



Redefining disease emergence to improve prioritization and macro-ecological analyses



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ABSTRACT

Microbial infections are as old as the hosts they sicken, but interest in the emergence of pathogens and the diseases they cause has been accelerating rapidly. The term ‘emerging infectious disease’ was coined in the mid-1900s to describe changes in disease dynamics in the modern era. Both the term and the phenomena it is meant to characterize have evolved and diversified over time, leading to inconsistencies and confusion. Here, we review the evolution of the term ‘emerging infectious disease’ (EID) in the literature as applied to human hosts. We examine the pathways (e.g., speciation or strain differentiation in the causative agent vs. rapid geographic expansion of an existing pathogen) by which diseases emerge. We propose a new framework for disease and pathogen emergence to improve prioritization. And we illustrate how the operational definition of an EID affects conclusions concerning the pathways by which diseases emerge and the ecological and socioeconomic drivers that elicit emergence. As EIDs appear to be increasing globally, and resources for science level off or decline, the research community is pushed to prioritize its focus on the most threatening diseases, riskiest potential pathogens, and the places they occur. The working definition of emerging infectious diseases and pathogens plays a crucial role in prioritization, but we argue that the current definitions may be impeding these efforts. We propose a new framework for classifying pathogens and diseases as “emerging” that distinguishes EIDs from emerging pathogens and novel potential pathogens. We suggest prioritization of: 1) EIDs for adaptation and mitigation, 2) emerging pathogens for preventive measures, and 3) novel potential pathogens for intensive surveillance.

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'Emerging infectious disease' – evolution of a term

"I always like informally to define emerging infections as those that would knock a really important story off the front page of the newspaper."

[Stephen Morse [1]]

Infectious disease events in humans, such as the initial outbreaks of measles in early agrarian societies 11,000 years ago, the geographic scope of the Black Death in the 14th century, and the introduction of smallpox to the New World in the 1500s undoubtedly would have made the 'front page' news of the time. These events have shaped human history for millennia, yet a growing body of literature suggests that host–pathogen dynamics are changing and giving rise to a novel cohort of 'emerging infectious diseases' (EIDs). Conceptualizations and definitions of EIDs have evolved in recent decades, affecting how epidemiologists and others interpret the causes and consequences of disease emergence. Below we explore the changing definitions of EIDs and their consequences, and offer an alternative framework that we hope will stimulate new efforts to better prioritize proactive and reactive approaches to disease emergence.

The earliest publications with 'emerging disease', 'emerging pathogen', or variations thereof in the title appeared in the 1950s and focused primarily on single disease events in livestock. Among these is a 1962 report on the introduction of Equine Piroplasmiasis into the United States [2]. The paper's title, *Equine Piroplasmiasis – Another Emerging Disease*, suggests that emergence was already a recognized phenomenon by the early 1960s. The 1970s and 1980s saw reports on EIDs in humans, livestock, pets, and in association with food crops [3–8]. The first review of the topic, published in 1971 [9], chronicled the important EIDs of the time (cholera, diphtheria, gonorrhoea, cryptococcosis, malaria, and hemorrhagic fevers to name a few), but did not provide a specific definition for emerging infectious diseases or emerging pathogens. Nevertheless, the final sentences established what most EID researchers

would agree with today – change is to be expected. "The microbiological system is closely allied with man; changes in the environment alter his relationship with organisms whether they be beneficial, symbiotic, or pathogenic. Man's way of life, his human behavior, his technological advances, his mere existence foster the conquest of some disease organisms, the emergence of others, and his introduction to unfamiliar ones. The infectious disease picture, therefore, is as subject to change as life itself [9]."

It was not until the late 1980s/early 1990s that organized scientific groups like the Institute of Medicine (IOM) became publicly concerned with EIDs [10,11]. Institutional interest in EIDs manifested through conferences, reports, and publications that sparked multi-disciplinary focus on the topic and set the stage for the surge in research that followed (Fig. 1) [10,12,13]. Two scientists in particular were especially influential in these years, Stephen Morse and Joshua Lederberg. Morse's work on viruses provided some of the first published definitions of emergence. "We may use the term 'emerging viruses' to refer to viruses that either have newly appeared in the population or are rapidly expanding their range, with a corresponding increase in cases of disease [12,14]." Morse's opinion was that despite appearances, emerging viruses are often not newly evolved organisms, but instead are existing viruses in the process of invading new host groups or regions, a process he called 'viral traffic' [12,14].

Arguably, it was the 1992 IOM study, *Emerging Infections: Microbial Threats to Health in the United States*, co-authored by Lederberg, Robert Shope and Stanley Oaks [10], that launched the current phase of research on patterns, causes and consequences of emerging infectious diseases. The establishment of the Program for Monitoring of Emerging Diseases (ProMED) and the Centers for Disease Control and Prevention's (CDC) journal *Emerging Infectious Diseases* soon followed, as did initial research aimed at identifying the general characteristics and drivers of emerging diseases [15,16]. EIDs were defined in the IOM (1992) report as "clinically distinct conditions whose incidence in humans has increased" while re-emergence was defined as "the reappearance of a known disease

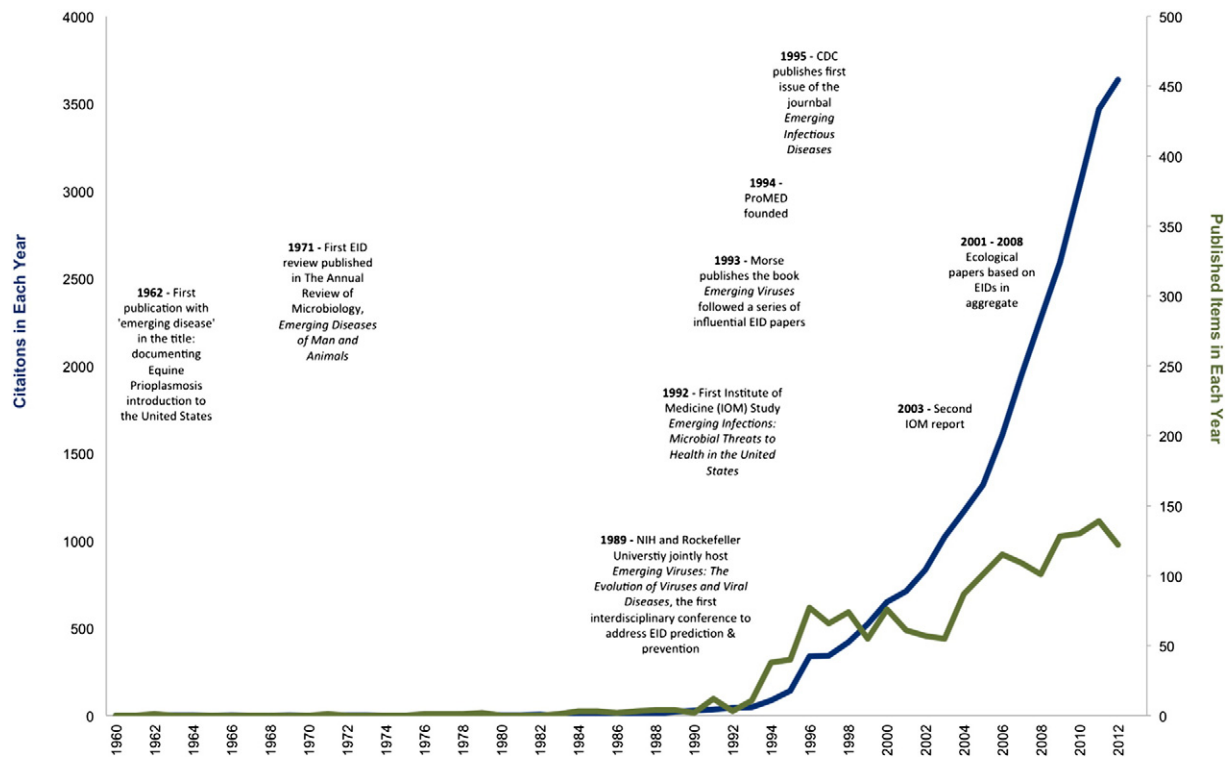


Fig. 1. Emerging infectious disease publications and citations over time. We searched the Science Citation Index Expanded (ISI Web of Science) for papers published from 1900 to 2013 with English titles containing specific disease and pathogen emergence terms. Abstracts are not reliably available before 1990 so only titles were searched for 1900 to 1990. Our advanced search string was as follows: TI = ("emerging infect*") OR TI = ("emerging disease*") OR TI = ("emerging pathogen*") OR TI = ("emerging virus") OR TI = ("emerging bacteria") OR TI = ("emerging helminth") OR TI = ("emerging parasit*") OR TI = ("emerging fung*"). Returned articles were used to create a graphic illustration of the number of published reports and citations of these reports in each year. Events, reports and publications influential in the development of the field of emerging infectious diseases are noted.

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