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ABSTRACT

Methodology for prediction of outbreaks of diseases of military importance

AL Buczak, PT Koshute, SM Babin, BH Feighner, and SH Lewis

Applied Physics Laboratory, Johns Hopkins University, Baltimore, MD, USA
E-mail: anna.buczak@jhuapl.edu

Objective
This paper addresses the problem of predicting outbreaks of diseases of military importance in a chosen region of the world, one to several months in advance.

Introduction
Traditional public health practice has relied on public health surveillance of disease to detect outbreaks in an effort to mitigate their effects. Often the earlier an outbreak is detected, the greater the mitigation of its effects. The logical extension of this relationship is to predict outbreaks before they occur. A predictive model for an emerging infectious disease would forecast, when and where an outbreak of a given disease will occur, well before its emergence. This is a challenging task and truly predictive models for emerging infectious diseases and is still in their infancy.

Methods
Burnette, *et al.*[1] developed a methodology for identifying infectious diseases of military importance, which identified malaria, bacterial diarrheal diseases, and dengue fever as the top three endemic threats to deployed US forces. Of those three diseases, we believe dengue fever is the most suitable for predictive modeling. Dengue was at one time a significant disease in the United States and concern about its potential domestic re-emergence is growing.[2] Dengue fever is recognized in over 100 countries and there are an estimated 50–100 million cases of dengue fever annually.[2]

Predictive disease modeling attempts to exploit the complicated relationship between disease outbreaks and measurable environmental, biological, ecological, and socio-political variables. Previous studies[3–5] identified several factors associated with dengue outbreaks. The most common include past cases, ambient temperature (daily or weekly mean, min, and max), precipitation (weekly, cumulative), and relative humidity (mean, min). Less commonly used factors include Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index, Southern Oscillation Index, Sea Surface Temperature, socio-political stability, sanitation, altitude, wind, cloudiness, seroprevalence in humans, mosquito infection rate, mosquito biting activity, and public health interventions.

For rigorous disease prediction, all predictor variables need to be collected for the previous time period (for example, month) and be used for prediction of outbreaks during a later time period. This ensures a realistic prediction, that is, one in which the values of all the predictor variables can be obtained before performing prediction for the next time period.

Another necessary step when developing disease prediction methods is their validation. The model needs to be validated on a part of the data set, which were not used in its development. The prediction accuracy should then be described in terms of sensitivity (the proportion of actual outbreaks correctly identified) and specificity (the proportion of non-outbreaks correctly identified).

We are presently in the process of collecting the predictor data, the dengue epidemiological data, and developing dengue prediction models including linear regression and Support Vector Machines.

Conclusions
Effective methodologies to predict outbreaks of diseases of military importance would allow taking the preventive actions early to avert large epidemics. For best results, the researchers must have access to data streams with timely, detailed, and accurate values of predictor variables. Model validation is of paramount importance as health officials may be unlikely to spend resources on mitigation efforts based on model predictions without evidence of accuracy on past outbreaks.

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