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Systematic Review of Surveillance Systems for Emerging Zoonotic Diseases



LINDA VRBOVA, CRAIG STEPHEN, NAOMI
KASMAN, RICHARD BOEHNKE, MIMI DOYLE-
WATERS, ANDENYE CHABLITT-CLARK, BRIAN
GIBSON, MICHAEL BRAUER, DAVID PATRICK

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ABSTRACT

A systematic review of peer-reviewed articles that described and/or evaluated surveillance systems for emerging zoonotic diseases between 1992 and 2006 revealed that only 17 of 221 identified systems were evaluated. Only four of these used their evaluation results to examine the usefulness of their systems in identifying outbreaks or cases of disease. This lack of evidence makes it difficult for decision-makers to choose surveillance initiatives that have been shown to be effective. Many systems included in this review claim to be surveillance systems, but it remains unclear how many of them were just monitoring systems, highlighting confusion in the use of the term 'surveillance'.

LIST OF AUTHORS AND ROLES

Authors

Linda Vrbova (LV): School of Population and Public Health, University of British Columbia

Craig Stephen (CS): Faculty of Veterinary Medicine, University of Calgary; Centre for Coastal Health; School of Population and Public Health, University of British Columbia

Naomi Kasman (NK): Health Protection Division, York Region Health Services Department

Richard Boehnke (RB): Infectious Diseases Branch, Ontario Ministry of Health and Long Term Care

Mimi Doyle-Waters (MD-W): Centre for Clinical Epidemiology & Evaluation, Vancouver Coastal Health Research Institute

Andenye Chablitt-Clark (AC-C): Environmental Health Branch, Ontario Ministry of Health and Long-Term Care

Brian Gibson (BG): Environmental Health Branch, Public Health Division, Ontario Ministry of Health and Long-Term Care; Dalla Lana School of Public Health, University of Toronto

Michael Brauer (MB): School of Environmental Health, University of British Columbia

David Patrick (DP): Epidemiology Services, British Columbia Centre for Disease Control; School of Population and Public Health, University of British Columbia

Roles

LV and CS designed the study and determined the study questions, LV and MD-W developed and implemented the search strategy, with help from CS, RB, NK, AC-C, DP, BG, and MB at a mid-study meeting, LV and NK selected the articles for inclusion from article titles (round 1) and abstracts, LV obtained the articles and LV and NK completed the second round of inclusion/exclusion and extracted the data from the articles, LV cleaned and analyzed the database. The first draft report was prepared by LV, while editing and preparation of the final document was conducted by all authors (LV, CS, RB, NK, MD-W, AC-C, DP, BG, and MB).

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CHAPTER 1. BACKGROUND AND INTRODUCTION

Emerging Infectious Diseases and Zoonoses

Emerging infectious diseases (EIDs) can be broadly defined as diseases that have newly appeared in a population or are rapidly increasing in incidence or geographic range [1]. They can include 1) a known agent appearing in a new geographic area, or 2) a known agent or its close relative occurring in a hitherto uninfected species, or 3) a previously unknown agent detected for the first time [2]. The number of EIDs has been increasing globally over the past 50 years [3].

Estimates of the proportion of EIDs that involve pathogens transmitted from animals to humans, or *zoonoses*, range from 60% to 75% [3-5]. Although the number of emerging zoonoses worldwide depends highly on the case definitions used, a recent review lists 177 emerging pathogen species, of which 130 (73%) are known to be zoonoses [4]. Examples of emerging zoonoses in Canada include novel agents such as mad cow disease (Bovine Spongiform Encephalopathy or BSE), evolving agents such as *Avian Influenza virus* (AIV) and antimicrobial-resistant *Salmonella* and *Escherichia coli*, and agents expanding in their host range such as *Hantavirus*, Lyme disease (LD) and *West Nile virus* (WNV) [1, 2, 6]. Emerging zoonoses can become devastating if they become transmissible from person to person. For example, the complete genetic characterization of the pandemic 1918 “Spanish Flu” virus suggests it not only originated from an avian influenza virus, but that the pandemic virus was in fact an adapted avian influenza virus; these findings show that zoonotic agents can result in severe impacts with minimal genetic changes, in this case increased severity and facilitated human to human transmission, some of which are already present in the current circulating avian viruses [7].

Factors Leading to Emergence of Infectious Diseases

Reasons for infectious disease emergence are numerous: 1) pathogen biology, including microbial adaptation and change, 2) human demographic changes and behaviour, 3) human biology including immune status, 4) ecologic changes such as those due to agricultural or economic development including land use, or anomalies in climate, 5) technology and industry, including food production and health care, 6) expansion of travel and commerce, and 7) breakdown of public health measures [1-5]. There is a growing sentiment in the literature that society would be better prepared to detect and prevent EIDs if we can get “ahead of the curve”: if we are able to identify risky situations before the first cluster of cases in humans are identified in hospitals [8].

Specifically, for emerging zoonoses, it has been suggested that animal health information should be used in surveillance systems for early warning purposes [9].

Surveillance for Emerging Infectious Diseases

Good surveillance has been identified as the first major goal in preventing EIDs that arise naturally or through terrorist activities [10-12]. Preventing or restricting the impact of an EID is dependent on the ability to rapidly detect the first cases [13]. The earlier cases are identified, the more likely it is that an intervention will prevent further cases, especially if the intervention occurs in advance of the logarithmic growth phase of the epidemic.

The US Centers for Disease Control and Prevention (CDC) define surveillance systems as those that collect and analyze morbidity, mortality, and other relevant data and facilitate the timely dissemination of results to appropriate decision makers [14]. Such systems, therefore, consist of routine data collection, data analyses, followed by a response when required. It is this element of decision and timely response based on interpretation of the data that makes surveillance different from monitoring, making it more than just a system for event detection. Surveillance is 'action-oriented', wherein 'real-time' decisions are linked to current findings. Therefore, surveillance includes timely response to the data. Monitoring, on the other hand, does not necessarily include a timely response. Monitoring sacrifices timeliness for accuracy, looking to make summary reports of what has happened rather than what is happening (see Figure 1). A disease surveillance system specifically designed for EIDs is sometimes referred to as an early warning system, and therefore these two terms are used interchangeably in this paper.

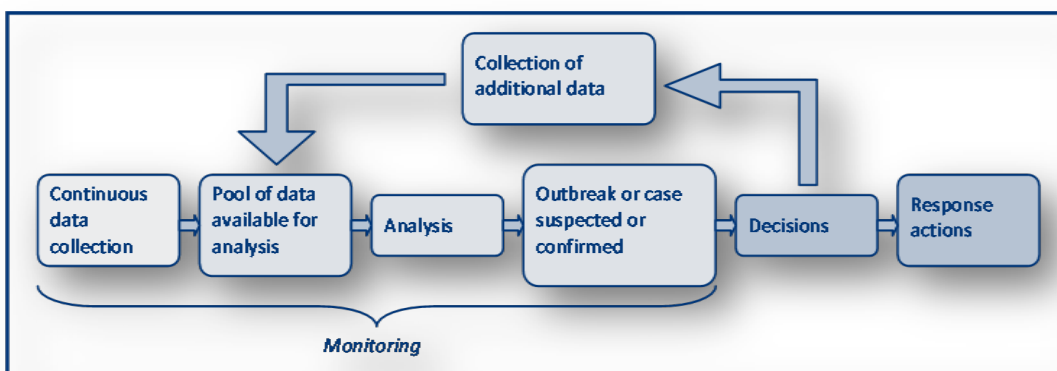


Figure 1. Structure of a Surveillance System. Data collection to detection of an outbreak or case consists of monitoring, the addition of timely decisions and response actions makes the system a surveillance system. Figure adapted from Wagner et al., 2006 [15].

There has been a proliferation of surveillance systems for various diseases over the past 50 years, with many more geared towards EIDs in the past decade [16]. In North America, EID systems, many of these so-called “syndromic surveillance” systems, have increased in number since WNV first appeared on the continent in 1999 and fears of bioterrorism increased after the terrorist attacks of September 11, 2001 [16]. Syndromic surveillance loosely refers to collection of “new” data types that are not diagnostic of a disease, but that might indicate early stage of an outbreak, such as prescriptions filled and school/work absenteeism [17]. There are published recommendations for evaluating various types surveillance systems available (including syndromic surveillance systems) [14, 15, 17], but minimal attention has been placed on whether or not EID surveillance requires a different set of criteria for design and evaluation when compared to systems intended to keep endemic and non-infectious diseases under surveillance.

Surveillance in Human and Animal Public Health Sectors, and Integrated Surveillance

The term ‘surveillance’ is used differently in veterinary and human public health literature, and really refers to different concepts of ‘surveillance’. This difference stems from the mandates to collect animal and human data respectively. Animal health surveillance is often much more passive than human public health surveillance, since the collection and reporting of animal disease and zoonotic disease in animals is not legally mandated to the same extent as in humans, particularly in wildlife. This lack of legal mandate and structured reporting mechanism also means that animal surveillance is not population-based to the same extent as human public health surveillance. Although neither human nor animal agencies currently have a clear mandate to compare animal and human disease data in an integrated fashion [18], such a mandate would be instrumental in developing and sustaining these efforts.

Despite these challenges, current trends are to integrate human and animal data in one surveillance initiative [18-20], often under the flag of “One Health”¹. Zoonotic EID surveillance initiatives range from the international, such as the Global Avian Influenza Network for Surveillance²; to the national, where in Canada initiatives include the Canadian Animal Health Surveillance Network (CAHSN)³, and the Canada Cooperative Wildlife Health Centre (CCWHC)⁴ which receives approximately \$¾ to \$1½ million Canadian dollars per year for Avian Influenza surveillance; to the provincial, where the West Nile virus program in British Columbia costs approximately \$1 million Canadian dollars per year⁵. The significant investment of resources in this area makes the fundamental deficit in our knowledge of surveillance system design and evaluation for EIDs of prime importance. These, and

¹ <http://www.onehealthinitiative.com>

² <http://www.gains.org>

³ <http://www.inspection.gc.ca/english/anima/surv/cahsnrscsze.shtml>

⁴ <http://wildlife1.usask.ca/en/aiv/index.php>

⁵ <http://www.bccdc.org/content.php?item=183>

other systems such as the 'From Farm to Fork' Integrated Surveillance in British Columbia [21], are examples of surveillance systems that show the movement towards integration of human and animal information in surveillance, a priority in the international sphere [13].

The interconnected roles of agricultural animals, pets, wildlife, the environment and human populations in zoonosis transmission and pathogenesis creates a number of distinct challenges for surveillance [19]. Surveillance for zoonoses is necessarily a multi-disciplinary endeavor, crossing not only human and animal health, but also environmental health and public health practice and policy. Collaboration of these fields is even more important for emerging zoonotic disease surveillance, as identification of new diseases draws on reports from various types of practitioners on the front lines, public health professionals and researchers: e.g. human and veterinary medicine practitioners, biologists, public health inspectors⁶ and epidemiologists. Information is needed on how best to structure these interdisciplinary surveillance efforts, including specific information on the required roles.

Objectives of this Review

The architects of EID surveillance systems suffer from the lack of a systematic accounting of the necessary elements for integrated EID surveillance and are thus left to use anecdotal information and/or trial and error when developing and evaluating their programs. It is imperative that we identify which systems have been proven effective worldwide. The purpose of this review is to synthesize available evidence for public health practitioners making decisions in the event of an emerging zoonosis, by finding public health surveillance initiatives for emerging zoonoses, and seeing what criteria have been used to evaluate these systems.

⁶ These health professionals are referred to as Environmental Health Officers or Sanitarian in other jurisdictions. For consistency, in this review we use only the term Public Health inspector or PHI.

CHAPTER 2. METHODS

Three questions guided this systematic review:

1. *What public health surveillance initiatives for emerging zoonotic diseases exist worldwide?*
2. *Have these surveillance initiatives been evaluated?*
3. *What criteria were used to evaluate the surveillance initiatives?*

These questions were addressed by: 1) finding reports of systems that met our case definitions for surveillance and for emerging disease, 2) reviewing qualified reports to determine whether they had been evaluated, and 3) assessing which criteria were used for the evaluations. Articles were gathered from published peer-reviewed literature in English, and from one select non-peer reviewed source, chosen based on the anticipated high quality of their evaluations of surveillance initiatives.

Search Strategy

The process of creating the search strategy consisted of two steps: 1) identification of key concepts characterizing the study questions and 2) generation of a list of search terms that reflected these key concepts. The two main concepts identified were: surveillance systems and zoonotic diseases. For each concept a number of subject terms and keyword terms were identified, which were then combined for the search (see Appendix 3). The case definitions adopted for defining the search were:

1. Surveillance

Systematic ongoing collection, collation, and analysis of data and the timely dissemination of information to those who need to know so that action can be taken. It is distinguished from monitoring by the fact that it is continuous and ongoing, whereas monitoring is intermittent or episodic [22], and does not include timely response.

The overall search term components considered to define “surveillance” for the search were: 1) information technology, 2) public health and 3) organizational structure. MEDLINE MeSH terms were hand-searched for relevance under each component. For example, the “information technology” MeSH terms included "decision making, computer-assisted", "decision techniques", "clinical laboratory informatics systems", OR "decision support systems, clinical", "hospital information systems", "integrated advanced information management systems"; the “public health” MeSH terms included "diagnosis, computer-assisted",

"epidemiologic methods", "disease outbreaks", "disease reservoirs", "disease transmission", "environmental medicine", "environmental microbiology", "environmental monitoring", "food contamination", "communicable disease control", "mandatory reporting", "disease management"; the "organizational structure" terms included "communication", "decision making", "information dissemination", "interprofessional relations", "public health administration", "organization and administration", and "health care organization" (see Appendix 3 for a list of all MEDLINE search terms).

2. Emerging Zoonosis

A zoonosis that is newly recognized or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographical, host or vector range [13]. The lists of emerging zoonoses used for the literature search are in the Appendix (see Appendix 1, Appendix 2). Diseases were searched by their common names, as well as the names of the causative agents.

We recognized that the published literature in this subject area was not confined to a restricted set of journals. While broad searches resulted in the inclusion of many papers later deemed irrelevant, it increased the retrieval of relevant studies and reduced potential biases that narrower search terms could have produced. To ensure a very high degree of sensitivity, both subject and keyword searches were used. For example, *population surveillance, communicable diseases emerging, zoonoses, and disease outbreaks* are all medical subject headings (MeSH), whereas *disease\$ adj5 outbreak\$* are keyword terms that retrieved variations of these terms, such as *outbreaks of lethal disease, disease causing destructive outbreaks, and disease associated with recent WNV outbreaks*. Because the research questions encompassed topics in medicine, veterinary medicine, public health, zoology, biology, environmental studies, and agriculture, the published literature search was limited to: MEDLINE, EMBASE, AGRICOLA, several subsets of databases under Environmental Sciences and Pollution Management, and Zoological Record. The exact search strategy was unique for each database due to differences in subject thesauri or subject terminology (see Appendix 3).

In addition to the search of published literature, individuals from the Canadian Field Epidemiology Program (CFEP) in the Public Health Agency of Canada (PHAC) provided surveillance system evaluations completed by their trainees between 1999 and 2007. These CFEP reports were chosen to represent the best non peer-reviewed literature available on the evaluation of public health surveillance of infectious diseases in Canada. The local, provincial/territorial and federal agencies that hosted the CFEP epidemiologist's placement and commissioned the reports were contacted in order to obtain permission to use the reports. A condition of the

data sharing agreement struck with these placements prohibits identification of individual systems under evaluation in this report. All results are grouped to preserve this anonymity.

All search strategies were recorded at each step and citations from database searches were downloaded or manually entered into RefWorks (RefWorks, LLC) and duplicates were removed. Counts from initial citation results were recorded and dated both initially and throughout the identification of research papers. The review was limited to papers published between 1992 and 2006, and written in English, thereby leading to an overwhelming majority of papers describing surveillance initiatives in English-speaking countries (Australia, Canada, New Zealand, the United Kingdom and the United States).

Study Selection

The first round of inclusion/exclusion was done using only titles, subject headings and abstracts (if available) of the articles. The inclusion/exclusion criteria used at this initial stage were broad (Table 1).

Two reviewers assessed the reliability of the initial inclusion/exclusion decision process using a sub-section of the total MEDLINE search. In this pilot, the two researchers applied the initial inclusion/exclusion criteria separately, and then compared their selections. Where there was disagreement regarding a specific paper, the researchers met to discuss their initial decisions and the final choice was decided based upon consensus. The degree of agreement was tested using the Cohen's Kappa statistic. After this pilot phase, articles were included and/or excluded independently by the two reviewers.

The second round of inclusion/exclusion criteria, modified based on the results of the pilot reviewer consensus study, were applied to full texts of articles (Table 1). The totals of articles included/excluded at each stage were recorded to create flow charts to illustrate the process. Articles were included if they described and/or evaluated emerging zoonoses surveillance systems. We included systems such as diagnostic, management, reporting and/or communications systems if they could potentially be classified or used as surveillance systems. Because the focus of our analysis was on systems intended for use by public health officials, clinicians, and environmental health practitioners, we did not include systems designed for other decision makers unless clinicians or public health officials could also use them. The same inclusion/exclusion criteria were applied to the selection of the peer-reviewed articles and the field epidemiology (CFEP) reports.

Table 1. Inclusion and Exclusion Criteria. Initial exclusion criteria (*) applied only to titles, subject headings and abstracts (if available) of the articles. Secondary exclusion criteria () applied to full texts of articles.**

	Initial Exclusion Criteria*	Secondary Exclusion Criteria**
Language	<ul style="list-style-type: none"> Non-English 	<ul style="list-style-type: none"> Non-English
Time Period	<ul style="list-style-type: none"> Prior to 1987 	<ul style="list-style-type: none"> Prior to 1992
Study Type	<ul style="list-style-type: none"> Basic research articles Organ transplant articles 	<ul style="list-style-type: none"> Basic research articles Organ transplant and blood transfusion articles
Diseases	<ul style="list-style-type: none"> Does not relate to an emerging/re-emerging zoonotic disease (<i>not in Tables A1 and A2 in Appendix</i>) 	<ul style="list-style-type: none"> Does not relate to an emerging/re-emerging zoonotic disease (<i>not in Tables A1 and A2 in Appendix</i>)
System Description/ Type	<ul style="list-style-type: none"> Reports of the results of a surveillance system only, not discussing the system 	<ul style="list-style-type: none"> No statement of purpose or no description of system Reports of the results of a surveillance system, not discussing the system General listserves, e-mail distribution lists, chat rooms, electronic versions of textbooks or Web sites that provide information on emerging zoonoses without a moderator or peer-review process

Data Extraction and Quality Assessment

In the pilot phase data extraction and application of inclusion/exclusion criteria was carried out by two reviewers (LV and NK). Extensive discussions resulted in clarification of the definitions of the data to be extracted, and data extraction was thereafter conducted by the two reviewers independently. The data extracted from the articles are listed in Table 2.

An evaluation was considered to have been conducted (Evaluated Category: Yes/No) if the paper stated that an evaluation was conducted and/or if the paper contained at least two of the following three criteria: sensitivity, positive predictive value (specificity), or timeliness. These three criteria were chosen from of the nine evaluation criteria outlined by the CDC's "Guidelines for Evaluating Public Health Surveillance Systems": simplicity, flexibility, data quality, acceptability, sensitivity, positive predictive value, representativeness, timeliness and stability [14]; they were chosen as they were the components deemed most pertinent for an EID surveillance system by the authors. However, if any of the other six evaluation criteria outlined by the CDC were assessed, the information was recorded in the database (Evaluated: Other). The evaluation criteria were considered to be "assessed" if the necessary elements of the criterion were contained in the article, the authors did not have to specify that they were indeed addressing the specific criterion. For example, if the authors included the time taken from data capture to analysis, then the "timeliness" criterion was considered to be "assessed".

Quality assessment of studies is an important part of systematic reviews. Criteria to assess study biases and quality are usually applied to observational studies to assign levels of quality [23]. These criteria include the study design used (cohort studies rating higher than case-control studies) and treatment of bias (selection,

performance, measurement and attrition). However, in this review the unit of study is the surveillance system, not the study, therefore quality was assessed for the surveillance systems using the CDC surveillance system evaluation criteria outlined above. The same data was extracted from the peer-reviewed articles and the CFEP reports.

Table 2. Data extracted from articles.

No.	Field Name	Field Description
1	System Name	the name of the system
2	Purpose	the purpose of the system
3	Location	the location of the system, systems entered into the database at their highest form of aggregation, i.e. if the system was both local and national, it was entered at the national level (Continent, "International" was used for systems that spanned two or more countries, and Country)
4	Population	a description of the population the system covers
5	Year Started	the year the system started operating
6	Organizations Involved	the organizations involved in the operation of the system
7	Agent: Known and/or Unknown	the nature of the infectious disease agent the system could identify, whether the agent is known or defined, or unknown and undefined
8	System Type	the type of system, such as whether it is a true surveillance system, monitoring system, or research project
9	Syndromes and/or Diseases Under Surveillance	the types of diseases or syndromes that the system identifies
10	Type of Data Collected	the type of data the system collects, such as laboratory diagnoses or administrative health records
11	Data Category: Human/Animal/Other	the type of data collected category, defining whether the data collected was human, and/or animal, and/or other
12	Method of Data Collection and Analysis	a description of the methods employed by the system to collect the necessary data, and how the data was analyzed
13	Evaluation: Timeliness	whether the system was evaluated for timeliness
14	Evaluation: Sensitivity/Specificity	whether the sensitivity or specificity of the system was determined
15	Evaluation: Other	whether any other evaluation of the system was explicitly performed, see methods for more details
16	Evaluated Category: Yes/No	a categorical assessment of whether an evaluation was conducted, see methods for more details
17	Role of Public Health Inspectors	detailed account of the role of public health inspectors or analogous personnel in the system
18	References	a list of all references associate with the system, as often more than one reference was associated with one system

Descriptive Analysis

The data synthesis stage involved the collation and summarization of the results in tabular form indicating the characteristics of the surveillance system: whether the agent under surveillance was known or unknown; whether the number of diseases under study was one vs. many; whether the type of data collected was human, animal, or other; and whether an evaluation of the system was conducted or not. The same analyses were conducted for the peer-reviewed literature and the CFEP reports; however the latter are grouped to preserve anonymity.

CHAPTER 3. RESULTS

The literature search identified 2,263 articles from the various databases (see Figure 2). Initially there was difficulty in agreement on the application of inclusion and exclusion criteria, mostly due to variability in what authors described as a surveillance system and the problem of distinguishing which papers described the system or merely presented results.

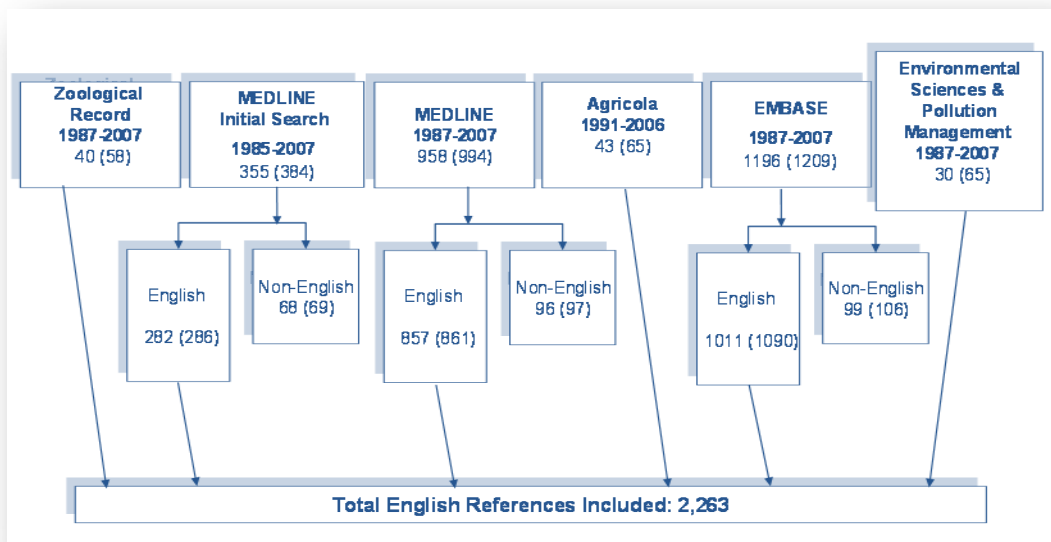


Figure 2. Search results Citation Counts from Bibliographic Databases. The number of references in brackets represent totals with duplicates, the numbers not in brackets represent the number of references after duplicates have been removed.

After the first round of applying inclusion/exclusion criteria, a total of 603 articles were selected: 370 from MEDLINE, 187 from EMBASE, 16 from AGRICOLA, 16 from Environmental Sciences and Pollution Management, and 14 from Zoological Record. All but 20 articles were obtained in full (96.7%). The Cohen's Kappa measuring inter-rater agreement of the pilot MEDLINE search was 0.47 or moderate (see Figure 3). Since this pilot phase was used to foster discussion on study selection criteria between the two reviewers, and consensus was reached on the articles chosen from this pilot phase, the pilot phase Kappa did not provide an estimate of agreement that could be extended to the rest of the study. Of the initial 583 full text articles, 214 contained systems meeting the study inclusion criteria (see Appendix 6). More than half (55%) of the articles were published in the four-year period from 2003 to 2006 (see Figure 4).

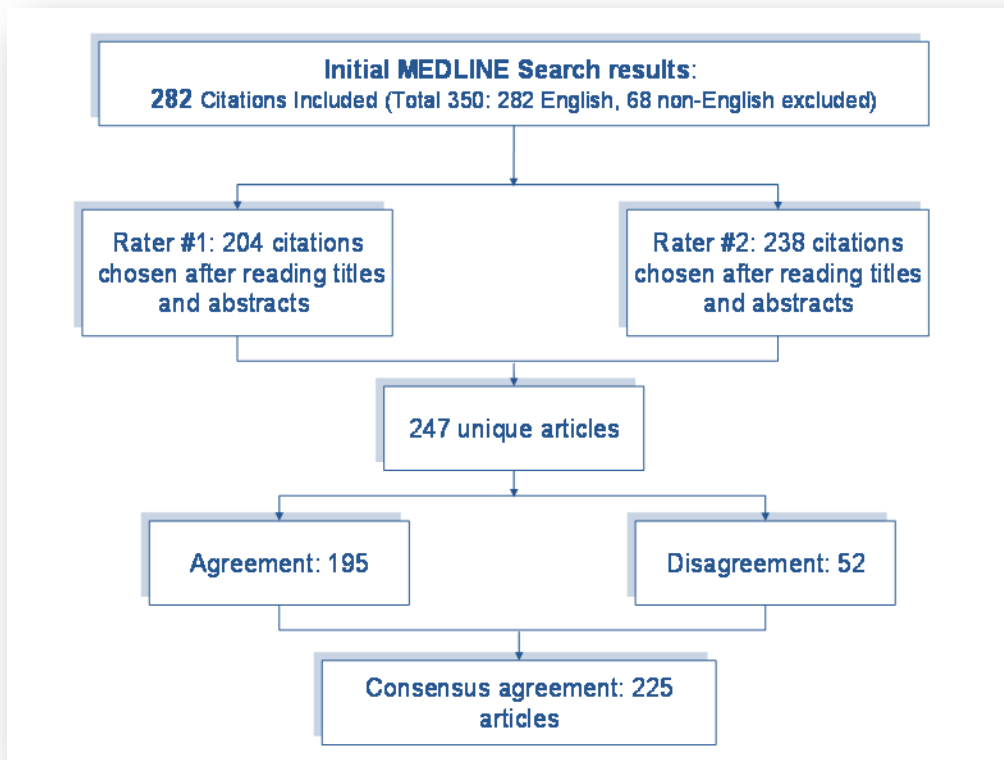


Figure 3. Initial (Pilot) MEDLINE Search Results: Inter-Rater Agreement. Inter-rater agreement of the MEDLINE Initial Search (1985-2007), Cohen's Kappa = 0.47.

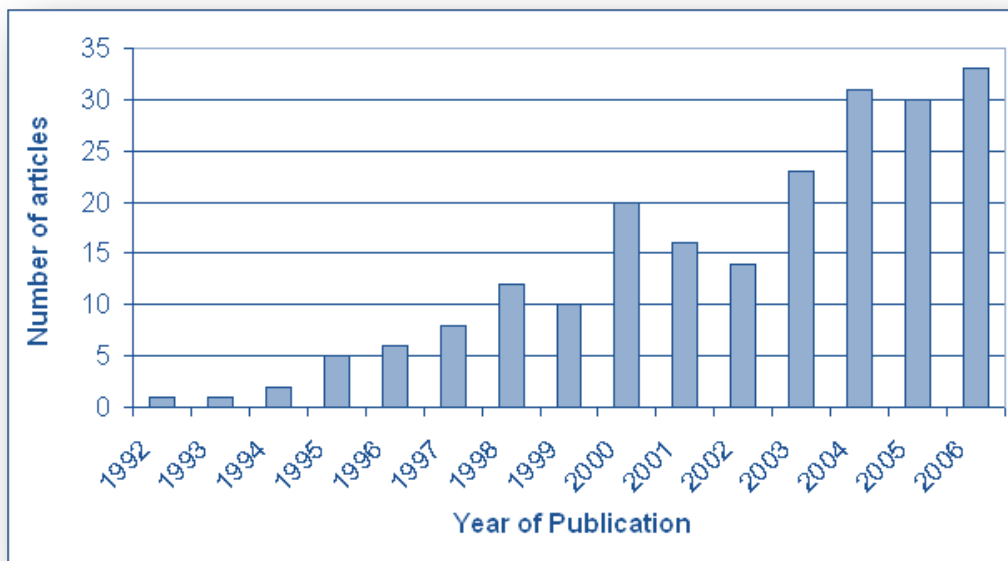


Figure 4. Articles of Emerging Zoonoses Surveillance Systems by Year of Publication: 1992-2006 (N=212)

Results of all Surveillance Systems

Data extraction was plagued by similar problems as the selection of articles due to unclear terminology. For example, we could not use the data field “System Type”, because of the difficulty in determining what was a monitoring system and what was a surveillance system, as they were both often called surveillance systems in the articles. Data extraction from the 214 articles resulted in 221 different systems, as some articles described more than one system (see Appendix 4).

Table 3 shows the results of these included systems by continent. Most systems were from North America (39.8%), followed by Europe (28.5%), and the least in Africa (5.0%) and Central and South America (1.4%). The majority (61.5%) of the systems were designed to detect ‘known’ pathogens only, followed by systems designed to detect both known and unknown pathogens (19.9%), with the fewest systems (6.8%) intended to detect only unknown pathogens; North America had the largest number of systems for detecting unknown pathogens while Europe focused almost exclusively on detection of known zoonotic diseases. The systems primarily examined human data only (49.3%), followed by animal data only (22.2%) with the fewest looking at both human and animal data in one system (16.3%). Finally, more systems looked at multiple diseases (63.8 %) than one disease exclusively (33.9 %) (see Table 3). Overall, the published literature on surveillance systems of emerging zoonoses did not mention the specific roles played by environmental health practitioners.

There was much missing information on the structure and components of the surveillance systems. The most complete data field was whether the system collected data on one disease versus multiple diseases (100%), followed by what country or continent the system was in (both 99.5%), if the system was evaluated (93.2%), whether the system collected known and/or unknown pathogen data (88.2%) and the type of data collected (human and/or animal) (87.8%), the specific syndromes or diseases under surveillance (80.5%), organizations involved (78.7%), purpose of the system (78.7%), information on the population that the system covers (72.4%), type of data collected (66.5%), methods of data collection and analysis (66.5%), and finally year started (60.2%). The most incomplete data were those for system type (27.6%), whether timeliness was evaluated (26.2%), whether sensitivity or specificity were assessed (14.5%), and finally any other evaluation information (10.5%).

Table 3. Systems by Continent (N=221), by pathogen(s) under surveillance, type of data collected, and number of diseases under surveillance. Totals do not always add to 221 due to missing values.

Continent	Number of Systems for Known and Unknown Pathogens (N=190)			Number of Systems Collecting Human and Animal Data (N=194)			Number of Systems Collecting One Disease versus Multi-disease Data (N=216)		Total Number of Systems Included (N=220)
	Only Known Pathogens	Only Unknown Pathogens	Both Known and Unknown Pathogens	Human Data	Animal Data	Human and Animal Data	One Disease	Multi-Disease	Total
Africa	8	0	0	4	3	4	7	4	11
Asia	11	1	3	11	0	1	8	8	16
Australia and Oceania	13	0	2	9	4	4	6	12	18
Central and South America	3	0	0	2	0	1	1	2	3
Europe	48	1	11	30	24	7	26	35	63
North America	41	11	23	46	16	15	21	65	88
International	12	2	4	7	2	4	6	14	21
Unknown	0	0	1	0	0	0	0	1	1
Total	136	15	44	109	49	36	75	141	221

Results of Evaluated Surveillance Systems

Only 17 of the 221 (7.7%) systems were considered ‘evaluated’ according to the definition of this review (see Methods), with most (64.7%) in North America (Table 3). Appendix 5 lists all 17 of the evaluated systems. Eleven papers reported timeliness and one of sensitivity, specificity or positive predictive value; three stated they conducted an evaluation but did not present any results. Although these papers also looked at the other evaluation criteria outlined by the CDC evaluation framework [14], they were not used consistently. There was not enough information in the reports to determine whether these evaluations were conducted on an *ad hoc* basis or as an ongoing part of the systems.

Only four of the papers evaluating systems addressed the general usefulness of their system for detection of disease: the Boston Bioterrorism Surveillance Systems [24]; NHS Direct [25]; Health Partners Medical Group Surveillance System [26] and Sentinelles [27-33]. All looked at human disease data only. Three of the four targeted both known and unknown pathogens while one looked exclusively at known pathogens. Since none of the four systems had detected an emerging disease, either retrospective data or modeled data were used to assess the detection capability of the system. Three of the four evaluations concluded that the system was useful because it identified the chosen outbreak of disease [24, 26-33], while one concluded that it was not useful because it did not identify the chosen outbreak [25].

Results of Select Non-Peer Reviewed Search

A total of 45 “surveillance of health events” evaluations conducted by epidemiologists in the Canadian Field Epidemiology Program (CFEP) were identified between 1999 and 2007. Although eleven reports fit the initial inclusion criteria, only seven were included in this review, as two were incomplete, one was not available, and the last one turned out to not fit the inclusion criteria.

Two of the reports looked at the same surveillance system, and therefore all descriptive statistics are calculated for only six of the seven reports, while all seven reports were used for the description of the evaluations performed (see Table 4). Three of the six reports featured true surveillance systems, one was a pilot system which was more of a monitoring system, and the remaining two were alerting systems. Three of the systems were provincial, two were national and one was local. Unlike the many of the peer-reviewed articles, all of the CFEP reports described the systems in sufficient detail to obtain all of the necessary descriptive data. Three of the systems were started in 2001, the remaining three in 1997, 1998 and 2005 respectively. Most (4/6) of the systems were for known agents only, the remaining two were for both known and unknown agents. Similarly, most (4/6) of the systems gathered information on multiple diseases, while two focused on one disease. Half (3/6) of the systems only looked at human data, while one system looked at human and animal data, one looked at human and other data, and the last one looked at human, animal and other data.

All of the CFEP reports contained evaluations of the selected systems as per the definition of evaluation in this report (see Methods). The reports often used multiple evaluation criteria which varied depending on the system attributes, data availability and the specific objectives of each evaluation (Table 4). Table 4 also shows how often each criterion was assessed in the reports: the most common evaluation criterion was timeliness, followed by acceptability, utility and relevance.

Table 4. Evaluation criteria used in the Canadian Field Epidemiology Program’s Surveillance System Evaluation Reports (N=7).

Evaluation Criteria	Number of Reports Using Criteria
Timeliness	5
Acceptability	4
Utility/Relevance	4
Flexibility	3
Sensitivity/Specificity/Positive Predictive Value	3
Data Quality	2
Representativeness	2
Simplicity	2
Sustainability	1

The role of public health inspectors (PHIs) was mentioned in two of the seven reports. In those two reports, PHIs were identified as integral to the system, either by being the frontline responders who notify medical health officers of a potential outbreak, or by doing the case follow-up.

CHAPTER 4. DISCUSSION

Our systematic review identified 221 existing surveillance and monitoring systems that tracked emerging zoonoses worldwide in the peer-reviewed literature, and 6 systems in the selected non peer-reviewed literature search. A comparable systematic review of surveillance systems that focused on systems designed for early detection of bioterrorism-related diseases found 115 systems of which only 29 were designed for surveillance of syndromes or illnesses associated with bioterrorism-relevant pathogens [16]. This suggests a marked increase in the number of surveillance systems for emerging diseases in the intervening years, supported by the increasing number of articles published later in this review (see Figure 4).

Evaluation of Surveillance Systems

Of the 221 existing surveillance and monitoring systems that tracked emerging zoonoses worldwide in the peer-reviewed literature, only 17 of those were evaluated. Unfortunately these evaluations were very limited in the majority of papers, with very few papers adhering to any of the criteria for evaluations of surveillance systems: simplicity, flexibility, data quality, acceptability, sensitivity, positive predictive value, representativeness, timeliness and stability[14] and no paper addressed all of the criteria. Only four articles explicitly used their evaluation to assess the utility of their systems, although these evaluations were not comprehensive [24-33]. It would be very troubling if this lack of evaluations in peer reviewed literature reflects that these organizations are in fact not conducting evaluations, as evaluation should be an ongoing component of any surveillance system. However, there may be other explanations. The general lack of evaluation data presented in the peer-reviewed literature describing EID surveillance systems may be due to an unwillingness to publicly report negative evaluation results, as they could result in negative actions such as funding cuts, or because the government agencies that often operate surveillance systems support the publication of internal reports rather than scientific articles. It may be due to the relative novelty of many of these systems, as evidenced by more than half of the articles used for this review being published in the last four years of the study period (2003-6) (see Figure 4).

Closely related to the novelty of these systems is the lack of collection of independent data that would enable comparisons and establishment of 'gold' standards by the profession. At the very least this lack of an available gold standard complicates calculations of evaluations measures such as sensitivity and specificity of the surveillance systems, and, at worst makes comparisons very difficult. Nevertheless, researchers have been able to obtain measures of imprecision in their surveillance efforts without an independent collection mechanism

giving them a gold standard for Rocky Mountain spotted fever by comparing hospital multiple cause of death data with nationally collected surveillance data [34].

Despite the existence of valid explanations for the lack of evaluations of surveillance systems in the literature, this dearth of information highlights that current systems may not be constructed using evidence-based methods. If the literature contains no evidence as to what systems work and why, then there is little basis for those developing new systems or refining existing systems.

Definition of Surveillance

This review highlights that there is difficulty in identifying what system is a ‘surveillance system’, as illustrated by the inconsistent application of the term ‘surveillance’ to systems in the reports included. A number of articles stated that they described surveillance systems. However, the information provided suggested they were monitoring systems with no timely analysis or ongoing dissemination of data. Unfortunately, because most of the articles did not contain enough information to correctly distinguish whether the systems were surveillance systems or monitoring systems, monitoring systems were included in this review incorrectly classified as surveillance systems, and their exact number could not be quantified. This lack of specificity in the term ‘surveillance’ likely reflects the fact that, to date, there has been very little ‘surveillance theory’ in public health, resulting in the term not being consistently defined or applied. Surveillance in general has not been subjected to much academic scrutiny, as many consider it philosophically dichotomized away from research itself. It is seen as a compromise, since only limited data are collected to get a “sense” of what is happening. While surveillance data are not necessarily amenable for the study of complex etiologic questions such as disease transmission dynamics and biology, the identification of the most useful types of surveillance data, the most effective and efficient way to collect those data and the most reliable way to interpret their meaning for a particular purpose must be done using scientific methods.

Definition of Emerging Zoonoses

The general definition of emerging zoonosis used in this study may have resulted in the inclusion of some surveillance systems for endemic zoonoses because the definition excluded geographic region. This is because an emerging zoonosis in one area is not necessarily an emerging zoonosis in another, and may, in fact, be a well established endemic zoonoses not changing in any manner. For example, although *West Nile virus* (WNV) is an emerging disease in North America, it is not an emerging disease in the Middle East or Northern Africa. Nevertheless, an article on WNV in the Middle East or Northern Africa would have been included in this review, since the articles were chosen based on the causative agent (WNV) and not location.

Case Definitions of Diseases or Syndromes under Surveillance

Surveillance systems differ markedly depending on whether they are designed to track a specific disease or disease agent (known pathogen), or a more general (and therefore less specific) syndrome which could encompass many different types of conditions including potentially unknown pathogens. These latter systems, so-called syndromic surveillance systems, are becoming more popular. While the majority of systems in this review (61.5%) were designed to detect 'known' pathogens only, syndromic surveillance systems, such as systems designed to detect both known and unknown pathogens (19.9%), and systems intended to detect only unknown pathogens (6.8%) were also included. The importance of these syndromic surveillance systems which use a broader case definition for surveillance is that these systems are able to detect completely unexpected diseases. One such instance of serendipitous detection using syndromic surveillance systems comes from a public health surveillance system designed to capture anthrax cases in New York, and resulted in the detection of another zoonosis, Rickettsialpox [35, 36].

Integration of Human and Animal Data

Surveillance for emerging zoonoses is a multi-disciplinary endeavor, one that becomes more complex if we do not limit ourselves to identifying human cases but include animal and other data as surveillance signals. Collaboration across various fields is even more important for emerging zoonotic disease surveillance, as opposed to non-emerging or endemic zoonosis surveillance, because identification of new diseases draws on reports from various types of practitioners and researchers and does not necessarily exhibit a known pattern.

This review shows that there is indeed movement towards integration of human data with animal data in surveillance initiatives. While almost half (49%) of all 221 systems looked at human data alone, and about a quarter looked at animal data only (22%), there was a smaller but sizeable proportion (16%) who tracked both human and animal data. This suggests that inroads are being made to integrate human and animal data for certain diseases, particularly for WNV in North America, where human diagnostic data was in the same system as bird and/or mosquito data. Unfortunately, since none of the evaluated systems in this review were those that captured both human and animal data in one system, it is difficult to assess how well these integrated systems perform.

As stated in the introduction, a main issue for those attempting to combine human and animal surveillance data is that the mandates of their home institutions may hinder such efforts. What needs to occur is for one of the agencies, either the one responsible for animal health or the one responsible for human health to somehow bridge this impasse. Currently, neither human nor animal health agencies have an explicit mandate to compare animal and human disease data in a 'One Health' manner [18]. If one agency, or ideally both agencies, were to

adopt such a mandate, a common surveillance system could be created, funded and populated by people from both agencies on an ongoing basis. In this way both agencies would remain responsible for feeding information into the system, allowing both agencies to respond to a generated surveillance signal. Without formal legislation, these 'integrated' surveillance systems will remain in the hands of key motivated individuals, susceptible to disuse or complete collapse if these individuals burn out or depart from their positions.

Role of Public Health Inspectors

The published literature on surveillance systems of emerging zoonoses did not mention the specific roles played by public health inspectors (PHIs). The roles of PHIs were also not commonly included in the grey literature reports; however, in the two that did state their role, they were integral to the functioning of the systems. For example, in one of the systems they were involved with examining cases with symptoms of unspecified gastrointestinal illness (i.e. with unknown etiology). The lack of information about their roles in the articles was probably largely due to the fact that specific roles for those involved with the system were not regularly described in the articles. Unfortunately, there were a number of articles which did specify roles, although this discussion was often related to those who initially identified the emerging disease. Without more information from the literature, comment on the roles of PHIs in emerging zoonosis surveillance cannot be made at this time.

Comparison of Peer-reviewed Literature and Non Peer-Reviewed Literature

The sample of non peer-reviewed literature reviewed showed that the same lack of clarity exists with respect to the definition of what constitutes a surveillance system as in the peer-reviewed literature. However, the quality of the evaluations was much higher than those in most of the peer-reviewed articles in that they contained many more of the elements that comprise an evaluation according to the US CDC: simplicity, flexibility, data quality, acceptability, sensitivity, positive predictive value, representativeness, timeliness and stability [14]. Therefore, government agencies and epidemiology training programs should encourage peer-reviewed publishing of their surveillance evaluation reports, even when their current mandate does not support such efforts.

Limitations

Our systematic review has three main limitations: 1) the scope of the search strategy, including the search terms used and the databases searched, 2) the included articles did not provide all of the necessary data, and 3) the focus on peer-reviewed literature for this review.

First, since the purpose of the project was to synthesize available evidence on current surveillance for public health practitioners who would make decisions in the event of an emerging zoonosis, we may have neglected some relevant surveillance systems that were published in journals not indexed in the chosen search databases. For example, this review did not pick up papers discussing a relatively new area of research showing promise, namely the use of spatial data to determine risk of zoonotic diseases, especially those associated with wildlife: remotely sensed data has been used to predict risk of Hantavirus pulmonary syndrome [37] and *Sin Nombre virus* [38]. These methods hold promise not only for research, but could be used either in conjunction with other surveillance data in a surveillance system or to help evaluate surveillance systems. Further, since this review was limited to articles in English only, this necessarily resulted in a bias towards systems in North America and Europe, to the detriment of groups of countries with a different dominant language, such as South America.

Second, many articles did not contain basic descriptive information of the systems, making missing values an issue and even making it a challenge to identify unique surveillance systems. Duplicates of systems occurred either when 1) a system changed over the study time, either in name or in scope, or 2) a system was described at a local level in one paper, and at a regional or national level in another paper. With the information provided in the articles, it was often not possible to conclusively state whether a particular system was the same as another. Although this information may have been possible to obtain by contacting the individual researchers or the agencies maintaining the system, this was outside the scope of this project.

Third, and perhaps most important, the review focused mainly on published and peer-reviewed literature, and there is considerable evidence that papers describing and evaluating surveillance systems are in the realm of “grey” or unpublished literature. Our limited look into the grey literature supports this view, as these reports contained higher quality evaluations and more complete information on all aspects of the program. Although future reviews should attempt to include internet searches for reports, such as those by various government agencies, these agencies often do not post their reports, and in fact may not want to publicize their reports at all.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Detailed descriptions and evaluations of surveillance systems are scarce in peer-reviewed literature and the definition of surveillance is unclear in both peer-reviewed and non peer-reviewed literature. There is a need for further research into the science of surveillance: surveillance needs to be studied, defined and standardized.

The result is that decision-makers lack an evidence basis on which to choose effective systems. In light of this gap in information, systems may not have been developed using evidence-based methods. However, since such systems are still in their infancy, we expect proper evaluations in the future when the necessary data is collected. Whether these evaluations will be available in the peer-review literature or will remain primarily in the realm of non peer-reviewed literature remains unclear.

Recommendations

1. Government agencies and epidemiology training programs should encourage the publishing of their surveillance evaluation reports, including detailed descriptions of their surveillance programs, in the peer-review literature.
2. There is a need for further research into the science of surveillance: surveillance needs to be studied, defined and standardized. Public health professionals should recognize that surveillance is a valid scientific discipline.
3. Evaluation must be built into surveillance systems as an ongoing component. Decision makers need to be cautious when making decisions based on systems that have not been adequately evaluated.
4. While the role of public health inspectors in emerging zoonoses surveillance is unclear from the data gathered in this review, their inclusion should be contemplated by those setting up such systems.

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APPENDICES

Appendix 1: Emerging and re-emerging zoonoses listed by agent

Appendix 1. Emerging and re-emerging zoonoses listed by agent

Viruses and prions	Viruses and prions (N=51)	Bacteria & rickettsia (N=29)	Helminths (N=9)
Andes Australian bat lyssavirus Bagaza Banna Barmah Forest California encephalitis Cercopithecine herpes Chikungunya Crimean-Congo hemorrhagic fever Dengue Eastern equine encephalitis Tickborne encephalitis Guama Guanarito Hantaan Hendra Influenza A* Japanese encephalitis Junin Laguna Negra Lassa Machupo Marburg Mayaro Menangle Monkeypox	Murray Valley encephalitis Nipah O'nyong-nyong Oropouche Picobirnavirus Puumala Rabies Reston Ebola Rift Valley fever Ross River Sabia Salehabad Sandfly fever Naples Severe acute respiratory syndrome coronavirus Seoul Sin Nombre Sindbis St. Louis encephalitis Venezuelan equine encephalitis Wesselsbron West Nile Western equine encephalitis Yellow fever Zaire Ebola Zika Bovine spongiform encephalopathy agent	<i>Aeromonas caviae</i> <i>A. hydrophila</i> <i>A. veronii</i> (var. <i>sobria</i>) <i>Anaplasma phagocytophila</i> <i>Bacillus anthracis</i> <i>Borrelia burgdorferi</i> <i>Brucella melitensis</i> <i>Campylobacter fetus</i> <i>C. jejuni</i> <i>Clostridium botulinum</i> <i>Ehrlichia chaffeensis</i> <i>E. ewingii</i> <i>Escherichia coli</i> <i>Francisella tularensis</i> <i>Leptospira interrogans</i> <i>Listeria monocytogenes</i> <i>Mycobacterium avium</i> <i>M. bovis</i> <i>M. marinum</i> <i>Rickettsia prowazekii</i> <i>Salmonella enteritidis</i> <i>S. typhi</i> <i>S. typhimurium</i> <i>Shigella dysenteriae</i> <i>Vibrio cholerae</i> <i>V. parahaemolyticus</i> <i>V. vulnificus</i> <i>Yersinia enterocolitica</i> <i>Y. pestis</i>	<i>Anisakis simplex</i> <i>Echinococcus granulosus</i> <i>Loa loa</i> <i>Metorchis conjunctus</i> <i>Onchocerca volvulus</i> <i>Strongyloides stercoralis</i> <i>Taenia solium</i> <i>Trichinella spiralis</i> <i>Wuchereria bancrofti</i>
			Protozoa (N=11)
			<i>Babesia microti</i> <i>Cryptosporidium hominis</i> <i>C. parvum</i> <i>Giardia duodenalis</i> <i>Leishmania donovani</i> <i>L. infantum</i> <i>Plasmodium falciparum</i> <i>P. vivax</i> <i>Toxoplasma gondii</i> <i>Trypanosoma brucei</i> <i>T. cruzi</i>
			Fungi (N=9)
			<i>Histoplasma capsulatum</i> <i>Malassezia pachydermatis</i> <i>Penicillium marneffei</i> <i>Encephalitozoon cuniculi</i> <i>E. hellem</i> <i>E. intestinalis</i> <i>Enterocytozoon bieneusi</i> <i>Nosema connori</i> <i>Trachipleistophora hominis</i>

* Only Avian Influenza or other "animal" Influenzas were included; systems looking only at "human-human" Influenzas (i.e. those including both influenza A and Influenza B) not designed to pick up potential "animal" influenzas (including avian) were not included.

Appendix 2: Emerging and re-emerging zoonoses listed by transmission route and disease

Appendix 2. Emerging and re-emerging zoonoses listed by transmission route and disease

Zoonoses Transmitted by Direct Contact, Alimentary (Foodborne and Waterborne), or Aero-genic (Airborne) Routes

Aeromonas infection: *Aeromonas hydrophila*
Anisakiasis: *Anisakis simplex*
Anthrax: *Bacillus anthracis*
Argentine hemorrhagic fever: *Junin virus (Arenavirus)*
Avian tuberculosis: *Mycobacterium avium*
Bat Lyssavirus (formerly known as Pteropid bat virus): *Australian bat lyssavirus*
Bovine tuberculosis: *Mycobacterium bovis*
Bolivian hemorrhagic fever (also known as black typhus or Machupo virus): *Machupo virus (Arenavirus)*
Botulism: *Clostridium botulinum*
Bovine spongiform encephalopathy (BSE): BSE prion
Brazilian hemorrhagic fever: *Sabia virus (Arenavirus)*
Brucellosis (also called Undulant fever, Malta fever): *Brucella melitensis*
Bubonic plague (also known as Black Death, Great Plague): *Yersinia pestis*
Campylobacteriosis: *Campylobacter coli*, *Campylobacter jejuni*, *Campylobacter* spp
Cercopithecine herpesvirus 1 (or B virus) infection: *Cercopithecine herpesvirus 1*
Cholera: *Vibrio cholerae*
Cryptosporidiosis : *Cryptosporidium hominis*, *C. Parvum*
Ebola hemorrhagic fever: *Reston ebolavirus*, *Zaire ebolavirus* (previously Reston Ebola virus , Zaire Ebola virus)
Echinococcosis (also known as hydatid disease or hydatid cyst): *Echinococcus granulosus*
Giardiasis: *Giardia duodenalis* (formerly also *Lambliia intestinalis* and also known as *Giardia duodenalis* and *Giardia intestinalis*)
Hantavirus pulmonary syndrome (HPS): *Sin Nombre virus*, *Andes virus*, *Laguna Negra virus (Hantavirus)*
Hendra hemorrhagic bronchopneumonia: *Hendra virus (Henipavirus)*
Hemorrhagic colitis: *Escherichia coli (E. coli)*
Hemorrhagic fever with renal syndrome: *Hantaan virus*, *Seoul virus*, *Puumala virus (Hantavirus)*
Hemolytic uremic syndrome (HUS): *Escherichia coli (E. coli)*
Histoplasmosis: *Histoplasma capsulata*, *Ajellomyces capsulatus* (telomorph)
Human monkeypox: *Monkeypox virus (Orthopoxvirus)*
Influenza: *Influenza A virus**
Lassa hemorrhagic fever: *Lassa virus (Arenavirus)*
Listeriosis: *Listeria monocytogenes*
Malassezia pachydermatis infection (seborrheic dermatitis and otitis externa in dogs): *Malassezia pachydermatis*
Marburg hemorrhagic fever: *Lake Victoria marburgvirus* (previously Marburg virus)
Menangle: *Menangle virus* (Family *Paramyxoviridae*, genus not yet assigned)
Metorchiasis: *Metorchis conjunctus*
Microsporidiosis (can also exhibit as Encephalitozoonosis , Cerebral Microsporidiosis) : *Encephalitozoon cuniculi*, *Encephalitozoon hellem*, *Encephalitozoon intestinalis*, *Enterocytozoon bieneusi*, *Nosema connori*, *Trachipleistophora hominis*
Nipah hemorrhagic bronchopneumonia: *Nipah virus (Henipavirus)*
Penicilliosis: *Penicillium marneffeii*
Picobirnavirus: *Picobirnavirus*
Pork tapeworm: *Taenia solium*
Rabies: *Rabies virus (Lyssavirus)*
Salmonellosis: *Salmonella*, *S. enterica*, *S. enteritidis*, *S. typhi*, *S. typhimurium*
SARS (Severe Acute Respiratory Syndrome): *Severe acute respiratory syndrome virus (Coronavirus)*
Strongyloidiasis: *Strongyloides stercoralis*
Swimming Pool Granuloma: *Mycobacterium marinum*
Toxoplasmosis: *Toxoplasma gondii*
Trichinellosis (also called trichinosis, or trichiniasis): *Trichinella spiralis*
Tularemia : *Francisella tularensis*
Venezuelan hemorrhagic fever (VHF): *Guanarito virus (Arenavirus)*
Vibrio infections: *Vibrio parahaemolyticus*, *Vibrio vulnificus*
Yersiniosis: *Yersinia enterocolitica*

Zoonoses Transmitted by Hematophagous Arthropods

Hard ticks:

African tick typhus (also called African tick-bite fever): *Rickettsia africae*
Babesiosis: *Babesia microti*
Crimean-Congo hemorrhagic fever: *Crimean-Congo hemorrhagic fever virus (Nairovirus)*
Human granulocytotropic anaplasmosis (HGA) (also known as Human Granulocytic Ehrlichiosis (HGE) and Sennetsu Fever):
Anaplasma phagocytophilia
Human ehrlichiosis: *Ehrlichia ewingii*
Human monocytic ehrlichiosis (HME): *Ehrlichia chaffeensis*
Lyme disease (European version called Tickborne encephalitis): *Borrelia burgdorferi*

Soft Ticks:

Kyasanur Forest disease (also known as Monkey disease): *Kyasanur Forest disease virus (Flavivirus)*

Lice:

Trench fever (also called Wolhynia fever, shin bone fever, quintan fever, five-day fever, Meuse fever, His disease and His-Werner disease): *Bartonella quintana*

Mosquitoes:

Bagaza virus: Bagaza virus (*Flavivirus*)

Banna virus: Banna virus (*Seadomavirus*)

Barmah Forest: *Barmah Forest virus* (*Alphavirus*)

California encephalitis (viral encephalitis): California encephalitis virus (*Orthobunyavirus*)

Chikungunya fever: *Chikungunya virus* (*Alphavirus*)

Dengue fever (also called Dengue hemorrhagic fever, Dengue shock syndrome): *Dengue virus* (*Flavivirus*)

Eastern Equine Encephalitis (EEE): *Eastern equine encephalitis virus* (*Alphavirus*)

Filariasis (also called lymphatic filariasis or elephantiasis): *Wuchereria bancrofti*

Guama virus: Guama virus (*Orthobunyavirus*)

Japanese encephalitis (also known as Japanese B encephalitis): *Japanese encephalitis virus* (*Flavivirus*)

Leptospirosis: *Leptospira interrogans*

Malaria: *Plasmodium* sp. – *Plasmodium falciparum* and *Plasmodium vivax*

Mayaro virus fever: *Mayaro virus* (*Alphavirus*)

Murray Valley encephalitis (formerly known as Australian encephalitis): *Murray Valley encephalitis virus* (*Flavivirus*)

O'nyong nyong fever: *O'nyong-nyong virus* (*Alphavirus*)

Oropouche Fever: *Oropouche virus* (*Orthobunyavirus*)

Rift Valley fever: *Rift Valley fever virus* (*Phlebovirus*)

Ross River epidemic polyarthrititis (also known as Ross River fever): *Ross River virus* (*Alphavirus*)

Shigellosis: *Shigella dysenteriae*

Sindbis fever: *Sindbis virus* (*Alphavirus*)

St. Louis Encephalitis (SLE): *St. Louis encephalitis virus* (*Flavivirus*)

Venezuelan Equine Encephalitis: *Venezuelan equine encephalitis virus* (*Alphavirus*)

Western Equine Encephalitis (WEE): *Western equine encephalitis virus* (*Alphavirus*)

Wesselsbron: *Wesselsbron virus* (*Flavivirus*)

West Nile illness, West Nile fever, West Nile neurological illness: *West Nile virus* [WNV] (*Flavivirus*)

Yellow fever (also called yellow jack, black vomit or vomito negro in Spanish, or sometimes American Plague): *Yellow fever virus* (*Flavivirus*)

Zika fever: *Zika virus* (*Flavivirus*)

Sandflies:

Sandfly fever : Salehabad virus; Sandfly fever Naples virus (Phlebovirus)

Leishmaniasis (visceral, cutaneous, and mucocutaneous leishmaniasis, kala-azar, dum-dum fever): *Leishmania donovani*, *Leishmania donovani infantum*, *Leishmania donovani chagasi*

Tse Tse Fly/Reduviid Bugs:

Sleeping sickness (also known as African trypanosomiasis, Nagana): *Trypanosoma brucei*

Chagas disease (also known as American trypanosomiasis): *Trypanosoma cruzi*

Deer Flies/Black Flies:

Loa loa filariasis (also loiasis and African eyeworm): *Loa loa*

River Blindness (also known as onchocerciasis): *Onchocerca volvulus*

Fleas:

Cat-Scratch Fever (also called Cat-scratch disease, Cat-Scratch Adenitis, Cat-Scratch-Oculoglandular Syndrome, Debre's Syndrome, Debre-Mollaret Syndrome, Foshay-Mollaret Cat-Scratch Fever, Foshay-Mollaret syndrome, Foshay-Mollaret Cat-Scratch Fever Syndrome, Lymphadenitis-Regional Nonbacterial, Lymphoreticulosis-Benign Inoculation, maladie des griffes du chat, Parinaud oculoglandular disease, and Petzetakis' disease): *Bartonella henselae*, *Bartonella clarridgeiae*

Murine typhus: *Rickettsia typhi*, *Rickettsia felis*, *Rickettsia prowazekii*

* Only Avian Influenza or other "animal" Influenzas were included; systems looking only at "human-human" Influenzas (i.e. those including both Influenza A and Influenza B) not designed to pick up potential "animal" influenzas (including avian) were not included.

Appendix 3: MEDLINE search terms used for the review

Appendix 3. MEDLINE search terms used for the review

Pilot Search

Database: Ovid MEDLINE(R) 1950 to Present with Daily Update Search Strategy:

-
- 1 population surveillance/ (27146)
 - 2 surveillance.mp. (72696)
 - 3 or/1-2 (72696)
 - 4 zoonoses/ (7640)
 - 5 3 and 4 (384)
 - 6 limit 5 to yr="1985 - 2007" (355)
 - 7 limit 6 to english language (286)
 - 8 6 not 7 (69)

Final Search

Database: Ovid MEDLINE(R) 1950 to Present with Daily Update Search Strategy:

-
- 1 artificial intelligence/ or expert systems/ or fuzzy logic/ or knowledge bases/ or natural language processing/ or "neural networks (computer)"/ (18972)
 - 2 medical informatics/ or medical informatics applications/ (5026)
 - 3 Public Health Informatics/ (571)
 - 4 decision making, computer-assisted/ or diagnosis, computer-assisted/ (14602)
 - 5 information systems/ or clinical laboratory information systems/ (16796)
 - 6 decision support systems, clinical/ or geographic information systems/ or hospital information systems/ or integrated advanced information management systems/ or knowledge bases/ or management information systems/ or ambulatory care information systems/ or clinical pharmacy information systems/ or database management systems/ or decision support systems, management/ or medical records systems, computerized/ or reminder systems/ (29392)
 - 7 databases/ or databases, factual/ (25911)
 - 8 computer simulation/ or computer systems/ or computer communication networks/ (73001)
 - 9 decision support techniques/ or data interpretation, statistical/ or decision trees/ (35950)
 - 10 systems analysis/ or operations research/ or systems integration/ (9622)
 - 11 data collection/ or death certificates/ or hospital records/ or medical records/ or medical records systems, computerized/ (93920)
 - 12 vital statistics/ (3604)
 - 13 morbidity/ or incidence/ or prevalence/ or mortality/ or "cause of death"/ or child mortality/ or fatal outcome/ or hospital mortality/ or infant mortality/ or maternal mortality/ or survival rate/ (369637)
 - 14 decision\$.mp. (142670)
 - 15 expert\$.mp. (52741)

- 16 computer\$.mp. (334061)
- 17 informatic\$.mp. (8533)
- 18 information system\$.mp. (37270)
- 19 or/1-18 (990362)
- 20 Disease Outbreaks/ (42573)
- 21 Disease Reservoirs/ (9659)
- 22 Disease Transmission/ (1165)
- 23 Environmental Medicine/ (265)
- 24 Environmental Microbiology/ (2738)
- 25 Environmental Monitoring/ (29649)
- 26 Inhalation Exposure/ (2600)
- 27 Food Contamination/ (18165)
- 28 Communicable Disease Control/ (12815)
- 29 Mandatory Reporting/ (1190)
- 30 disease management/ (4987)
- 31 disease notification/ (2052)
- 32 population surveillance/ or sentinel surveillance/ (28870)
- 33 epidemiologic methods/ (20117)
- 34 health care surveys/ or interviews/ or questionnaires/ or incidence/ or prevalence/ (353762)
- 35 community health planning/ (3176)
- 36 disaster planning/ (6213)
- 37 Health Plan Implementation/ (1599)
- 38 public health practice/ or communicable disease control/ (14760)
- 39 disease notification/ (2052)
- 40 sanitation/ or food inspection/ (6229)
- 41 universal precautions/ or environmental monitoring/ (30852)
- 42 primary prevention/ (8896)
- 43 veterinary medicine/ (15450)
- 44 control\$.mp. (1835160)
- 45 response.mp. (1118156)
- 46 prevent\$.mp. (566536)
- 47 early warning.mp. (1143)
- 48 threat\$.mp. (59068)
- 49 agrobioterrorism.mp. (1)
- 50 (bio-surveillance or biosurveillance).mp. (29)
- 51 outbreak\$.mp. (55709)
- 52 monitor\$.mp. (350590)
- 53 detect\$.mp. (971613)
- 54 surveillance\$.mp. (72819)
- 55 alert\$.mp. (15727)
- 56 contaminat\$.mp. (94199)
- 57 exposure\$.mp. (381229)
- 58 emergenc\$.mp. (158314)
- 59 diagnos\$.mp. (1252022)
- 60 notification.mp. (5509)
- 61 or/20-60 (5438486)
- 62 Communication/ (42166)
- 63 dialogue.mp. (4248)
- 64 Communication Barriers/ (2659)
- 65 Cooperative Behavior/ (10892)
- 66 (data adj3 shar\$.mp. (1050)67 (ownership adj3 data).mp. (65)
- 68 Program Development/ (11917)
- 69 consensus/ (1704)
- 70 Decision Making/ (41957)
- 71 dynamic environment\$.mp. (291)
- 72 Information Dissemination/ (3665)
- 73 "diffusion of innovation"/ or technology transfer/ (7708)
- 74 interdisciplinary communication/ (2484)
- 75 Interprofessional Relations/ (32153)

- 76 International Cooperation/ (27287)
- 77 Internationality/ (6771)
- 78 cross-disciplinary.mp. (220)
- 79 (interstate or inter-state).mp. (528)
- 80 Public Health Administration/ (11818)
- 81 systems integration/ (4513)
- 82 multi-institutional systems/ or hospital shared services/ (7981)
- 83 "Decision Support Systems, Management"/ (763)
- 84 Management Information Systems/ (3318)
- 85 infrastructure.mp. (4971)
- 86 ((corporate or organization\$ or health unit\$) adj10 plan\$.mp. (10476)
- 87 "Organization and Administration"/ (13938)
- 88 ((polic\$ or decision) adj5 maker\$.mp. (6565)
- 89 network\$.mp. (106344)
- 90 hierarchy.mp. (6907)
- 91 authority.mp. (8296)
- 92 formalization.mp. (356)
- 93 codification.mp. (325)
- 94 jurisdiction.mp. (958)
- 95 (coordination adj5 activit\$.mp. (868)
- 96 (coordination adj10 system\$.mp. (1124)
- 97 (coordination or co-ordination).mp. (25076)
- 98 government/ or federal government/ or "united states department of agriculture"/ or "united states dept. of health and human services"/ or "united states centers for medicare and medicaid services"/ or united states public health service/ or "centers for disease control and prevention (u.s.)"/ or "national institute for occupational safety and health"/ or national center for health care technology/ or "national center for health statistics (u.s.)"/ or "national institutes of health (u.s.)"/ or "united states agency for healthcare research and quality"/ or "united states food and drug administration"/ or exp "united states health resources and services administration"/ or united states indian health service/ or "united states office of research integrity"/ or united states environmental protection agency/ or united states government agencies/ or "united states occupational safety and health administration"/ or local government/ or state government/ or government programs/ (76066)
- 99 Confidentiality/ (15579)
- 100 (cross-disciplinar\$ or crossdisciplinar\$.mp. (228)
- 101 (interdisciplinar\$ or interdisciplinar\$.mp. (12712)
- 102 ((law\$ or regulation\$ or rule\$) adj20 (observance\$ or adherence\$ or enforce\$)).mp. (4313)
- 103 or/62-102 (457139)
- 104 19 and 61 and 103 (52172)
- 105 aeromonas/ (2619)
- 106 caviae.mp. and aeromonas/ (382)
- 107 aeromonas caviae.mp. (206)
- 108 or/105-107 (2644)
- 109 Aeromonas hydrophila/ (622)

- 110 hydrophila.mp. and aeromonas/ (944)
111 or/109-110 (1506)
112 veronii.mp. and aeromonas/ (170)
113 sobria.mp. and aeromonas/ (426)
114 (aeromonas veronii or aeromonas sobria).mp. (288)
115 or/112-114 (512)
116 Anisakiasis/ (273)
117 Anisakis/ (298)
118 simplex.mp. and (Anisakis/ or Anisakiasis/) (228)
119 Anisakis simplex.mp. (297)
120 or/116-119 (473)
121 Anthrax/ (2592)
122 Bacillus anthracis/ (2215)
123 or/121-122 (3897)
124 Argentine hemorrhagic fever.mp. (148)
125 Hemorrhagic Fever, American/ (340)
126 Junin virus/ (69)
127 Arenaviruses, New World/ (415)
128 or/124-127 (597)
129 Tuberculosis, Avian/ (393)
130 Mycobacterium avium/ (1927)
131 or/129-130 (2240)
132 lyssavirus/ (161)
133 ((pteropid or bat\$) adj5 (virus\$ or lyssavirus\$)).mp. (556)
134 Rhabdoviridae Infections/ (515)
135 or/132-134 (1019)
136 Tuberculosis, Bovine/ (1707)
137 Mycobacterium bovis/ (6465)
138 or/136-137 (7575)
139 Hemorrhagic Fever, American/ (340)
140 Hemorrhagic Fevers, Viral/ (1022)
141 Arenaviruses, New World/ (415)
142 Machupo virus\$.mp. (50)
143 (bolivian adj5 fever).mp. (43)
144 or/139-143 (1506)
145 Botulism/ (2145)
146 Clostridium botulinum/ (1996)
147 or/145-146 (3602)
148 Encephalopathy, Bovine Spongiform/ (1876)
149 prions/ or prpc proteins/ or prpsc proteins/ or prp 27-30 protein/ (6537)
150 or/148-149 (7809)
151 arenavirus/ or lassa virus/ or lymphocytic choriomeningitis virus/ or arenaviruses, new world/ or junin virus/ or pichinde virus/ (2518)
152 (sabria adj5 virus\$).mp. (14)
153 Arenaviridae Infections/ (197)
154 Hemorrhagic Fevers, Viral/ (1022)
155 or/151-154 (3527)
156 Brucellosis/ (7007)
157 Brucellosis, Bovine/ (1598)
158 or/156-157 (8199)
159 Brucella melitensis/ (616)
160 Malta fever.mp. (85)
161 Undulant fever.mp. (54)
162 or/159-161 (743)
163 or/158,162 (8353)
164 Plague/ (3176)
165 Yersinia pestis/ (2203)
166 Yersinia Infections/ (2647)
167 black death.mp. (107)
168 bubonic plague.mp. (240)
169 or/164-168 (7181)
170 campylobacter/ or campylobacter coli/ or campylobacter fetus/ or campylobacter hyointestinalis/ or campylobacter jejuni/ or campylobacter lari/ or campylobacter rectus/ or campylobacter sputorum/ or campylobacter upsaliensis/ (7058)
171 Campylobacteriosis.mp. (6)
172 Campylobacter Infections/ (4585)
173 or/170-172 (8184)
174 Herpesvirus 1, Cercopithecine/ (211)
175 exp Herpesviridae Infections/ (78911)
176 174 and 175 (145)
177 or/174,176 (211)
178 Cholera/ (5706)
179 vibrio cholerae/ or vibrio cholerae non-o1/ or vibrio cholerae o1/ or vibrio cholerae o139/ (5464)
180 or/178-179 (9410)
181 Cryptosporidiosis/ (3130)
182 Cryptosporidium hominis.mp. (56)
183 cryptosporidium/ or cryptosporidium parvum/ (3144)
184 or/181-183 (4315)
185 Hemorrhagic Fever, Ebola/ (464)
186 Ebolavirus/ (616)
187 or/185-186 (826)
188 echinococcosis/ or echinococcosis, hepatic/ or echinococcosis, pulmonary/ (12900)
189 echinococcus/ or echinococcus granulosus/ or echinococcus multilocularis/ (2459)
190 or/188-189 (13480)
191 Giardiasis/ (3659)
192 giardia/ or giardia lamblia/ (2668)
193 Giardia virus/ (15)
194 Lamblia intestinalis.mp. (54)
195 (Giardia adj3 (duodenalis or intestinalis)).mp. (692)
196 or/191-195 (5258)
197 Hantavirus Pulmonary Syndrome/ (317)
198 Sin Nombre virus/ (43)
199 ((andes or sin nuombre or laguna negra) adj5 (virus or hantavirus)).mp. (69)
200 Hantavirus/ (1473)
201 197 and 200 (163)
202 or/197-199,201 (362)
203 Hendra Virus/ (30)
204 Henipavirus Infections/ (60)
205 Paramyxoviridae Infections/ (1831)
206 or/203-205 (1907)
207 206 and (hendra or hemorrhagic or bronchopneumonia).mp. (104)
208 or/203-204,207 (146)
209 escherichia coli/ or escherichia coli o157/ (183629)
210 Hemorrhagic colitis.mp. (478)
211 209 and 210 (287)
212 Escherichia coli Infections/ (18672)
213 210 and 212 (203)
214 or/211,213 (318)
215 Hemorrhagic Fever with Renal Syndrome/ (1753)
216 Hantaan virus/ (227)
217 Seoul virus/ (25)
218 Puumala virus/ (86)
219 or/215-218 (1857)
220 Hemolytic-Uremic Syndrome/ (3412)
221 Escherichia coli/ (180844)
222 220 and 221 (378)
223 or/220,222 (3412)
224 Histoplasmosis/ (4264)
225 Histoplasma/ (1667)
226 Histoplasma capsulatum.mp. (1711)
227 Ajellomyces capsulatus.mp. (9)
228 or/225-227 (2355)
229 224 and 228 (1386)
230 or/224,229 (4264)
231 Monkeypox/ (68)
232 Monkeypox virus/ (215)
233 or/231-232 (248)
234 Influenza, Human/ (17375)
235 influenza a virus/ or influenza a virus, h1n1 subtype/ or influenza a virus, h2n2 subtype/ or influenza a virus, h3n2 subtype/ or influenza a virus, h3n8 subtype/ or influenza a virus, h5n1 subtype/ or influenza a virus, h5n2 subtype/ or influenza a virus, h7n7 subtype/ or influenza a virus, h9n2 subtype/ (13120)
236 or/234-235 (26099)
237 Lassa Fever/ (352)
238 Lassa virus/ (340)
239 or/237-238 (551)
240 Listeria monocytogenes/ (6853)
241 listeria infections/ or meningitis, listeria/ (5296)
242 Listeriosis.mp. (2027)
243 240 and 242 (946)
244 241 and 242 (1763)
245 or/243-244 (1915)
246 Otitis Externa/ (1721)
247 Dogs/ (248573)
248 246 and 247 (200)
249 pachydermatis.mp. (187)
250 Dermatitis, Seborrheic/ (1905)
251 or/248-250 (2257)
252 Malassezia/ (1045)
253 251 and 252 (337)
254 Marburg Virus Disease/ (234)
255 Marburgvirus/ (243)
256 or/254-255 (371)
257 Paramyxoviridae/ (874)
258 Paramyxoviridae Infections/ (1831)
259 measles/ or subacute sclerosing panencephalitis/ or mumps/ (13395)
260 258 not 259 (1773)
261 menangle.mp. (17)
262 or/260-261 (1786)
263 or/257,262 (2621)
264 Trematode Infections/ (2605)
265 Opisthorchiidae/ (27)
266 Metorchis.mp. (39)
267 Metorchiasis.mp. (5)
268 or/264-267 (2640)
269 microsporidiosis/ or encephalitozoonosis/ (868)
270 Cerebral Microsporidiosis.mp. (2)
271 Encephalitozoon cuniculi/ (275)
272 Encephalitozoon hellem.mp. (112)
273 Encephalitozoon intestinalis.mp. (139)
274 Enterocytozoon bienersi.mp. (296)
275 Nosema connori.mp. (5)
276 Trachipleistophora hominis.mp. (15)
277 Encephalitozoon/ (238)
278 or/270-277 (775)
279 or/269,278 (1181)
280 Nipah Virus/ (84)
281 Henipavirus Infections/ (60)
282 or/280-281 (92)
283 Penicilliosis.mp. (148)
284 Penicillium marneffeii.mp. (284)
285 Penicilliosis.mp. and Penicillium/ (113)
286 or/284-285 (326)
287 or/283,286 (356)
288 Picobirnavirus/ (23)

- 289 Picobirnavirus\$.mp. (41)
290 or/288-289 (41)
291 RNA Virus Infections/ (211)
292 290 and 291 (10)
293 or/290,292 (41)
294 Taenia solium/ (259)
295 taeniasis/ or cysticercosis/ or neurocysticercosis/ (4931)
296 or/294-295 (4971)
297 Rabies/ (6533)
298 Rabies virus/ (2845)
299 or/297-298 (7743)
300 salmonella infections/ or paratyphoid fever/ or salmonella food poisoning/ or typhoid fever/ (18322)
301 salmonella enteritidis/ or salmonella typhi/ or salmonella typhimurium/ (27788)
302 or/300-301 (41155)
303 SARS Virus/ (1604)
304 Severe Acute Respiratory Syndrome/ (3056)
305 or/303-304 (3624)
306 Strongyloidiasis/ (2545)
307 Strongyloides stercoralis/ (519)
308 or/306-307 (2596)
309 Granuloma/ (15917)
310 swim\$ pool\$.mp. (1521)
311 Swimming Pools/ (1079)
312 or/310-311 (1521)
313 309 and 312 (35)
314 Mycobacterium marinum/ (211)
315 or/313-314 (244)
316 toxoplasmosis/ or toxoplasmosis, animal/ or toxoplasmosis, cerebral/ or toxoplasmosis, ocular/ (12109)
317 Toxoplasma/ (6978)
318 gondii.mp. (6814)
319 317 and 318 (4896)
320 or/316,319 (14138)
321 Trichinellosis.mp. (757)
322 Trichinosis/ (3755)
323 321 and 322 (706)
324 trichiniasis.mp. (29)
325 or/323-324 (735)
326 Trichinella spiralis/ (793)
327 or/325-326 (1395)
328 Tularemia/ (1907)
329 Francisella tularensis/ (1152)
330 or/328-329 (2462)
331 Hemorrhagic Fever, American/ (340)
332 Hemorrhagic Fevers, Viral/ (1022)
333 or/331-332 (1335)
334 Venezuela/ (2975)
335 venezuela\$.mp. (5364)
336 or/334-335 (5364)
337 333 and 336 (17)
338 ((Venezuela\$ adj3 hemorrhagic) and fever).mp. (16)
339 or/337-338 (22)
340 Arenaviruses, New World/ (415)
341 Guanarito\$.mp. (23)
342 or/340-341 (425)
343 Vibrio parahaemolyticus/ (1103)
344 Vibrio Infections/ (1616)
345 parahaemolyticus.mp. (1728)
346 or/343,345 (1728)
347 344 and 346 (378)
348 or/343,347 (1183)
349 or/343,348 (1183)
350 Vibrio vulnificus/ (215)
351 Vibrio Infections/ (1616)
352 vulnificus.mp. (864)
353 or/350,352 (864)
354 351 and 353 (397)
355 or/350,354 (507)
356 Yersinia enterocolitica/ (2847)
357 Yersiniosis.mp. (428)
358 Yersinia Infections/ (2647)
359 356 and 357 (210)
360 357 and 358 (338)
361 or/359-360 (356)
362
363 or/108,111,115,120,122,128,131,135,138,144,147,150,155,163,169 (46590)
364
365 or/173,177,180,184,187,190,196,202,208,214,219,223 (46911)
366
367 or/230,233,236,239,245,253,256,263,268,279 (39759)
368
369 or/282,287,293,296,299,302,305,308,315,320 (74667)
370
371 or/325,327,330,333,337,339,342,349,355,361 (7323)
372 or/362-366 (208216)
373 Rickettsia/ (1733)
374 Ticks/ (9097)
375 or/368-369 (10530)
376 africae.mp. (74)
377 370 and 371 (60)
378 African tick typhus.mp. (4)
379 African tick-bite fever.mp. (63)
380 Rickettsia Infections/ (1970)
381 africae.mp. (74)
382 375 and 376 (45)
383 Tick-Borne Diseases/ (668)
384 Rickettsia/ (1733)
385 378 and 379 (78)
386 or/372-374,377,380 (154)
387 Babesiosis/ (2393)
388 Babesia microti/ (73)
389 Hemorrhagic Fever Virus, Crimean-Congo/ (244)
390 Crimean-Congo hemorrhagic fever.mp. (197)
391 or/384-385 (302)
392 Anaplasma phagocytophilum/ (271)
393 Ehrlichiosis/ (1221)
394 (phagocytophilum or phagocytophilum).mp. (353)
395 granulocytic.mp. (6195)
396 or/389-390 (6413)
397 388 and 391 (554)
398 (human adj5 anaplasmosis).mp. (76)
399 (granulocytic EHRlichiosis and human).mp. (424)
400 Sennetsu Fever.mp. (2)
401 or/392-395 (667)
402 or/387,396 (728)
403 Ehrlichia/ (945)
404 ewingii.mp. (53)
405 398 and 399 (41)
406 Ehrlichia ewingii.mp. (34)
407 or/399-401 (53)
408 Ehrlichiosis/ (1221)
409 Humans/ (9619411)
410 human\$.mp. (9824443)
411 404 or 405 (9824443)
412 403 and 406 (810)
413 Human ehrlichiosis.mp. (146)
414 or/407-408 (847)
415 or/402,409 (869)
416 Ehrlichia chaffeensis/ (274)
417 monocytic ehrlichiosis.mp. (184)
418 humans/ or human\$.mp. (9824443)
419 412 and 413 (118)
420 monocytic.mp. (10533)
421 Ehrlichiosis/ (1221)
422 415 and 416 (176)
423 or/414,417 (195)
424 or/411,418 (383)
425 Lyme Disease/ (6297)
426 Encephalitis, Tick-Borne/ (1904)
427 Borrelia burgdorferi/ (1198)
428 421 and 422 (12)
429 Encephalitis Viruses, Tick-Borne/ (1887)
430 420 and 421 (106)
431 Tickborne encephalitis.mp. (67)
432 420 and 422 (818)
433 or/420-427 (9499)
434 Hemorrhagic Fevers, Viral/ (1022)
435 Tick-Borne Diseases/ (668)
436 Flavivirus Infections/ (173)
437 or/429-431 (1852)
438 Kyasanur.mp. (129)
439 432 and 433 (20)
440 Kyasanur Forest Disease/ (38)
441 Monkey disease.mp. (21)
442 Kyasanur Forest disease.mp. (126)
443 or/434-437 (149)
444 (Kyasanur adj10 virus\$.mp. (78)
445 Flavivirus/ (790)
446 Kyasanur.mp. (129)
447 440 and 441 (27)
448 or/439,442 (87)
449 or/438,443 (149)
450 Bartonella quintana/ (166)
451 Trench Fever/ (135)
452 (Wolhynia adj5 fever\$.mp. (1)
453 (quintan adj5 fever\$.mp. (2)
454 (trench adj5 fever\$.mp. (182)
455 or/446-449 (183)
456 or/445,450 (269)
457
458 or/381,386,397,410,419,428,438,444,451 (11368)
459 bagaza.mp. (4)
460 Flavivirus/ (790)
461 ntaya.mp. (16)
462 454 and 455 (2)
463 or/455-456 (16)
464 or/453,457 (20)
465 coltivirus/ or colorado tick fever virus/ (57)
466 Reoviridae Infections/ (1462)
467 banna.mp. (42)
468 460 and 461 (4)
469 or/461-462 (42)
470 464 and 461 (7)
471 or/463-464 (42)
472 or/459,465 (92)
473 Alphavirus Infections/ (455)
474 barmah.mp. (70)
475 467 and 468 (35)
476 (Barmah and virus\$.mp. (66)
477 Alphavirus/ (550)
478 barmah.mp. (70)
479 471 and 472 (38)
480 or/470,472 (70)
481 or/469-470,472-473 (70)
482 Encephalitis, California/ (256)
483 encephalitis virus, california/ or la crosse virus/ (492)
484 or/476-477 (545)
485 Chikungunya virus/ (466)
486 Alphavirus Infections/ (455)

- 481 Chikungunya.mp. (561)
482 480 and 481 (88)
483 481 or 482 (561)
484 or/479,483 (561)
485 dengue/ or dengue hemorrhagic fever/ (3574)
486 Dengue Virus/ (2609)
487 or/485-486 (4657)
488 Encephalomyelitis, Eastern Equine/ (29)
489 Encephalitis Virus, Eastern Equine/ (306)
490 or/488-489 (316)
491 filariasis/ or elephantiasis, filarial/ (6003)
492 Wuchereria bancrofti/ (1609)
493 or/491-492 (6165)
494 Orthobunyavirus/ (70)
495 guama.mp. (29)
496 Bunyaviridae Infections/ (381)
497 495 and 496 (2)
498 or/494-495 (92)
499 Encephalitis, Japanese/ (1605)
500 Encephalitis Virus, Japanese/ (1177)
501 or/499-500 (2216)
502 leptospirosis/ or weil disease/ (5295)
503 Leptospira interrogans/ (1226)
504 or/502-503 (5778)
505 malaria/ (24885)
506 malaria, avian/ (356)
507 malaria, cerebral/ (947)
508 malaria, falciparum/ (7894)
509 blackwater fever/ (68)
510 malaria, vivax/ (1513)
511 or/505-510 (33962)
512 plasmodium/ (5070)
513 plasmodium falciparum/ (15320)
514 plasmodium malariae/ (676)
515 plasmodium ovale/ (37)
516 plasmodium vivax/ (2470)
517 or/512-516 (21420)
518 or/511,517 (42008)
519 Mayaro virus fever.mp. (1)
520 Alphavirus/ (550)
521 Monkey Diseases/ (3517)
522 mayaro.mp. (65)
523 520 and 522 (37)
524 521 and 522 (2)
525 or/519,522-524 (65)
526 Encephalitis Virus, Murray Valley/ (74)
527 Encephalitis, Arbovirus/ (1615)
528 (murray adj5 valley).mp. (275)
529 527 and 528 (104)
530 Australian encephalitis.mp. (11)
531 Murray Valley encephalitis.mp. (238)
532 or/529-531 (257)
533 or/526,532 (261)
534 Alphavirus/ (550)
535 Alphavirus Infections/ (455)
536 O'Nyong-nyong.mp. (53)
537 534 and 536 (21)
538 535 and 536 (14)
539 or/536-538 (53)
540 Oropouche.mp. (39)
541 Bunyaviridae/ (781)
542 Bunyaviridae Infections/ (381)
543 540 and 541 (5)
544 540 and 542 (19)
545 or/540,543-544 (39)
546 Rift Valley Fever/ (454)
547 Rift Valley fever virus/ (350)
548 or/546-547 (586)
549 Ross River virus/ (263)
550 (ross river adj5 (virus\$ or disease or fever or polyarthriti\$)).mp. (342)
551 ALPHAVIRUS INFECTIONS/ (455)
552 550 and 551 (113)
553 or/550,552 (342)
554 or/549,553 (342)
555 Dysentery, Bacillary/ (5986)
556 Shigella dysenteriae/ (1474)
557 or/555-556 (6883)
558 Sindbis Virus/ (1709)
559 Alphavirus Infections/ (455)
560 sindbis\$.mp. (2226)
561 559 and 560 (119)
562 or/558,561 (1720)
563 "Encephalitis, St. Louis"/ (393)
564 "Encephalitis Virus, St. Louis"/ (280)
565 or/563-564 (543)
566 Encephalomyelitis, Venezuelan Equine/ (316)
567 Encephalitis Virus, Venezuelan Equine/ (787)
568 or/566-567 (893)
569 Encephalomyelitis, Western Equine/ (10)
570 Encephalitis Virus, Western Equine/ (391)
571 or/569-570 (395)
572 Flavivirus/ (790)
573 Flavivirus Infections/ (173)
574 Wesselsbron.mp. (71)
575 572 and 574 (19)
576 573 and 574 (6)
577 or/574-576 (71)
578 West Nile Fever/ (1605)
579 West Nile virus/ (1754)
580 or/578-579 (2232)
581 Yellow Fever/ (1852)
582 Yellow fever virus/ (763)
583 or/581-582 (2293)
584 Flavivirus/ (790)
585 Flavivirus Infections/ (173)
586 zika.mp. (53)
587 584 and 586 (15)
588 585 and 586 (1)
589 or/586-588 (53)
590 Phlebotomus Fever/ (156)
591 Phlebotomus/ (128)
592 (naples adj20 virus\$).mp. (75)
593 (sandfly or sandflies).mp. (1387)
594 592 and 593 (47)
595 Sandfly fever Naples virus/ (22)
596 Salehabad.mp. (3)
597 or/594-596 (49)
598 591 and 597 (16)
599 or/590,597-598 (178)
600 leishmaniasis/ or leishmaniasis, cutaneous/ or leishmaniasis, diffuse cutaneous/ or leishmaniasis, mucocutaneous/ or leishmaniasis, visceral/ (11962)
601 leishmania/ or leishmania braziliensis/ or leishmania donovani/ or leishmania guyanensis/ or leishmania infantum/ or leishmania major/ or leishmania mexicana/ or leishmania tropica/ (10159)
602 (600 or 601) and aethiopica.mp. (123)
603 (600 or 601) and pifanoi.mp. (54)
604 or/600-603 (16606)
605 Trypanosomiasis, African/ (3629)
606 Trypanosoma brucei gambiense/ (703)
607 Trypanosoma brucei rhodesiense/ (301)
608 or/606-607 (935)
609 or/605,608 (3950)
610 chagas disease/ or chagas cardiomyopathy/ (7236)
611 Trypanosoma cruzi/ (6326)
612 or/610-611 (10615)
613 Loiasis/ (367)
614 Loa/ (311)
615 Filariasis/ (4853)
616 loiasis.mp. (421)
617 615 and 616 (196)
618 or/613,617 (395)
619 or/614,618 (534)
620 Onchocerca volvulus/ (618)
621 Onchocerciasis/ (2911)
622 Onchocerciasis, Ocular/ (273)
623 river blindness.mp. (154)
624 621 and 623 (72)
625 or/621-624 (3155)
626 or/620,625 (3294)
627 Cat-Scratch Disease/ (1425)
628 Bartonella henselae/ (696)
629 Bartonella/ (470)
630 clarridgeiae.mp. (73)
631 henselae.mp. (974)
632 629 and 630 (47)
633 629 and 631 (145)
634 Bartonella Infections/ (580)
635 630 and 634 (42)
636 631 and 634 (195)
637 or/627,635-636 (1576)
638 Cat-Scratch Adenitis.mp. (3)
639 maladie des griffes du chat.mp. (68)
640 or/637-639 (1586)
641 or/628,632-633 (798)
642 or/640-641 (1763)
643 Rickettsia typhi/ (277)
644 Rickettsia felis/ (44)
645 Rickettsia prowazekii/ (701)
646 or/643-645 (951)
647 Typhus, Endemic Flea-Borne/ (452)
648 Typhus, Epidemic Louse-Borne/ (1289)
649 Rickettsia Infections/ (1970)
650 felis.mp. (1987)
651 649 and 650 (43)
652 Murine typhus.mp. (340)
653 or/647-648,651-652 (1778)
654 or/646,653 (2357)
655 or/458,466,475,478,484,487,490,493,498 (12319)
656 or/501,504,518,525,533,539,545,548 (50875)
657 or/554,557,562,565,568,571,577,580,583,589 (14895)
658 or/599,604,609,612,619,626,642,646,654 (38399)
659 or/655-658 (113339)
660 or/367,452,659 (328232)
661 19 and 61 and 103 and 660 (683)
662 bioterrorism/ (3311)
663 Biological Warfare/ (1619)
664 bacterial infections/ (48487)
665 exp bacteremia/ (12826)
666 exp central nervous system bacterial infections/ (24473)
667 exp endocarditis, bacterial/ (15148)
668 exp eye infections, bacterial/ (10923)
669 fournier gangrene/ (287)

- 670 exp gram-negative bacterial infections/ (222063)
- 671 exp gram-positive bacterial infections/ (273167)
- 672 exp pneumonia, bacterial/ (11081)
- 673 exp sexually transmitted diseases, bacterial/ (31551)
- 674 exp skin diseases, bacterial/ (13482)
- 675 exp spirochaetales infections/ (32215)
- 676 vaginosis, bacterial/ (1427)
- 677 virus diseases/ (26615)
- 678 exp arbovirus infections/ (17363)
- 679 bronchiolitis, viral/ (1007)
- 680 exp central nervous system viral diseases/ (45425)
- 681 exp dna virus infections/ (142588)
- 682 exp encephalitis, viral/ (13651)
- 683 exp eye infections, viral/ (6415)
- 684 exp fatigue syndrome, chronic/ (2952)
- 685 exp hepatitis, viral, animal/ (1672)
- 686 exp hepatitis, viral, human/ (76549)
- 687 exp meningitis, viral/ (4466)
- 688 exp opportunistic infections/ (24363)
- 689 pneumonia, viral/ (3509)
- 690 exp rna virus infections/ (332372)
- 691 exp sexually transmitted diseases/ (196626)
- 692 exp skin diseases, viral/ (20329)
- 693 exp slow virus diseases/ (73893)
- 694 exp tumor virus infections/ (32478)
- 695 viremia/ (4590)
- 696 parasitic diseases/ (5778)
- 697 exp central nervous system parasitic infections/ (4619)
- 698 exp eye infections, parasitic/ or exp helminthiasis/ (86617)
- 699 exp intestinal diseases, parasitic/ (16275)
- 700 exp liver diseases, parasitic/ (11438)
- 701 exp lung diseases, parasitic/ (3633)
- 702 exp mesomycetozoa infections/ (339)
- 703 exp opportunistic infections/ (24363)
- 704 parasitemia/ (2254)
- 705 exp parasitic diseases, animal/ (19438)
- 706 pregnancy complications, parasitic/ (1801)
- 707 exp protozoan infections/ (103999)
- 708 exp skin diseases, parasitic/ (23559)
- 709 coroner\$.mp. (2142)
- 710 military\$.mp. (45684)
- 711 bioterror\$.mp. (3885)
- 712 biowar\$.mp. (117)
- 713 bacter\$.mp. (766473)
- 714 viral\$.mp. (352932)
- 715 virus\$.mp. (444871)
- 716 parasit\$.mp. (106293)
- 717 infection\$.mp. (889562)
- 718 communicable.mp. (25724)
- 719 Communicable Diseases/ (11734)
- 720 foodborne.mp. (2124)
- 721 waterborne.mp. (1549)
- 722 vectorborne.mp. (42)
- 723 disease vectors/ or arthropod vectors/ or arachnid vectors/ or insect vectors/ (20330)
- 724 drug resistance, microbial/ (51021)
- 725 exp drug resistance, bacterial/ (32364)
- 726 exp drug resistance, fungal/ (1279)
- 727 exp drug resistance, viral/ (3486)
- 728 antimicrobial resistance.mp. (3542)
- 729 Animals/ (4011447)
- 730 animal population groups/ or animals, domestic/ or exp animals, inbred strains/ or exp animals, laboratory/ or animals, newborn/ or animals, outbred strains/ or exp animals, poisonous/ or animals, suckling/ or animals, wild/ or animals, zoo/ (641222)
- 731 veterinar\$.mp. (34778)
- 732 zoonoses/ (7650)
- 733 (zoonosis or zoonoses).mp. (8570)
- 734 zoonotic.mp. (2766)
- 735 enzootic.mp. (2501)
- 736 epizootic.mp. (2174)
- 737 or/662-736 (5691663)
- 738 Communicable Diseases, Emerging/ (1335)
- 739 ((emerg\$ or re-emerg\$ or reemerg\$) adj10 (disease\$ or outbreak\$)).mp. (13546)
- 740 ((new or recent or incident\$ or occur\$ or re-occur\$ or reoccur\$) adj10 (disease\$ or outbreak\$)).mp. (94641)
- 741 recurrence/ and (disease\$ or outbreak\$).mp. (47650)
- 742 (emerg\$ adj10 disease\$).mp. (13088)
- 743 or/738-742 (151843)
- 744 737 and 743 (59095)
- 745 19 and 61 and 103 and 744 (416)
- 746 19 and 61 and 103 and 660 (683)
- 747 or/745-746 (1007)
- 748 population surveillance/ (27179)
- 749 surveillance.mp. (72805)
- 750 or/748-749 (72805)
- 751 zoonoses/ (7650)
- 752 750 and 751 (387)
- 753 747 not 752 (994)
- 754 limit 753 to yr="1987 - 2007" (958)
- 755 limit 754 to english language (861)
- 756 754 not 755 (97) non-english

Appendix 4: List of all 221 systems included in the review

Appendix 4. List of all 221 systems included in the review

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
121 Cities Surveillance System (121 Cities)	North America	176	Known	Multi	Human	No
ABCs - Active Bacterial Core Surveillance	North America	170	Known	Multi	Human	No
Active Surveillance for Sporadic Illness (not official name)	North America	199	Known	Multi	Human	Yes
Ambulatory Sentinel Practice Network	North America	134	Blank	Missing	Human	No
Antibiotic Resistance	Europe	56	Known	Multi	Animal	No
APEC Telecommunications Network for Emerging Infections (EINet)	Asia	105,106	Both	Multi		No
Arbeitsgemeinschaft Influenza (ARI)	Europe	184	Both	Multi	Human	No
ArboNET	North America	102,146	Both	One	Animal, Human	No
Arbovirus Surveillance (not official name)	North America	7,12,85	Known	Multi	Animal, Human	No
Asian Rotavirus Surveillance Network (ARSN)	Asia	16	Known	Multi	Human	No
Australian Sentinel Practice Research Network (ASPREN)	Oceania	10,41,202,29	Known	Multi	Human	No
Automated Laboratory-Based Reporting to California Department of Health Services	North America	20	Known	Multi	Human	No
Belgian Salmonella Surveillance (not official name)	Europe	73	Known	One	Animal	No
BioSense	North America	119,167	Both	Multi	Human, Other	No
Border Infectious Disease Surveillance Project (BIDS)	North America	167	Both	Multi		No
Boston Bioterrorism Surveillance System (not official name)	North America	128	Both	Multi	Human	Yes
Bovine and Ovine Brucellosis	Europe	56	Known	One	Animal	No
Bovine Spongiform Encephalopathy in France (not actual name)	Europe	56	Known	One	Animal	No
Bovine Tuberculosis Surveillance (not official name)	North America	103	Known	One	Animal	No
Brucellosis surveillance system (not official name)	Europe	84	Known	One	Human	No
BSE Surveillance in the EU	Europe	90	Known	One	Animal	No
California Mosquito-Borne Virus Surveillance and Response Plan	North America	23	Known	One		

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
Canada Database of Animal Parasites (CDAP)	North America	156,157	Known	Multi	Animal, Human	No
Canadian Cooperative Wildlife Health Centre	North America	135	Blank	Multi	Animal	No
Canadian Integrated Public Health Surveillance (CIPHS)	North America	123	Blank	Multi	Human?	No
Canadian Listeriosis Reference Service	North America	148	Known	One	Animal, Human, Other	No
Canadian Paediatric Surveillance Program (CPSP)	North America	160	Known	Multi	Human	No
Care Telematics Network for the Surveillance of Influenza in Europe	Europe	179	Known	One	Human	No
Caribbean Public Health Laboratory Surveillance	Central South America	209	Known	Multi	Human	No
Central animal health database of the Department of Agriculture and Rural Development (DARD)	Europe	3	Known	One	Animal	No
CJD Surveillance Unit	Europe	165	Known	One		
Clinical Management System (CMS)	Asia	16	Known	One	Human	Yes
ComBase (Combined database)	International	129	Known	Multi	Animal	No
Daily emergency department surveillance system (DEDSS)	North America	149	Unknown	Multi	Human	No
Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP)	Europe	1,22,87,203	Known	Multi	Animal, Human, Other	No
Danish Pig Health Scheme: DPHS	Europe	56	Blank	Missing	Animal	No
Danish Salmonella Surveillance and Control Programme	Europe	143	Known	One	Animal	No
Data Mining Surveillance System (DMSS)	North America	32	Blank	Multi		Yes
Dengue surveillance (not official name)	Oceania	159	Known	One	Animal, Human	No
Dengue surveillance (not official name)	Asia	116	Known	One	Animal, Human	No
Diarrheal Disease Surveillance	North America	89	Unknown	Multi	Human, Other	No
Drop-In Surveillance Systems	North America	194	Blank	Multi	Human	No
Dutch Sentinel Practice Network (DSN)	Europe	68	Both	Multi	Human	No
Early Warning Outbreak Recognition System	Asia	167	Both	Multi		No
Ehrlichia chaffeensis surveillance using White-tailed Deer (not official name)	North America	210	Known	One	Animal	No
Emerging Infections Program (EIP)	North America	11	Both	Multi	Human	No

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
Electronic Surveillance System for the Early Notification of Community-Based Epidemic (ESSENCE)	North America	80,128,167,194	Unknown	Multi	Human	In process
Emergency Department visits (not official name)	North America	89	Unknown	Multi	Human	No
EMERGENCY ID NET	North America	99,186	Known	Multi	Human	No
Emergency Medical Services Ambulance Dispatch Calls	North America	89	Unknown	Multi	Human	No
Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES)	Africa	175,204	Known	Multi	Animal, Other	No
Emerging Infectious Disease Network (EIDNET)	International	55	Known	Multi	Animal, Human	No
Enter-net	Europe	64,65	Known	Multi	Human	No
EPI-BAC	Europe	78	Known	Multi	Human	Yes
Epidemic Information Exchange Program (Epi-X)	North America	108,131	Both	Multi	Human	No
Equinella	Europe	56	Known	Multi	Animal	No
eSARS	Asia	33,115	Known	One	Human	No
European collaborative programme for influenza surveillance	Europe	67	Known	One	Human	No
European Groupes Regionaux d'Observation de la Grippe (EuroGROG, GROG)	Europe	4,19,161	Known	One	Human	No
European Influenza Surveillance Scheme (EISS)	Europe	4,113,130	Known	One	Human	No
European Network for Diagnostics of "Imported" Viral Diseases (ENIVD)	Europe	54	Both	Multi	Human	No
European Network on Imported Infectious Disease Surveillance (TropNetEurop)	Europe	100,138	Known	Multi	Human	No
Eurosentinel	Europe	134	Blank	Missing	Human	No
Foodborne Disease Active Surveillance Network (part of FoodNet)	North America	11,97	Known	Multi	Human	No
Foodborne Disease Outbreak Surveillance System	North America	50	Blank	Multi	Human	No
FoodNet	North America	8,11,27,88,124	Known	Multi	Human	Yes
Frontlines of Medicine Project	North America	24	Both	Multi	Human	No
GeoSentinel	International	70,99	Both	Multi	Human	No
Giardia Surveillance in Scotland (not official name)	Europe	158	Known	One	Human	No
Global Initiative on Sharing Avian Influenza Data (GISAID)	International	13	Blank	One		No

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
Global Outbreak Alert and Response Network (GOARN)	International	50,92,93,94,114,129,211	Both	Multi		No
Global Public Health Information Network (GPHIN)	International	50,62,93,141	Unknown	Multi	Human	No
HEALTH Alert Network	North America	26	Both	Multi		No
Health Buddy and the Biothreat Active Surveillance Integrated Information and Communication System		167	Both	Multi		No
Health Information Network	North America	60,150	Known	Multi	Animal, Human	Yes
HealthMapper	International	190	Known	Multi		No
HealthPartners Medical Group Surveillance System (not official name)	North America	132	Both	Multi	Human	Yes
IDS A EIN	North America	186	Both	Multi		No
Indianapolis Network for Patient Care in Indianapolis	North America	24,50	Blank	Multi	Human	No
Infectious Disease Information System (IDIS)	Europe	172	Known	Multi	Human	No
Infectious disease Surveillance and Information System (ISIS)	Europe	91	Known	Multi	Human	No
Influenza Surveillance of the Emerging Infections Program Network	North America	169	Known	One	Human	No
Integrated environmental health surveillance program	Europe	83	Known	Multi	Human	No
Inter-agency Research Partnership for Infectious Diseases (IntRePID)	International	140	Known	One	Human, Other	In process
Japanese Veterinary Antimicrobial Resistance Monitoring (JVARM) Program	Asia	1	Known	Multi		No
Laboratory data management system (LDMS)	North America	123	Known	Multi	Animal, Human, Other	No
Laboratory Response Network (LRN)	North America	74,104,155,181	Both	Multi	Animal, Human, Other	
Laboratory-based Global Influenza Surveillance System (Project Gargle)	North America	34	Known	One	Human	No
Laboratory-based Surveillance System of Salmonellae (SALM-NET)	Europe	171,172	Known	One	Animal, Human, Other	No

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
LEADERS	North America	167	Both	Multi		No
Leptospirosis surveillance in Australia (not official name)	Oceania	177	Known	One	Animal, Human	No
Leptospirosis surveillance in Thailand (not official name)	Asia	173	Known	One	Human	Yes
Light-weight Epidemiology Advanced Detection and Emergenc Response System (LEADERS)	North America	80,194	Both	Multi		In process
Lyme Disease surveillance (not official name)	North America	39	Known	One	Human	No
Malaria Early Warning System (MEWS)	Africa	49,81	Known	One	Human, Other	No
Malaria Information System (MIS)	Africa	174	Known	One	Animal, Human, Other	No
Malaria surveillance (not official name)	Africa	2	Known	One	Human	No
Malaria surveillance in Trinidad (not official name)	Central South America	36	Known	One	Human	No
Manitoba Health Public Health Communicable Disease database (MPHCDD)	North America	79	Known	Multi	Human	
MedDay	Europe	62	Unknown	Multi	Human	No
MIIDSS	Asia	33,115	Unknown	One	Human	No
Mycobacterium bovis surveillance in Slovakia (not official name)	Europe	21	Known	One	Animal, Human	No
National Animal Health Monitoring System (NAHMS)	North America	56	Blank	Multi	Animal	
National Antimicrobial Resistance Monitoring System (NARMS)	North America	1,76,192,203	Known	Multi	Animal, Human	No
National Australian Health Information System: NAHIS	Oceania	56	Known	Multi	Animal	No
National Bioterrorism Syndromic Surveillance Demonstration Program	North America	212	Unknown	Multi	Human	No
National Botulism Surveillance and Reference Laboratory	North America	50	Known	One		No
National Brucellosis Eradication Program	North America	46	Known	One	Animal	
National Companion Animal Surveillance Program	North America	75	Both	Multi	Animal	No
National Electronic Disease Surveillance System (NEDSS)	North America	24,50,108,131, 168	Both	Multi	Human	No
National Electronic Telecommunications System for Surveillance (NETSS)	North America	50,140	Blank	Multi	Human	No
National Emergency Medicine Sentinel Surveillance Network	North America	134	Both	Multi	Human	No

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
National Enteric Pathogens Surveillance System (NEPSS)	Oceania	10,29	Known	Multi	Human	No
National Epidemiological Surveillance of Infectious Diseases (NESID)	Asia	9	Known	Multi	Human	No
National Hantavirus Surveillance (not official name)	North America	133	Known	One	Animal, Other	No
National Health Information System (NHIS)	Oceania	95	Known	Multi		No
National Health Service Direct	Europe	167	Both	Multi		
National Infectious Diseases Reporting System (NIDRS)	Europe	172	Known	Multi	Human	No
National Laboratory Response Network	North America	108	Known	Multi	Human?	No
National Laboratory-based Surveillance System (NLSS)	Europe	172	Known	One	Animal, Human	No
National Mycobacterial Surveillance System	Oceania	43	Known	One	Human	
National Notifiable Diseases Surveillance System (NNDSS)	Oceania	10,29	Known	Multi	Animal, Human	No
National Reportable Diseases in USA (not official name)	North America	37	Known	One	Human	No
National Retail Data Monitor (NRDM)	North America	194, 201	Unknown	Multi	Human	No
National Tsutsugamushi Disease Surveillance	Asia	127	Known	One	Human	No
Networks for Surveillance of Emerging Infectious Diseases	International	114	Unknown	Multi		No
NH Pharmaceutical Sales Surveillance (NHPSS)	North America	214	Unknown	Multi	Other	No
NHS Direct	Europe	42	Both	Multi	Human	Yes
Northern Australia Quarantine Strategy (NAQS)	Oceania	189	Both	Multi	Animal	No
Office International des Epizooties (OIE) (not official name)	International	56	Known	Multi	Animal	
Oklahoma Physicians Resource/Research Network's OKAlert-ILI System	North America	142	Both	Multi	Human	Yes
OzFoodNet	Oceania	18,47	Known	Multi	Animal, Human	No
Pan African Programme for the Control of Epizootics (PACE)	Africa	175	Blank	Multi	Animal, Human	No
Pediatric Research in Office Settings Network	North America	134	Blank	Missing	Human	No
PHLS Communicable Disease Surveillance Centre	Europe	152,178	Known	Multi	Human	No
Portugese National Sentinel Network of Physicians (not official name)	Europe	163	Known	One	Human	No

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
Program for Monitoring Emerging Diseases (ProMED & ProMED-mail)	International	120, 121, 122, 129, 136, 141, 206, 207, 208	Both	Multi	Animal, Human, Other	No
Public Health Early Warning System (PHEW)	Oceania	98	Blank	Multi	Human	No
Public Health Emergency Response Information System (PHERIS)	Asia	118	Blank	Multi		
Public Health Information Network (PHIN)	North America	69,24	Blank	Multi		No
Public Health Information System (PHIS)	North America	123	Known	Multi	Human	No
PulseNet	North America	72,97,99,129	Known	Multi	Human, Other	No
PulseNet International	International	183	Known	Multi	Human, Other	No
QFLU	Europe	96	Known	One	Human	No
RabID	North America	28	Known	One	Animal	
Rabies Suveillance (not official name)	Europe	56	Known	One	Animal	No
Rabies Suveillance (not official name)	Europe	56	Known	One	Animal	No
Rabies Suveillance (not official name)	North America	30, 77, 109, 110, 111, 112	Known	One	Animal, Human	No
Rabnet	International	31	Blank	One		
Rapid Epidemiological Mapping of Onchocerciasis (REMO)	Africa	144	Known	One	Human, Other	No
Rapid Syndrome Validation Project (RSVP)	North America	80,167,194,213	Both	Multi	Human	In process
Rapid Syndrome Validation Project - Animal (RSVP-A)	North America	198	Both	Multi	Animal	No
Real-time Outbreak and Disease Surveillance System (RODS)	North America	24, 50, 61, 194, 200	Both	Multi	Human	Yes
Regional Animal Disease Surveillance and Control Network (RADISCON)	Africa	175,204	Blank	Multi	Animal	No
RENESA	Europe	57	Known	Multi	Animal	
RESABO	Europe	125,203	Known	Multi	Animal	No
Reseau d'Alerte et d'Intervention Zoosanitaire: RAIZO	North America	56	Known	Multi	Animal	No
Reseau d'Epidemiosurveillance des Suspensions Cliniques de Salmonelloses Bovines (RESSAB)	Europe	56,125	Known	One	Animal	No
Reseau National d'Observations Epidemiologiques en Aviculture: RNOEA	Europe	56	Both	Multi	Animal	No
Retail pharmacy sales	North America	89	Unknown	Multi	Human	No

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
Romania Brucellosis Surveillance	Europe	53	Known	One	Animal	
SAGIR Network (Reseau national de surveillance de l'etat sanitaire de la faune sauvage)	Europe	56,135	Both	Multi	Animal	No
Salmonella data bank (SDB)	Europe	187	Known	One	Human	No
Salmonella Network (not official name)	Europe	56,125	Known	One	Animal, Human	No
Salmonella resistance pattern surveillance (not official name)	North America	123	Known	One	Animal, Human	No
Salmonella Surveillance and Control Program	Europe	137	Known	One	Animal, Human	No
Salmonella Surveillance System (not official name)	North America	185	Known	One	Human	Yes
SARS-CCIS	Asia	33	Known	One	Human	No
Sentinel network for Influenza (not official name)	Oceania	25	Known	One	Human	No
Victorian Infectious Disease Reference Laboratory (VIDRL) Sentinel surveillance for influenza (not official name)	Oceania	195	Known	One	Human	No
Sentinelles or French Communicable Diseases Computer Network (FCDN)	Europe	4, 35, 117, 140, 150, 193, 196	Both	Multi	Human	Yes
Virology and Serology Laboratory Reporting Scheme (LabVISE)	Oceania	10	Blank	Multi	Human	No
Severe Malaria in African Children (SMAC): A Clinical Network	Africa	188	Known	One	Human	No
Sicilian Agrometeorology Information System	Europe	151	Known	Multi	Other	No
SmiNet-1	Europe	166	Known	Multi	Human	No
South Eastern Sydney PHU cruise ship health surveillance program (not official name)	Oceania	63	Known	Multi	Human	No
Southeastern Cooperative Wildlife Disease Study	North America	135	Blank	Multi	Animal	No
St. Louis Encephalitis Surveillance in Florida (not official name)	North America	51	Known	One	Animal, Human, Other	No
Surveillance Importierter Infektionen in Deutschland (SIMPID)	Europe	138	Known	Multi	Human	No
Surveillance of acute respiratory infections (not official name)	Europe	180	Both	Multi	Human	No
Surveillance of bovine facial eczema	Oceania	56	Blank	Multi	Animal	No
Surveillance of certain notifiable diseases (not official name)	Europe	56	Known	Multi	Animal	No
Surveillance of Rinderpest	Africa	56	Blank	Multi	Animal	No

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
Surveillance to detect Influenza A (H5N1) (not official name)	Asia	38	Known	One	Human	No
Surveillance during Rugby World Cup (not official name)	Oceania	139	Both	Multi	Human	No
Swedish Veterinary Antimicrobial Resistance Monitoring	Europe	203	Known	Multi	Animal	No
Syndromal Surveillance Tally Sheet	North America	167	Both	Multi		In process
Syndromic Surveillance Using Automated Records	North America	167	Known	Multi		No
Tickbuster Tick Surveillance (not official name)	Europe	14	Known	Multi	Animal	No
Traveller's Diarrhoea Network	Asia	147	Both	Multi	Human	No
Trypanosomiasis surveillance in Africa (not official name)	Africa	15	Known	One	Animal, Human	No
Trypanosomiasis surveillance in Kenya (not official name)	Africa	126	Known	One	Animal, Human, Other	No
Trypnet: Hemoparasite Information Network	Central South America	197	Known	Multi	Animal, Human	No
Tuberculosis Freedom Assurance Program 2 (TFAP 2)	Oceania	162	Known	One	Animal	No
Tularemia surveillance in Central Europe (not official name)	Europe	82	Known	One	Animal	No
Unexplained Deaths and Critical Illnesses (UNEX)	North America	86,153,154	Unknown	Multi	Human	No
US Department of Defense Global Emerging Infections Surveillance and Response System (DoD-GEIS)	International	40	Blank	Multi	Human	No
US Naval Medical Research Unit-2 (NAMRU-2 & NAMRU-3)	International	40	Known	Multi	Human	No
Vaccine-Preventable Disease Surveillance System (not official name)	Asia	101	Known	Multi	Human	No
Vector Surveillance Program	North America	44,45	Known	Multi	Animal	No
VEGA	Europe	56	Both	Multi	Animal	
VIALINE	Europe	56	Known	Multi	Animal	No
Weekly Returns Service of the Royal College of General Practitioners (WRS)	Europe	68	Both	Multi	Human	No
West Nile Virus Mosquito Surveillance - Connecticut (not actual name)	North America	6,52	Known	One	Animal	Yes
West Nile Virus Surveillance - National (not official name)	North America	102,146	Both	One	Animal, Human	Yes
West Nile Virus Surveillance (not official name)	North America	205	Known	One	Animal	No

System Name	Continent	References (see Appendix 6)	Agent Known/ Unknown	One vs. Multi- disease	Data Category Human/Animal/Other	Evaluated Yes/No
West Nile Virus Surveillance and Reporting System	North America	145	Known	One	Animal, Human	No
West Nile Virus Surveillance in California (not actual name)	North America	164	Known	Multi	Animal, Human	No
WHO Collaborating Centre for Rabies Surveillance and Research	International	135	Known	One	Animal, Human	No
WHO Collaborating Centres for Influenza Reference and Research	International	5	Known	One	Human	No
WHO Collaborating Laboratories	International	50	Known	Multi		No
WHO Food Surveillance Programme for the Control of Foodborne Diseases in Europe	Europe	191	Known	Multi	Human	Yes
WHO Global Influenza Surveillance Network (Flu-Net)	International	66,182	Both	Multi		No
WHO Global Salm-Surv	International	71	Known	One	Animal, Human	No
WHONET	International	50	Known	Missing		No
Wildlife Health Research Centre	North America	135	Blank	Multi	Animal	No
Wildlife surveillance (not official name)	Europe	135	Blank	Multi	Animal	No
WONDER e-mail system	North America	48	Both	Multi	Human, Animal, Other	No
Worker absenteeism (not official name)	North America	89	Unknown	Multi	Human	No
Zoo Surveillance (not official name)	North America	107	Known	Multi	Animal	No
Zoonosis Surveillance in Cyprus (not official name)	Europe	58,59	Known	Multi	Animal, Human	No

Appendix 5: List of all 17 evaluated systems included in the review

Appendix 5. List of all 17 evaluated systems included in the review

System Name	Continent	References	Agent Known/Unknown	One vs. Multi-disease	Data Category Human/Animal/Other	Evaluated Yes/No
Active Surveillance for Sporadic Illness (not official name)	North America	199	Known	Multi	Human	Yes
Boston Bioterrorism Surveillance System (not official name)	North America	128	Both	Multi	Human	Yes
Clinical Management System (CMS)	Asia	16	Known	One	Human	Yes
Data Mining Surveillance System (DMSS)	North America	32	Blank	Multi		Yes
EPI-BAC	Europe	78	Known	Multi	Human	Yes
FoodNet	North America	8,11,27,88,124	Known	Multi	Human	Yes
Health Information Network	North America	60,150	Known	Multi	Animal, Human	Yes
HealthPartners Medical Group Surveillance System (not official name)	North America	132	Both	Multi	Human	Yes
Leptospirosis surveillance in Thailand (not official name)	Asia	173	Known	One	Human	Yes
NHS Direct	Europe	42	Both	Multi	Human	Yes
Oklahoma Physicians Resource/Research Network's OKAlert-ILI System	North America	142	Both	Multi	Human	Yes
Real-time Outbreak and Disease Surveillance System (RODS)	North America	24, 50, 61, 194, 200	Both	Multi	Human	Yes
Salmonella Surveillance System (not official name)	North America	185	Known	One	Human	Yes
Sentinelles or French Communicable Diseases Computer Network (FCDN)	Europe	4, 35, 117, 140, 150, 193, 196	Both	Multi	Human	Yes
West Nile Virus Mosquito Surveillance - Connecticut (not actual name)	North America	6,52	Known	One	Animal	Yes
West Nile Virus Surveillance - National (not official name)	North America	102,146	Both	One	Animal, Human	Yes
WHO Food Surveillance Programme for the Control of Foodborne Diseases in Europe	Europe	191	Known	Multi	Human	Yes

Appendix 6: List of all 214 articles included in review

Appendix 6. List of all 214 articles included in review

- 1 Aarestrup FM. Monitoring of antimicrobial resistance among food animals: principles and limitations. *Journal of Veterinary Medicine* 2004;51:380-388.
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