissibility parameter Tab. These parameters were estimated by Keeling et al. I for their values. The probability for each farm to be infected by neighboring farms in a 10 km radius buffer [16] was estimated daily and the infection process from the susceptible state to the latent state was assessed by the Monte Carlo sampling method [24]. Next, each latent farm was individually tracked each day and stayed in each state according to the specific mean length of the transition state. In France, we simulated epidemics over a period of days in order to ensure stable results, since the same patterns were observed by repeating several runs of epidemics about 6 h to be complete. The program was written in the C language and the results were analyzed with Matlab v. The model started with 50 initially infected farms; this number was in agreement with what was observed in the UK outbreak2. We randomly chose the 50 initial infected in regards to farm density and kept the same initial infected throughout the simulation runs. We also provided the peak of the epidemic defined as the maximum of the daily mean incidence and the probability that an epidemic ended after one year by calculating the percentage of ended epidemics out of the simulated epidemics. An epidemic was considered over when no cases were reported over 9 days the maximum lag time before the disease is seen by the authorities. Modeling dynamics of foot-and-mouth disease Table I. Values of the parameters Suk Susceptibility parameter and Trk Transmissibility for the two species, cows and sheep. Control strategies The effect of control strategies such as pre-emptive culling and ring vaccination may be studied with this model. A farm, which fell within a selected buffer around an infected farm, could be classified as Contiguous Premises CP and might be culled or vaccinated after a delay of two days2. This concerned Susceptible, Latent and Subclinical farms. The protection was conferred four days after injection and lasted for 4 to 6 months. The vaccine was considered to have no efficacy with animals belonging to Latent or Subclinical farms. In our model, the farms which were infected within the four days after vaccination, were classified as Latent [3, 4, 19, 25] and the farms for which vaccination was not successful were classified as Susceptible. This corresponded to what was observed in the UK outbreak. We explored four other types of control policies: All the farms within the radius buffer around an IP followed control strategies. We used the nonparametric Kruskall-Wallis test [7] to assess the significance of the various control strategies for the number of cases, the number of culled animals and the number of vaccinated animals. Farm network in France For reasons of confidentiality, we were unable to obtain the exact geographic coordinates of the French farms. Among all these towns, 23 owned farms, for a country wide total of approximately holdings with about 20 million cows and about 7 million sheep. The town was assumed to be a square whose boundaries are estimated from its surface area and from the geographical coordinates of its center. We distributed the location of the farms and the number of cows and sheep within each town in the following manner. First, within each town boundary, the location of the farm was uniformly distributed allowing spatial clustering of farms at the town level. The number of animals in each holding was bounded between positive extreme values. This resulted in an empirical right-skewed distribution in agreement with statistics obtained at the town level3 and allowing for more variability than with other known right-skewed distributions. The number of mixed farms i. High-risk zones The model provided a map of high-risk zones for the disease based on the basic reproduction number R0 [1]. It was estimated empirically by simulating infection of an initial farm and then counting the number of secondary cases generated by this farm for the length of the infectious period 8 days at the onset of the epidemic. Once a farm was secondarily infected, its ability to transmit the disease was set to 0. In order to build a map of R0 values, we performed simulations for each of the farms; it took about one month to be complete. Only the farms with mean R0 greater than 1 were represented as a colored square on the map, which allowed us to identify high-risk zones in France.

## Chapter 2 : Spatial pattern of foot-and-mouth disease in animals in China, â€“ [PeerJ]

*The model is intended to support analysis of policies to control foot and mouth disease (FMD) in the Southern Cone. The dynamic nature of the model differs from past models of FMD control and.*

Since eradicating the disease in , the U. Locking out FMD provides benefits in the form of greater productivity and the ability to export into the higher-price FMD-free markets. However, as technical and institutional changes have accelerated the volume of international trade, the capacity of a country to lock out the FMD virus through traditional methods may be questioned. In the last two years, the failure of import controls to hold out the virus from the United Kingdom, France, South Korea and Japan has heightened concerns about the appropriateness of the current U. The proposed research considers an alternative approach of subsidizing FMD control programs in currently endemic regions to reduce the risk of outbreaks in the United States. The long term goal of this project is to contribute to the competitiveness and sustainability of the U. The specific research questions to be addressed here are: Project Methods Various approaches will be used to address distinct research questions. This research will concentrate on the impacts of animal disease control in Argentina, Brazil, Uruguay, and Paraguay. The benefits of animal disease control programs in endemic areas can be evaluated using cost-benefit analysis based on epidemiological and economic models. In such a framework, the net benefits are simply the present value of the flow of incremental returns with the control as opposed to without the control. An epidemiological will describe changes in disease infection rates over time under different control scenarios. Because disease control status varies over time and is subject to uncertainty, the epidemiological model is both dynamic and stochastic. The epidemiological model is linked to the cost-benefit calculation through the relationship between the infection rate and the quantities and prices of products produced. The primary benefit to the U. Quantitative risk assessment QRA will be used to determine how a reduction in the incidence of FMD abroad influences the probability of an outbreak in the U. A simulation model will be used to estimate the costs of an outbreak in the U. The value of risk reduction is taken as the product of a reduced probability of an outbreak and the forecasted cost of an outbreak. To estimate the costs of an outbreak in the U. The combined incremental benefits of disease control in an FMD-endemic country are the incremental net benefits calculated in objective one, plus the benefits to the U. The benefit-cost analysis will indicate whether the combined internal and U. The analysis will suggest the appropriate degree of U. If a group of large exporters eradicated the disease, prices for some types of meat in the FMD-free market would fall, while prices in the FMD- endemic market could rise. Such market effects would influence the scale and distribution of external benefits experienced in the U. If the results from questions 1 through 3 suggest that FMD eradication could be appropriate for a large group of countries which also have high export potential, these issues relating to trade impacts could be addressed in a model of the international livestock market, similar to that in Ekboir et al,  The proposed research would extend earlier work by distinguishing among qualities of meat. While elimination of FMD in other regions would reduce the risk of an outbreak in the U. Evidence of price convergence suggests that the price premium for beef exports from FMD-free countries may be falling. Thus, the potential losses to the U. Meanwhile, because the risk of infection from Latin America is already low, the gains from further risk reduction are also small. In order to assess the net benefits and feasibility of eradicating FMD in the Southern Cone of Latin America, researchers developed improved methods for including epidemiological factors in economic models. The methodological contributions focused on improved spatial modeling of disease impacts over time and analysis of regulatory cooperation among affected countries. The analytical models developed in this project measure the direct economic impacts of an animal disease, the indirect impacts on related sectors of the economy, and the spread of these impacts over time and space under different disease control scenarios. The model has been parameterized for Argentina, Paragruay and Uruguay in order to assess the internal costs and benefits of disease control in those regions under a number of scenarios. Results suggest divergent control strategies and costs in these countries. Because FMD control in Latin America requires international cooperation, researchers assessed the institutional constraints on coordination among countries. This research has extended the literature on spatial coordination by recognizing the importance of heterogeneous incentives, differential sensitivities to neighbors, and hard boundaries on interactions. The methods may be applied within the U. Impacts The published work, presentations and internal reports of this research provide animal health specialists with guidance for improved analysis of the economics of animal disease control. Modeling regional externalities with heterogeneous incentives and fixed boundaries: Applications to foot and mouth disease control in South America. Review of Agricultural Economics. Regionalization and foot and mouth disease control: Lessons from spatial models of coordination and interactions. Quarterly Review of Economics and Finance. Is there evidence of convergence? A review of economic tools for assessment of animal disease outbreaks. Enhancing economic models for analysis of animal disease. Researchers intended to determine the potential costs of an FMD outbreak in the U. During the first year of the project, researchers concentrated on improving methods for including epidemiological factors in economic models. Research in the second year focused on improved spatial modeling of disease impacts and analysis of regulatory cooperation among affected countries. Combined with estimates of the impacts of outbreaks in the U. Concerning the economics of FMD control, we have reviewed methods currently used to assess economic impacts of animal disease and identified areas in which these methods can be improved or extended. We have developed a model of FMD control that is spatial and dynamic and captures both economic and epidemiological factors for national or regional analysis. This multi-market model measures the direct impacts of an animal disease, the indirect impacts on related sectors of the economy, and the spread of these impacts over time and space under different disease control scenarios. Because FMD control in the Latin America requires international cooperation, researchers have assessed the institutional constraints on coordination among countries. In terms of practical implications, the research highlights specific factors that work against international cooperation to address FMD in Latin America. Thus, it suggests issues that could be addressed to improve the probability of successful interventions to control the disease. Impacts Interim findings from this project have been presented in seminars and conferences and disseminated through working papers to economists in government agencies and universities. The anticipated impact of the work is in improved management of animal disease control efforts in the United States and globally. In terms of training, this research project has enabled one graduate student to develop substantial skills in epidemiological economics which can be used in applied economic and multi-disciplinary research. Regionalization and foot and mouth disease control in South America: Regional externalities and spatial interactions with heterogeneous incentives and fixed boundaries: A review of economic tools relevant for assessment of animal disease outbreaks. Elimination of FMD in other regions would provide the U. This research project intended to determine the potential costs of an FMD outbreak in the United States, ascertain the reduction in the probability of such an outbreak through reduced disease incidence in Latin America, determine the impacts on international trade from and into the U. During the first year of the project, researchers concentrated on improving methods for including epidemiological factors into economic models in order to address questions regarding the potential cost of an outbreak in the U. Concerning the economics of FMD control, we have reviewed methods currently used to assess economic impacts of animal disease outbreaks or control in general and identified areas in which these methods can be improved or extended. This work has filled a need for clarification of the capacities and limitations of different approaches for quantifying the economic impacts of animal diseases. Beyond providing a critical review of existing methods, we have developed a model of disease control that is spatial and dynamic and captures both economic and epidemiological factors for national or regional analysis. This multi-market model will measure the direct impacts of an animal disease, the indirect impacts on related parts of the economy, and the spread of these impacts over time and space under different treatment scenarios. The model is currently being parameterized for Argentina, Paragruay and Uruguay in order to assess what the internal costs and benefits of disease control would be in those regions. Ultimately, the net benefits or costs of disease control in Latin

America will be considered in conjunction with the gains to the U. In terms of training, this research project has enabled one graduate student to develop substantial skills in epidemiological economics which can be applied in applied research. Supply constraints and mixed multipliers in input-output models of animal disease control. Preventative Vetrinary Medicine In Review. An assessment of economic tools relevant for consequence assessment of animal disease spread and control.

## Chapter 3 : A Spatial-Temporal ARMA Model of the Incidence of Hand, Foot, and Mouth Disease in Wenzh

*During the foot-and-mouth disease outbreak in the UK, three very different models were used in an attempt to predict the disease dynamics and inform control measures. This was one of the first times that models had been used during an epidemic to support the decision-making process.*

Modify existing simulation model to enable simulation of complex real world vaccination control strategies to be simulated. Evaluate the impact of vaccination as a control strategy in two states with similar numbers of livestock facilities by type. Make results available to state and US regulatory veterinary decision makers and industry. A spatial, epidemic simulation model written in R programming language, will be run to simulate FMD epidemics in California and Indiana. Vaccination constraints, such as number of doses delivered by time and herd type, e. Movement, surveillance and depopulation controls will be implemented, using current USDA recommended guidelines and vaccination will be added as a comparison. Outcomes to be compared are: IPs, epidemic duration, direct costs, and economics. Anticipated results - The data expected are distributions of epidemic size, duration and cost, numbers and types of herds infected, and numbers and types of animals. Comparisons of with and without vaccination will be made for each state. Data analysis - Cost information pertaining to the financial impact of FMD per herd and animal affected has been obtained from a recent evaluation of the economic impact of FMD in California8 and will be updated to reflect new USDA guidelines regarding the personnel and supplies required to control an FMD epidemic. Differences in number of IPs or duration will be further evaluated by calculating the cost for each alternative and combined with an economic equilibrium model Agriculture Sector Model, ASM to evaluate the economic impact of the alternatives examined. The simulated differences will be quantified and compared by different geographic location. Outcomes will be tested using a Kruskal-Wallis, 1-way ANOVA by ranks with a two-sided test of significance adjusted for multiple comparisons. Our findings have been presented in industry news letters as well as agriculture radio and TV shows. We have a well-documented record of disseminating our results. Nothing Reported What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest? Nothing Reported What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? PI left the University of California, Davis. Attempts to reach him have been unsuccessful. Please remove from reporting cycle. PI is no longer with UCD. PI assistant advises to report no activity. Surveys were sent to over salesyard operations. After removing salesyards that are not in operation any more we obtained a data set of geocoded salesyards in the US. Out of these, returned our surveys on sales practices. We developed an algorithm to sample stepwise data for salesyards for which we had incomplete or no information. For each simulated epidemic we recorded as outcome measures the epidemic duration, the total number of infected herds, the total number of culled herds, the total number of infected animals and the total number of culled animals. The outcome measures were compared among six scenarios three different salesyard closure strategies times two different index herds. All salesyard closure strategies closed all salesyards when the first animal was diagnosed with FMD. The first strategy kept salesyards closed throughout the entire outbreak. In the other two strategies re-opened salesyards 50 or days after the onset of the epidemic. Results from this project will will written up for publication in a peer reviewed journal. Additionally the resulting improvement to the DADS model parameter values will provide stake holders with a simulation model that better reflects real world scenarios. Nothing significant to report during this reporting period. Impacts Our results showed generally large effects of the index herd on outbreak size but not outbreak duration. Epidemics that started in large dairy herds were approximately twice as big as epidemics that started in a small dairy herd but persisted for roughly the same duration. Re-opening salesyards had small effects on any outcome measure. These effects were not statistically detectable among the herd-level outcome measures despite the large sample size. This was true even when salesyards were re-opened after 50 days, a time when most epidemics were still active. Our results suggest that localized movement bans around known infected herds and rapid slaughter of diagnosed herds might be sufficient to bring an FMD epidemic under control. Re-opening salesyards before the end of an outbreak might be a viable option. More analysis is required to determine whether these results are robust for a range of starting conditions and model assumptions. Model users may determine the vaccination radius around diagnosed infected premises, to which species receive vaccination, time for vaccination to take effect in days, and vaccine efficacy. The selected scenarios were as follows; 2 states California, CA and Indiana, IN , 2 index premises types dairy and swine with and without vaccination for 8 total scenarios. Parameters included in the model were: Data were presented at the first Epidemics conference in December in Asilomar. Addition of vaccination to the simulation model allow us to now analyze various control strategies for decision makers. The research findings have been presented at academic conferences and in seminars to visiting international delegates. Direct and indirect contact rates among dairy herds". Epidemics conference, Asilomar, CA, Dec , Not relevant to this project. Decision makers therefore need a variety of control strategies that will be optimal in different situations. Vaccination was found to reduce epidemic length and total numbers of animals infected, however, constraints on vaccine availability may reduce overall effectiveness and this should be studied along with varying vaccination radii in order to ascertain the optimal strategies. Cattle movements and other contact rates among beef herds in California, with reference to the potential spread and control of foot-and-mouth disease, JAVMA Vol. Use of heterogeneous operation-specific contact parameters changes predictions for foot-and-mouth disease outbreaks in complex simulation models. Prev Vet Med 87, Duration, number of infected premises and culled animals, and spatial distribution of infected herds, resulting from the simulated outbreaks, varied considerably among geographic regions, depending on index case type and location. Outbreaks beginning in the south region of California were consistently longest, while those beginning in the north region were shortest. The largest outbreaks resulted from index cases located in the south and valley regions, while outbreaks were the smallest when originating in the Sonoma or north regions. For all regions, when the index herd was a dairy, size and duration of the outbreak were consistently reduced with implementation of a 3-day or longer SWMB. Impacts Results show that following the introduction of FMDV from wild pigs into a dairy or beef herd, it could result in a large and rapidly spreading outbreak, potentially affecting large numbers of herds. The size and duration of the outbreak can be reduced with an SWMB; however, the impact is highly dependent on the index herd type and location. Potential impact of an introduction of foot-and-mouth disease from wild pigs into commercial swine and dairy premises in California, submitted to American Journal of Veterinary Research, in press. In addition an online survey was released nationally in to gather similar data on a national level. In a graphic user interface GUI was created for the model which allows non-programmers to run scenarios for various states. Presentations made during this period are given below; Invited Presentation - T. Carpenter Criticality Study Workshop: Impacts The data collected have allowed direct and indirect parameters to be calculated for this larger geographic area and the model has been expanded to run for the state of California. Information gathered regarding movements of animals has resulted in a new shipping distance parameter. Responses are still being collected from the national survey and the model has been scaled up to run on the national level. Currently it is parameterized with the data collected in California; however, once the national data have been analyzed these will be used to make changes as necessary to model parameters. Simulation runs performed in California have looked at various scenarios including the use of alternative ring vaccination strategies, use of movement controls, the importance of knowing accurate livestock facility locations, and resource constraints for example limited amounts of vaccine. The model now runs on a node computer cluster and measures were taken to increase the speed with which simulations run. As a result the model can not only be run at the state level but also nationally. Ring vaccination and surveillance strategies, and vaccination versus depopulation strategies have been evaluated. Model output suggests that vaccination is the optimal strategy if vaccination-to-live were an option. Vaccine constraints were identified and results suggest that when vaccine is limited, for an outbreak of FMD in California, vaccine should primarily be used to vaccinate dairy animals.

# DOWNLOAD PDF SPATIAL MODELS AND THE CONTROL OF FOOT-AND-MOUTH DISEASE

Model validation with UK data is currently being done. E, and Thurmond, M. Results of a survey of owners of miniature swine to characterize husbandry practices affecting risks of foreign animal disease. Biosecurity practices and travel history of individuals exhibiting livestock at the California State Fair. A dynamic optimal disease control model for foot-and-mouth disease. Model results and policy implications, Preventive Veterinary Medicine. The role of contact parameters, Preventive Veterinary Medicine. Comparing effectiveness of regional and circular intervention zones in case of a foot-and-mouth disease outbreak to be submitted to Preventive Veterinary Medicine or American Journal of Veterinary Research In progress Kobayashi M. Model description, Preventive Veterinary Medicine. An individually animal based intra-herd disease transmission model, to be submitted to Preventive Veterinary Medicine or American Journal of Veterinary Research. To date we have found that vaccination, if vaccinates were permitted to live, was the optimal strategy. Vaccine resource contraints have been identified. Impacts Identification of control strategy contraints will be identified. Time to diagnosis of the index case has been made variable, local area spread is now encorporated in the model, regional in addition to ring-based controls are now permitted, and the model is currently modified to run on a computer cluster, greatly enhancing its speed. Contact data have been collected for California and they are being analyzed statistically. Results will be forthcoming. Impacts The spatial epidemic simulation model will be used to reduce the economic and health impact of foot-and-mouth disease if it were introduced into the United States. To date, premises have been geolocated and animal and movement patterns determined and statistically summarized. Simulation runs have been conducted to estimate the spread and control of FMD if it were to be introduced into that area.

## Chapter 4 : Simulation Modeling of Foot-and-Mouth Disease Spread and Control - UNIV OF CALIFORNIA

*A model of epidemic dispersal (based on the assumption that susceptible cattle were homogeneously mixed over space, or non-spatial model) was compared to a partially spatially explicit and discrete model (the spatial model), which was composed of differential equations and used geo-coded data (Euclidean distances between county centroids).*

This is an open access article distributed under the Creative Commons Attribution License , which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The proposed model has two advantages: In the county-level analysis, we find that after first-order difference the spatial-temporal ARMA model provides an adequate fit to the data. Introduction Hand, foot, and mouth disease HFMD is a common infectious disease which usually affects children, particularly those less than 5 years old and younger. It is characterized by a distinct clinical presentation of fever or vesicular exanthema on their hands, feet, mouths, or buttocks [ 1 â€" 5 ]. The transmission of HFMD occurs from person to person through direct contact with saliva, faeces, vesicular fluid, or respiratory droplets of an infected person and indirectly by contaminated articles [ 1 ]. After a susceptible individual is infected he firstly enters the incubation period of HFMD, which is about 3 to 7 days. After the incubation period, the infected will show some clinical symptoms, such as having a fever, poor appetite, malaise, and sore throat, and few people may develop dehydration, febrile seizures, encephalitis, meningitis, cardiomyopathy, and so forth. And the infected people will fully recover after 7 to 10 days [ 1 ]. At present, there are still no available effective vaccines or drugs against HFMD human use, but such vaccines are being developed [ 6 ]. In , for instance, an epidemic in mainland China involved 2,, cases and deaths [ 2 ]. HFMD has become an emerging public health concern in the affected countries and a focus of increasing amounts of research [ 4 ]. Therefore, it is important to use mathematical models to improve our understanding of infectious disease dynamics of HFMD and to help us develop preventive measures to control infection spread qualitatively and quantitatively. There are several types of analytical models that are valuable to understand and predict the transmission of HFMD. One is compartmental differential equation model [ 8 â€" 15 ], which is important to understand the spread dynamics of HFMD among the susceptible populations and to enable policy makers to take effective measures to curb the disease spread and reduce the adverse impact of the disease [ 9 , 10 ]. Of them, Hu et al. All these studies increase our understanding of the distribution and severity of the disease. However, potential factors influencing the incidence of HFMD remain little understood. Wenzhou is a prefecture-level city in southeastern Zhejiang province in China. At the time of the Chinese census, 9,, people lived in Wenzhou [ 30 ]. Since Wenzhou has a humid subtropical climate zone with an annual average C F , it is of particular public health significance to update molecular epidemiology of HFMD in Wenzhou. The location of Wenzhou in China. However, spatial effect has not been considered in [ 15 ]. And in [ 4 , 5 , 28 ], the authors utilized spatial models to determine the risk factors of the incidence of HFMD and found that monthly average temperature, relative humidity, and total sunshine were important factors to affect the incidence of HFMD. However, their models have low power of prediction because future incidence rate is dependent on future risk factors. The goal of this paper is to explore a model that could describe spatial-temporal effects and that has the ability to forecast. Unlike [ 4 , 5 , 28 ], we do not take the risk factors into account. Based on the monthly observed data of HFMD in each county of Wenzhou [ 7 ], we present a spatial-temporal autoregressive moving average ARMA model and give a general Bayesian framework for parameter estimation. The paper is organized as follows. In Section 2 , we give a method to preprocess the original data and propose a spatial-temporal ARMA model. Finally, we give a brief discussion. According to the records obtained, all the cases were children aged between 0 years and 14 years, with county-specific case numbers varying from 0 to incident child cases. The HFMD dataset lists the number of incident cases in each county per month. It reflects the occurrence of the disease in different regions. However, it cannot reflect the risk of infecting the disease because of the different population sizes among counties or municipal districts. To reduce the influence of population size, cumulative incidence CI is utilized to reflect the risks of infecting HFMD in each county. It measures the disease frequency during a period of time [ 31 ]. However, cannot be used to compare the disease risk between different counties directly because of random effects. In fact, they had HFMD cases in other months. Thus, we use a hierarchical Bayes model to adjust CI [ 32 ]. The spirit of the idea to improve accuracy in the model is smoothing strength among counties. The model is as follow: That is, where is the spatial adjacent matrix defining the connectivity between counties. To perform Bayesian analysis, we assign gamma distributions with a large variance as the priors for the parameters and , and the trick is mostly used in Bayesian spatial analysis [ 34 ]. Thus, the priors for and The estimation of the parameters can be obtained by MCMC, and we use as the adjusted CI, where and are the posterior mean of the parameters and. Since , modeling such data is unstable and the fitted values may exceed the interval 0,1.

## Chapter 5 : Modeling spatial and temporal transmission of foot-and-mouth disease - calendrierdelascience.

*Regionalization and foot and mouth disease control: Lessons from spatial models of coordination and interactions. Quarterly Review of Economics and Finance. Jarvis, L., Bervejillo, J. and Cancino, J.*