Emerging Health Threats Journal 2011, **4**:s11. **doi:** 10.3134/ehtj.10.011

www.eht-journal.org

ABSTRACT

Forecasting high-priority surveillance regions: a socioeconomic model

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Objective

To evaluate the association between socioeconomic factors and infectious disease outbreaks, to develop a prediction model for where future outbreaks would most likely to occur worldwide and identify priority countries for surveillance capacity building.

Introduction

It has been suggested that changes in various socioeconomic, environmental and biological factors have been drivers of emerging and reemerging infectious diseases,[1,2] although few have assessed these relationships on a global scale.[3] Understanding these associations could help build better forecasting models, and therefore identify high-priority regions for public health and surveillance implementation. Although infectious disease surveillance and research have tended to be concentrated in wealthier, developed countries in North America, Europe and Australia, it is developing countries that have been predicted to be the next hotspots for emerging infectious diseases.[3]

Methods

We constructed negative binomial regression models to analyze the relationship between a set of outbreaks reported by the WHO during 1996–2009 and 60 national socioeconomic variables from the World Bank's World Development Indicators database; a Human Development Index (HDI) reported by the UN Development Programme; and a Democracy Index developed by The Economist. Initial 'univariate' models examined one socioeconomic variable at a time, while controlling for latitude, as parasitic and infectious disease species richness has been associated with latitude.[4] All significant variables ($\alpha = 0.0008$ with Bonferroni correction for multiple comparisons) were then combined in a multivariate model. Variables that were still significant ($\alpha = 0.05$) comprised the final model, which was then used for forecasting using the latest available socioeconomic data for each country.

Results

Birth rate, measles immunization, urban population with access to improved sanitation facilities, life expectancy, infant mortality rate, public health expenditure, net official development assistance (ODA) received, total population, refugee population by country of origin or territory and HDI were significant predictors in the 'univariate' analyses; the final multivariate model, with McFadden's pseudo R^2 of 0. 181, is shown in Table 1 and was used to predict regions at risk for future infectious disease outbreaks (Figure 1).

Figure 1 Risk map for future infectious disease outbreaks forecasted by a model based on various socioeconomic factors.

Table 1 Final negative binomial regression model predicting number of outbreaks in each country from socioeconomic variables

Variable	*Model coefficient (95% CI)*
(Intercept)	2.893 (2.404;3.381)
Public health expenditure (Percentage of total health expenditure)	−0.010 (−0.017;−0.003)
Net ODA received (US$)	3.941e-10 (2.171e-10;5.620e-10)
Total population	9.715e-10 (4.421e-10;1.481e-09)
Human development index	−1.501 (−2.363;−0.650)
Average latitude	−0.034 (−0.047;−0.021)

Abbreviations: CI, confidence interval; ODA, official development assistance.

Conclusions

Public health expenditure, net ODA received, total population and HDI were significantly associated with the number of outbreaks in a country, even after controlling for latitude. The final model identified regions in Africa, Asia and the Middle East as high-risk regions for future infectious disease outbreaks. The significance of ODA as a variable in the model may indicate that many of these countries may have limited capacity to support surveillance efforts, and highlights the need for assistance through international collaborations and financial support.

Acknowledgements

This paper was presented as an oral presentation at the 2010 International Society for Disease Surveillance Conference, held in Park City, UT, USA on 1–2 December 2010.

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