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One Health and its practical implications for surveillance of endemic zoonotic diseases in resource limited settings

Jan Hattendorf[a,b,*], Kevin Louis Bardosh[c], Jakob Zinsstag[a,b]

[a] Swiss Tropical and Public Health Institute, Department of Epidemiology and Public Health, Basel, Switzerland
[b] University of Basel, Basel, Switzerland,
[c] Division of Infection and Pathway Medicine, School of Biomedical Sciences, College of Medicine and Veterinary Medicine, The University of Edinburgh, Edinburgh, UK

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ABSTRACT

Surveillance of zoonotic disease requires special attention because the animal and human health sectors are involved. A proliferation of scholarly literature and technical guidelines exist for early detection of exotic and re-emerging diseases and to demonstrate freedom from disease as part of international trade agreements. In contrast, literature focussing on surveillance of endemic zoonotic diseases is relatively rare. In this article, we describe and discuss the main aspects to consider when planning a surveillance system for endemic zoonotic diseases in a resource-limited country. We describe advantages and disadvantages of different active and passive surveillance systems and explore how risk-based sampling might improve efficiency and reduce costs, and which tools are available to identify high-risk populations.

1. Introduction

Almost two-third of human infectious diseases are zoonoses (Taylor et al., 2001), which are responsible for about 2.7 million human deaths per year (Grace et al., 2012). Developing countries bear a disproportionately high burden of zoonotic diseases because of the strong association with poverty and the reliance on livestock. In addition, they impose a dual burden through human illness as well as losses to livestock they depend on (Maudlin et al., 2009).

'One Health' represents a concept that recognizes that human and animal health is closely linked and that a close interdisciplinary collaboration is required for the successful control of zoonoses. Although the need for collaboration between animal and human health sectors in zoonotic disease surveillance is widely recognised (WHO, 2008), most surveillance systems are implemented separately for the human and animal health sector (Wendt et al., 2015).

The main aims of zoonotic disease surveillance can be categorised into the following groups (adapted from (Pfeiffer et al., 2014; Willeberg et al., 2012)):

- Early detection of exotic, emerging and re-emerging diseases
- Demonstration of freedom from disease to comply with international trade regulations
- Monitoring of endemic diseases for case detection and disease prevalence estimation

Here we concentrate on the surveillance of endemic diseases, which has received far less attention. Although climate change, frequency of extreme weather events, the transition from extensive to intensive farming systems and the increased mobility of people and animals will particularly affect tropical countries, the first two aspects are likewise relevant. However, many guidelines and publications covering early detection and freedom from disease are available, not least because of the raised awareness associated with Highly Pathogenic Avian Influenza (HPAI) and other pandemic threats, whereas literature focussing on disease frequency estimations is less well represented. A key difference in the surveillance of endemic disease compared to emerging disease is related to the sampling design. For early detection of exotic and re-emerging diseases or to demonstrate freedom from disease it might be sufficient to sample only in high risk settings whereas disease frequency estimates always require some kind of representative sampling. In developed countries, the main objectives of zoonotic disease surveillance can be summarized as to prevent humans from becoming infected, to protect animal health and welfare, to reduce the negative impact on the farmers and societal economy and to comply

* Corresponding author at: Swiss Tropical and Public Health Institute, P.O. Box, CH 4002 Basel, Switzerland.
E-mail address: jan.hattendorf@unibas.ch (J. Hattendorf).

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with international trading regulations (Ahmadi, 2014). In developing countries many other aspects may be of interest ranging from food security, reduction of poverty as well as gender equity (Narrod et al., 2012). In the following, we will describe and discuss some of the main aspects to consider when implementing a surveillance system. We will review common active and passive surveillance systems and will discuss potential efficiency gains when following a One Health approach and their suitability for risk based sampling.

2. General considerations

Prioritisation represents the first phase in planning a surveillance system. In industrialised countries, risk-based prioritisation is a common strategy to identify and rank surveillance needs. It has been defined as "Determining which hazards should be selected (for surveillance) based on information about the probability and the extent of (biologic and/or economic) consequences of their occurrence" (Hoinville et al., 2013). However, in resource limited countries additional aspects are important. First of all, do appropriate interventions exist and are sufficient resources available to implement the control measures? Appropriate includes a variety of issues including efficiency and cultural acceptability. Sufficient resources include trained personnel and financial aspects but also the availability of transportation, laboratory material and other infrastructural determinants; for example, the ability to maintain an unbroken cold chain. These aspects might be interrelated, for example bovine tuberculosis has been successfully eliminated in large parts of the developed world by applying a test and slaughter strategy. However, without adequate compensation for the farmer, this approach will not be culturally accepted in many tropical countries. Cross sector collaboration might receive stronger support in the livestock sector than in the health sector, where the priorities may differ (Stärk et al., 2015).

Using a One Health approach for surveillance does not automatically imply that the surveillance system has to collect data from animals and humans, although advantages clearly exist in doing so. Animal cases usually precede human infections; consequently, surveillance of animals can detect outbreaks much earlier and might prevent human disease (IOM, 2009; WorldBank, 2012). However in practice, authorities often start control efforts only after human cases have been observed (WorldBank, 2012). For zoonotic diseases endemic in animals, a close collaboration between human and veterinary health services is essential and surveillance should include animals and humans simultaneously. That does not imply that it has to be implemented to the same extent or that the same surveillance approach has to be applied. The optimal balance depends rather on the main purpose of the surveillance, existence of already on-going data collection like routine data from hospitals or veterinary officers, the disease burden for humans and animals, the diagnostic tests available and logistic considerations. In addition, for endemic diseases, human data collection should be envisaged in order to assess the relevance from a human public health perspective to inform policy makers and to be able to conduct a complete (cross sector) economic analysis of the cost-benefit of the surveillance system and potential control measures.

The epidemiology of the disease – including the transmission routes between animals, from animals to humans and, if applicable, between humans – plays a central role. Besides the expected disease frequency in the general and high risk populations, the temporal, spatial as well as the age, sex and farming system specific distribution is of particular importance. For example, the epidemiology of brucellosis varies largely depending on livestock system. The disease persists at low endemic levels in traditional pastoralist systems whereas intensive farming systems are more commonly confronted with outbreaks (Ducrotoy et al., 2014). In addition, different *Brucella* species have different livestock species as principal hosts and different pathogenicity and clinical manifestations in humans.

Reporting of a disease is closely linked to the ability to detect the disease which might be compromised by vague clinical signs or asymptomatic cases, low awareness or insufficient diagnostic capacity (Halliday et al., 2012). The diagnostic tests available are of particular importance. Diagnostics testing presence of antibodies may remain positive for years and does not allow discrimination between current and past infections – for example in brucellosis in cattle – or are lacking at the early acute phase of the disease as, e.g. leptospirosis in slaughterhouse personnel. On the other hand, antigens may occur in detectable concentrations during a limited time window. In addition diagnostic test sensitivity and specificity should be considered (cross-reactivity) as well as costs per unit, requirement of personnel and laboratory resources to apply the test and if a cooling chain is necessary during the transport in case the test cannot be applied at the point of sampling. In the case of human African sleeping sickness, molecular techniques are recommended to distinguish between human pathogenic and non-pathogenic sub-species in cattle. In addition, community-level practices can mask the observability of livestock deaths by, for example, the killing or selling of infected animals at the first sign of illness. What cannot be seen, cannot be accounted for in some cases.

In this way, social contexts have multiple influences on surveillance systems. Issues of trust and existing formal and informal social networks between livestock keepers and veterinary and medical authorities play a central role in terms of communication and enforcement. There are different motivations and barriers to reporting disease information that needs to be considered, and varies greatly in different settings, by the specific types of rules already in place for reporting and by the relationship of these rules to the interests of different social groups. Institutional credibility, perceptions surrounding disease risk and perceived community benefit (versus the potential adverse consequences of reporting, for example) are important aspects to consider (Limon et al., 2014; Paige et al., 2014). Contextualising surveillance from the perspectives of local livestock keeping communities should also be accompanied by a broader systems approach that appreciates the motivations (or lack of motivation) for veterinary and laboratory personnel to collect samples, follow protocols and analyse and use data (Sawford et al., 2012). Hence investments in surveillance infrastructure clearly need to be accompanied by the empowerment of both frontline surveillance workers as well as local communities to be successful (Calain, 2007).

3. Selection of an appropriate surveillance system

Many different surveillance systems exist and their advantages and disadvantages are discussed below and summarized in Table 1.

3.1. Active surveillance systems

Conventional surveillance surveys: The aim is to detect cases by conducting surveys either in the field, abattoirs or at human or veterinary health care providers. In contrast to all other approaches, surveys can be designed that amount, quality and nature of data are adequate and meet the requirements of the decision maker.

Field surveys cover usually a small but representative sample of the population which is a central aspect for disease frequency estimation. However, field surveys are expensive and require a lot of personnel and acute diseases with short duration and high temporal or spatial clustering are difficult to assess. The potential for cost saving using a One Health approach is especially high when animals