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Review

Traditional and syndromic surveillance of infectious diseases and pathogens

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SUMMARY

Background: Infectious diseases remain a major public health problem worldwide. Hence, their surveillance is critical. Currently, many surveillance strategies and systems are in use around the world. An inventory of the data, surveillance strategies, and surveillance systems developed worldwide for the surveillance of infectious diseases is presented herein, with emphasis on the role of the microbiology laboratory in surveillance.

Methods: The data, strategies, and systems used around the world for the surveillance of infectious diseases and pathogens, along with current issues and trends, were reviewed.

Results: Twelve major classes of data were identified on the basis of their timing relative to infection, resources available, and type of surveillance. Two primary strategies were compared: disease-specific surveillance and syndromic surveillance. Finally, 262 systems implemented worldwide for the surveillance of infections were registered and briefly described, with a focus on those based on microbiological data from laboratories.

Conclusions: There is currently a wealth of available data on infections, which has been growing with the recent emergence of new technologies. Concurrently with the expansion of computer resources and networks, these data will allow the optimization of real-time detection and notification of infections.

1. Introduction

Classified as the second leading cause of death in humans by the World Health Organization, with approximately 15 million deaths worldwide every year,[1] infectious diseases remain a serious public health problem in the 21st century. Among them, HIV/AIDS, tuberculosis, and malaria have been nicknamed the 'big three' because of their important impact on global human health. In 2011, tuberculosis infected two billion people and killed 1.3 million, malaria infected 207 million people and killed 62 700, and HIV infected 35.3 million people and killed 1.6 million.[2]

For adequate measures to be taken to detect and fight infectious diseases, their surveillance is essential. Surveillance consists of "the ongoing systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know".[3]

Attempts to survey infectious diseases are not recent. One of the best known examples is the use of the London Bills of Mortality by clerks, starting in 1603, for weekly monitoring of the number of deaths in London.[4] Later, in 1854, John Snow performed a topographic study in London by systematically recording the addresses of people infected with cholera, to identify the source of the pathogen.[5] Currently, many surveillance strategies and systems are available around the world. Computer resources have expanded considerably, but infectious disease surveillance remains challenging. The 2009 H1N1 influenza pandemic[6] and the current Ebola outbreak in West Africa[7] are recent examples showing that infectious diseases cannot be predicted and modelled reliably.

Nevertheless, the detection and investigation of abnormal health-related events effectively allow the identification of true epidemic events. The abnormal increase in the number of young homosexual men infected by *Pneumocystis carinii* in Los Angeles between 1980 and 1981[8] prompted the discovery of the HIV virus in 1983.[9] Similarly, the outbreak of a severe respiratory illness of unknown origin that affected 180 people who had attended a state American Legion convention in Philadelphia in July 1976 allowed

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the identification of *Legionella pneumophila*.[10] In late 2002, an unknown respiratory disease with no identifiable cause was diagnosed and reported in several people living in Guangdong Province in China. The syndrome, termed 'severe acute respiratory syndrome' (SARS), rapidly crossed borders and became a worldwide threat.[11] A coronavirus (SARS-CoV) was finally identified as the causative agent of the syndrome.[12]

With consideration of these aspects, an inventory of the data, surveillance strategies, and surveillance systems developed worldwide for the surveillance of infectious diseases is presented herein, with emphasis on the role of the microbiology laboratory in surveillance.

2. Infectious disease surveillance — Data used for surveillance

Fig. 1 summarizes the main types of data available for surveillance. These were classified according to the outbreak detection continuum published by Texier and Buisson.[13]

2.1. Human environment

2.1.1. Environmental data

Environmental data include water pollution, weather, and air pollution. For example, water quality testing from samples collected at water treatment facilities could be used to explain an increase in the number of patients presenting to emergency departments because of gastrointestinal disorders, as was done in the case of ice made during the massive outbreak of Cryptosporidium in Milwaukee.[14]

2.1.2. Animal health

Animal health data come directly from wild and domestic animals and are particularly valuable for the surveillance of zoonotic diseases such as plague, rabies, and monkeypox. For example, Chaintoutis et al. successfully used serum collected from sentinel juvenile domestic pigeons for the early detection of West Nile virus in Central Macedonia, Greece.[15]

2.2. Human behaviour

2.2.1. Internet use

The Internet can be used for infectious disease surveillance.[16] Studies on influenza have proven the efficacy of the use of Web queries to complement existing surveillance methods. For example, the use of Web data to predict flu in Canada using FluWatch was done successfully and at a low cost, which inspired Google to develop Google Flu Trends, a free forecasting tool allowing the real-time surveillance of influenza activity in the USA .[17] However, such an approach should not be used to replace traditional epidemiological surveillance networks as flu-tracking techniques based on Web data are more likely to be affected by changes in people's search behaviour.[18] Another type of internet-based data usable for surveillance is health-related dispatches. These data include, among others, press dispatches from various origins like Reuters (http://fr.reuters.com/) and Humanitarian News (http://humanitariannews.org/), electronic mail-based discussion groups like ProMED-mail (http://www.promedmail.org/), press articles, and institutional and non-institutional warning networks like the World Health Organization.[19,20]

2.2.2. Telephone triage hotlines

Telephone triage hotlines receive numerous phone calls from people requiring immediate health care assistance. Electronic data extracted from these hotlines can be a valuable source of data for surveillance. Although hotlines are inherently non-specific, data can be produced regardless of the day of the week, weather conditions, or holidays if the triage hotline is operated around the

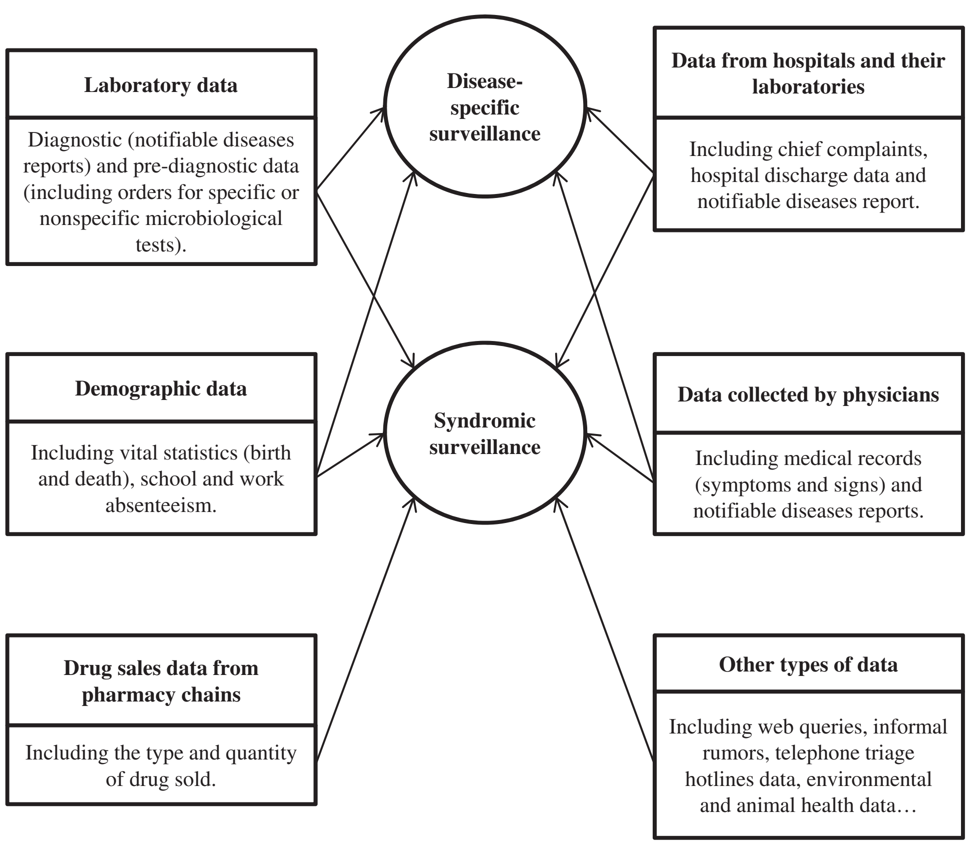

Fig. 1. Main sources of data used by syndromic and disease-specific surveillance systems.