

Spatial Patterns of Emerging Infectious Disease Outbreaks and Exploration of Geographic Drivers



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- Human emerging infectious diseases (EIDs) are diseases that have recently increased in incidence, impact or geographic range. They include diseases caused by newly evolved strains of existing pathogens (e.g., multi-drug resistant TB) and those that have recently entered the human population for the first time (e.g., HIV/AIDS, SARS, Ebola).
- A range of socio-economic and environmental factors (e.g., greater rates of trade and travel, agricultural changes and increased antibiotic drug use, and land cover and climate change) are considered as important drivers of the emergence of these diseases.
- Few studies, however, have explicitly analyzed these linkages to build a critical understanding of when, where and what diseases will be emerging next, despite the fact that infectious diseases remain a significant threat and challenge to human health.

Goal

- We investigate the temporal and spatial patterns of human EID events and examine their links to a range of socio-economic and environmental factors. We anticipate this analysis will be used to develop predictive models to understand and mediate the consequences of future emerging infectious diseases under different scenarios of global change.

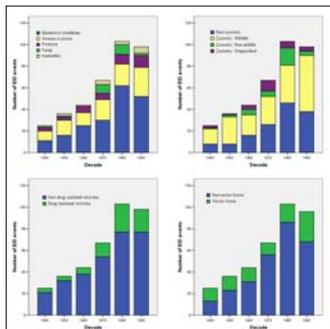
Human EID event database

- Biological, temporal and spatial data on human EID events were collected from 1940 to 2003 (391 EID events, 355 pathogens). We based our data collection on the list of emerging infectious diseases in Taylor *et al.* (2001, *Phil Trans.* 356:983) updated to 2004 and with additional information on emerging infectious microbial pathogens.



Temporal pattern of human EID events

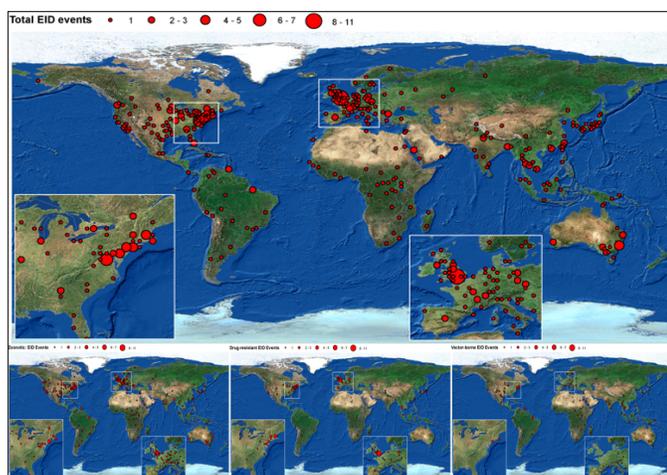
- Frequency of EID events has increased significantly since 1940 reaching a maximum in 1980-1990 (controlling for reporting effort).
- Majority of pathogens involved in EID events are bacterial or viral.
- 61% of EID events are caused by the transmission from animals (zoonotics).



Number of EID events per decade (plotted with respect to event categories).

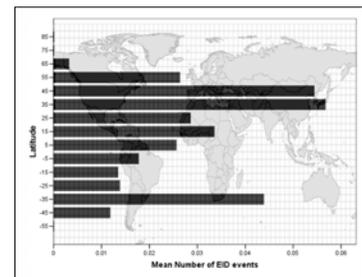
Spatial pattern of human EID events

- Maps of EID events are plotted here with respect to event categories. Points represent 1 degree grid cell centroids where the number of events per grid is proportional to the area of the point.



Richness patterns in human EID events

- No evidence that human EID frequency increases towards the equator.
- EID events are concentrated in higher latitudes. Highest mean number of events per grid are found between 30-50 degrees north and 30-40 degrees south.
- The main human EID hotspots are in north-eastern United States, western Europe, Japan and south-eastern Australia.



Mean number of all EID events in 1 degree terrestrial grid square at each 10 degree latitudinal band.

Modeling human EID events

- We propose EID events may be more influenced by the range of socio-economic drivers prevalent at higher latitudes (e.g., greater rates of trade and travel, agricultural changes and increased antibiotic drug use) than environmental conditions.
- We test this hypothesis by examining the relationship between the spatial pattern of EID events and a range of socio-economic and environmental drivers.

- We found that **human population density, latitude and rainfall** were significant independent predictors of all EID events (controlling for reporting bias), with no role for human population growth or host diversity in the model.

Variables	Any EID event 2087	
No. of EID event grids	b	B
Reporting Bias (No. of publications in JEID)	0.31-0.34***	1.36-1.40
Human Pop. Density	0.51-0.57***	1.67-1.77
Human Pop. Growth	0.14-0.47	1.15-1.60
Latitude	0.02-0.03**	1.02-1.03
Rainfall	0.00-0.00**	1.00-1.00
Host Diversity (Mammal Species Richness)	0.00-0.00	1.00-1.00
Constant	-13.69--12.66***	

Multivariate logistic regressions for all EID events. **b** = regression coefficients, **B** = odds ratio for the independent variables in the model, *** $p < 0.001$, ** $p < 0.01$.

- The odds ratios suggest that increases in **population density** have a higher likelihood of causing an EID event than **latitude** or **rainfall**.
- When EID events are split up into their different categories, different patterns emerge.
 - Although human population density remains a common important predictor in all models, **drug-resistant EID events** are more affected by **human population density and growth** than any other EID event category.
 - Host diversity** plays an important role in predicting the emergence of **zoonotic EIDs with a wildlife origin**.
 - Vector-borne diseases** were not influenced by any environmental or ecological variables that we considered here.

Conclusions and future work

- We have investigated the spatial and temporal patterns in human infectious disease emergence to demonstrate that they are non-randomly distributed with respect to time and place.
- Using a limited number of socio-economic and environmental variables we have started to explore the drivers of these patterns.
- Future work will investigate the effect of other socio-economic variables on our models (e.g., drug use levels, agricultural land use changes, levels of trade and transportation, GDP).
- Our more inclusive models will enable us to develop predictive models of human EIDs to understand and mediate the consequences of different scenarios of future global change.

Further information

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