INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS 78 (2009) 182–192

journal homepage: www.intl.elsevierhealth.com/journals/ijmi

A proposed taxonomy for characterization and assessment of avian influenza outbreaks

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ARTICLE INFO

Article history:
Received 14 October 2007
Received in revised form
28 June 2008
Accepted 30 June 2008

Keywords:
Avian influenza
Disease notification
Classification
Zoonoses
Disease attributes
Concept formation

ABSTRACT

Purpose: The speed and high potential impact of avian influenza's (AI) on local bird populations, poultry economies and human health make timely and coordinated characterization, assessment and response to possible threats essential. To collaborate effectively, stakeholders (public health, medical, veterinary, and agricultural professionals) must be able to communicate and record findings, assessments, and actions in a standard fashion. We seek to discern a taxonomy of concepts and relationships that are important to the stakeholder community when sharing information about the characterization and assessment of an AI outbreak, according to a consistent and common perspective, interpretation, and level of detail.

Methods: To derive concepts relevant to AI characterization and assessment, we reviewed selected journal articles, reporting and laboratory forms, and public health websites associated with AI case reporting. We mapped concepts to existing medical terminologies within the Unified Medical Language System when possible, using the National Library of Medicine's MetaMap program.

Results: From 54 distinct information sources, we extracted 1113 concepts, of which 533 mapped to 15 medical terminologies; 580 did not map to specific terminologies. Using a combination of semantic type-relationship matching and expert consensus, we constructed the proposed taxonomy, with linkages to existing terminologies where pragmatic.

Conclusion: The proposed taxonomy describes core knowledge, data and communication needs for the characterization and assessment of AI outbreaks in the context of existing medical terminologies across different domains. We also describe areas for further work.

1. Introduction

Avian influenza (AI), a disease caused by a virus of the family Orthomyxoviridae, genus Influenzavirus A, affects both avian and mammalian species (including humans). Its pathogenicity is categorized as low or high, with low pathogenic AI (LPAI) causing morbidity and mortality in birds and high pathogenic AI (HPAI) causing high fatalities in both birds and humans. Its antigenic categorization depends on biochemical assays for viral surface glycoproteins hemagglutinin (H) and neuraminidase (N). To date, 16 H and 9 N subtypes have been associated with AI [1–4]. Generalized AI diseases are associated with subtypes H5 and H7 (in birds and humans) and fatal human AI infections appear to be associated with the H5N1 subtype (as a causative agent). Its natural hosts are wild birds, in which the viruses are believed to be antigenically stable. In new hosts, however, it is believed that the viruses undergo antigenic shift and drift leading to differential virulence [5].

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doi:10.1016/j.ijmedinf.2008.06.015

The World Office for Animal Health (Office International des Epizootics, OIE) classifies high pathogenic AI as Class A because of its high mortality, its efficient transmissibility and pathogenicity [6] and the serious socioeconomic or public health consequences associated with it (in International Trade of Animals and Animal Products). The World Health Organization (WHO) believes a sustained and widespread HPAI epidemic (especially due to H5N1) in poultry increases the risk of a human influenza pandemic [7]. Because of the variable mutagenic potential of low pathogenic AI (LPAI) (H5N1) into HPAI, its short incubation period (3–5 days), increasing resistance to current therapies [8] and the increasing vulnerability of other mammals (pigs, tigers, horses, sea mammals and cats among others) [9–12], there is a need for timely and coordinated public health approach to understand, detect and control outbreaks.

2. Background

2.1. *Information model of the public health response to AI outbreaks*

The public health response to a disease such as HPAI is a collaboration of local, federal and international agencies, private groups and the public to achieve the multiple objectives including [13]:

1. determination and control of immediate health threats,
2. prevention of spread,
3. mitigation of human suffering, and
4. minimization of negative impacts on trade and travel.

Public health agencies information requirement to meet these objectives include [13]:

1. up-to-date knowledge of the disease pathogenesis and transmission,
2. real-time surveillance and report data from clinical and veterinary sources and
3. facilitated and timely collaboration and coordinated response among stakeholders on horizontal (commercial and private bird owners, public health and wildlife agencies, clinical laboratories, medical and veterinary practices) and vertical (local, national, regional and global) dimensions.

Stakeholder information tasks within the collaboration include [14]:

1. *detection*: reporting and investigation of cases;
2. *analysis*: characterization and assessment of cases in terms of potential threat and spread;
3. *response*: treatment/prevention of morbidity and mortality, containment of regional/national/international spread and minimization of impact to the public, trade and travel.

Each task requires communication within agencies or between agencies and health entities for detection (sentinel workers, local public health data collection agencies, laboratories) and response (health facilities, agriculture and food service regulatory agencies, law enforcement and military). Appropriate public health response depends on timely and effective analysis (characterization and assessment) by public health officials/agencies of reported cases as outbreaks.

Characterization of an outbreak is the discernment of attributes of a reported case that are important for identifying its threat potential [15]. Potential cases are identified by clinical or pathological data or through surveillance (routine cultures for avian influenza, for example). Follow up investigation includes collection of clinical and laboratory data to identify causative agents (for the clinical or surveillance data), their sources and routes of transmission.

Assessment of an outbreak patterns to the integration of data (from characterization) by decision makers to derive measures of risks and/or disease burden that determine actions and allocation of resources necessary to optimize public health in the context of the characterization data [15]. The urgency with which decisions and actions (including resource allocations for response) are required may be influenced by current and predicted local morbidity and mortality [16,17], estimations of current and projected economic losses (due to bird death), and problem scope [18]. Assessments may provide a combination of qualitative (expert opinion) and quantitative (rates and biostatistical) measures that may be of help to decision makers [6,19,20].

2.2. *Decision maker's information needs*

To facilitate an informed and effective public health response, the decision/policy maker must integrate information from a variety of sources including abstractions from case characterization and assessment in a timely fashion. Information sources include: surveillance of current incoming data, historical records of past data and previous decisions, responses and outcomes, evidence-based knowledge of disease and behavior patterns and other relationships and current hypotheses (based on observed patterns and logical inference) [21]. The development and use of statistical packages, analytical processing tools and conceptual bridging tools such as clinical and business dashboards [22] and controlled terminologies and description logic have been useful in bringing together heterogeneous biomedical information on syntactic and semantic levels for incorporation into decision tools.

2.3. *Need for sharable terminology/vocabulary*

The potential widespread severity and urgency of an AI outbreak and the need for timely management necessitate a consistent and common ground for rapid and accurate communication among all stakeholders in AI characterization and assessment. There is currently no common formal vocabulary for human understanding and electronic processing for this across the breadth of domains of stakeholders (the health community, veterinary care, farming, wildlife workers, food industry and the military).

We describe our effort to discern structural, administrative and descriptive data and metadata needs to character-