International Journal of Infectious Diseases 53 (2016) 15–20

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Review

Drivers of earlier infectious disease outbreak detection: a systematic literature review

Lindsay Steele [a,b], Emma Orefuwa [c], Petra Dickmann [d,e,*]

[a] MScPH student, McGill University, Montreal, Canada
[b] MScPH student intern, Connecting Organizations for Regional Disease Surveillance (CORDS), Lyon, France
[c] Programme manager Strategy & Operations (Consultant), Connecting Organizations for Regional Disease Surveillance (CORDS), Lyon, France
[d] Director Strategy & Operations (Consultant), Connecting Organizations for Regional Disease Surveillance (CORDS), Lyon, France
[e] Managing Director, Dickmann Risk Communication DRC, London, UK

ARTICLE INFO

Article history:
Received 27 May 2016
Received in revised form 9 August 2016
Accepted 6 October 2016

Corresponding Editor: Eskild Petersen, Aarhus, Denmark

Keywords:
Infectious disease outbreaks
Public health surveillance
Disease notification
Time factors

SUMMARY

Background: The early detection of infectious disease outbreaks can reduce the ultimate size of the outbreak, with lower overall morbidity and mortality due to the disease. Numerous approaches to the earlier detection of outbreaks exist, and methods have been developed to measure progress on timeliness. Understanding why these surveillance approaches work and do not work will elucidate key drivers of early detection, and could guide interventions to achieve earlier detection. Without clarity about the conditions necessary for earlier detection and the factors influencing these, attempts to improve surveillance will be ad hoc and unsystematic.

Methods: A systematic review was conducted using the PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-analyses) to identify research published between January 1, 1990 and December 31, 2015 in the English language. The MEDLINE (PubMed) database was searched. Influencing factors were organized according to a generic five-step infectious disease detection model.

Results: Five studies were identified and included in the review. These studies evaluated the effect of electronic-based reporting on detection timeliness, impact of laboratory agreements on timeliness, and barriers to notification by general practitioners. Findings were categorized as conditions necessary for earlier detection and factors that influence whether or not these conditions can be in place, and were organized according to the detection model. There is some evidence on reporting, no evidence on assessment, and speculation about local level recognition.

Conclusion: Despite significant investment in early outbreak detection, there is very little evidence with respect to factors that influence earlier detection. More research is needed to guide intervention planning.

1. Introduction

Infectious disease outbreaks can spread rapidly, causing enormous losses to individual health, national economies, and social wellbeing.[1–6] Through the early detection of an infectious disease outbreak, a small outbreak can potentially be contained at the local level, thereby reducing adverse impacts.[7–11] Early detection has been and remains the current narrative of infectious disease surveillance.

A variety of surveillance approaches to the early detection of outbreaks exist, many of these following advances in technology. Traditional indicator-based surveillance (IBS), e.g. mandatory disease-specific notification, laboratory surveillance, and syndromic surveillance, has been complemented by event-based surveillance (EBS), which gathers and analyzes information from drivers, formal or informal.[12,13] This has been done in order to broaden the scope of surveillance to an all-hazard approach, as requested in the International Health Regulations (2005) (IHR), and with the aim of detecting outbreaks earlier and faster using new technologies.

Over the last decade, there has been substantial investment in the development and operation of surveillance systems that use existing health data, both formal and ad hoc—from sources such as emergency department visits and sales of pharmaceuticals—to provide immediate analysis and feedback to those charged with investigating potential outbreaks.[14] New digital data streams for infectious disease surveillance have arisen from developments in

* Corresponding author. Tel.: +44 7766 902991.
E-mail address: pdickmann@dickmann-drc.com (P. Dickmann).

http://dx.doi.org/10.1016/j.ijid.2016.10.005

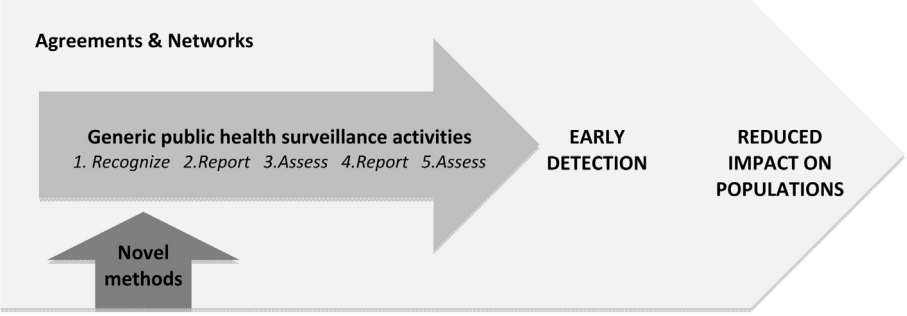

Figure 1. Landscape of approaches for early detection of infectious disease outbreaks.

information communication technology,[15] such as early adopters ProMED-mail and Global Public Health Intelligence Network (GPHIN), and more recently, numerous openly available news aggregators and visualization tools.[16] Diagnostics have progressed as a result of scientific developments, leading to automation and highly multiplexed assays and advances in point-of-care testing, making sample collection and testing possible in remote settings.[17]

Innovative governance structures have been established to promote early detection. Disease surveillance networks have formed, such as the World Health Organization (WHO) Global Outbreak Alert and Response Network (GOARN), combining human and technical resources around the world to rapidly identify, confirm, and respond to outbreaks. Cross-border regional disease surveillance networks have been established across the globe, connecting epidemiologists, scientists, ministry officials, health workers, border officers, and community members to engage in activities, such as training, capacity-building, and multidisciplinary research.[18] Agreements have been instituted, setting legal mandates around surveillance activities, such as the IHR (2005), which call for all WHO Member States to build, improve, and strengthen their capacity to prevent, detect, and respond to infectious diseases outbreaks that can have global spread.[19]

The proliferation of zoonotic diseases has demonstrated that the timely identification of future emerging microbial threats requires an integrated international approach to disease surveillance. Programmes working at the human–animal interface employ many of the same techniques as those for human health, such as the Global Avian Influenza Network for Surveillance (GAINS), which trains individuals and organizations to collect samples and disseminates laboratory results through an open-access electronic database.[7]

The list of novel strategies described above is not exhaustive, yet demonstrates the breadth and intricacy of surveillance approaches aimed at detecting outbreaks early. These approaches work in concert with generic infectious disease surveillance activities, which remain essential to public health practice, particularly at the local level.[7] Together, these approaches ultimately aim to decrease the impact of outbreaks on populations (Figure 1).

Generic infectious disease surveillance follows a multi-level public health model, where a case or an event must first be recognized as unusual, and then reported and assessed (as a signal). If the case or event meets criteria for further notification, it is reported to higher level authorities and subsequent assessment/investigation ensues. This detection process can be categorized into the following five generic steps: (1) recognition (of a case or an event), (2) low-level reporting, (3) low-level assessment, (4) higher level reporting, and (5) higher level assessment (when outbreak declaration occurs). While the key players involved at each step will vary by region/country and disease, the basic structure is the same. Inputs into the system include human and animal health events, risks (indicating a potential outbreak), and data.

Novel approaches link up with the generic five-step model at different stages. For example, alarms from syndromic surveillance input into the system as risk (of a potential outbreak), and ProMED-mail and GPHIN provide new data into the system. Both must be followed-up with an epidemiological investigation to determine whether a public health response is needed and what that response should be. Diagnostic tools aid in the assessment steps, and agreements and networks reinforce the entire system by building and strengthening overall capacity for carrying out surveillance activities.

Given the enormous amounts of time and money invested, measuring impact is a priority. A number of studies have aimed to quantitatively measure (in days) the timeliness of infectious disease surveillance systems, seeking to answer the question of how effective these interventions have been.[20–23] Additionally, the IHR (2005), Global Health Security Agenda (GHSA), and US Centers for Disease Control and Prevention (CDC) present useful frameworks for the evaluation of infectious disease surveillance systems, including timeliness of disease detection.[24–26]

Measuring change in timeliness can help us to hypothesize about effective approaches; however, it does not provide information about the causal mechanisms at play. Understanding why these surveillance approaches work and do not work will elucidate key drivers of early detection and enable us to refine and design interventions for earlier detection. The important question becomes: Why do certain approaches/interventions lead to early detection?

Leading organizations have offered guidelines on how early detection can be achieved. For example, the CDC Working Group produced a prominent guide that is useful and consistent with the landscape of approaches currently operating.[27] However, the recommendations are broad and it is unclear whether they are based on evidence.

In this study, a systematic review of the peer-reviewed literature was performed to identify what evidence exists about factors that influence earlier detection of infectious disease outbreaks. Focus was placed on the generic public health surveillance infrastructure, including inputs that novel approaches generate, i.e. risks and data. The goals of this review were (1) to synthesize what is currently known, and (2) to identify gaps and limitations that can be addressed by future research efforts. Understanding the evidence-base of influencing factors could guide approaches to achieve earlier detection.

2. Methods

2.1. Search strategy and selection criteria

A systematic review was conducted using the PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-analyses) to identify research articles published between January 1, 1990 and December 31, 2015 in the English