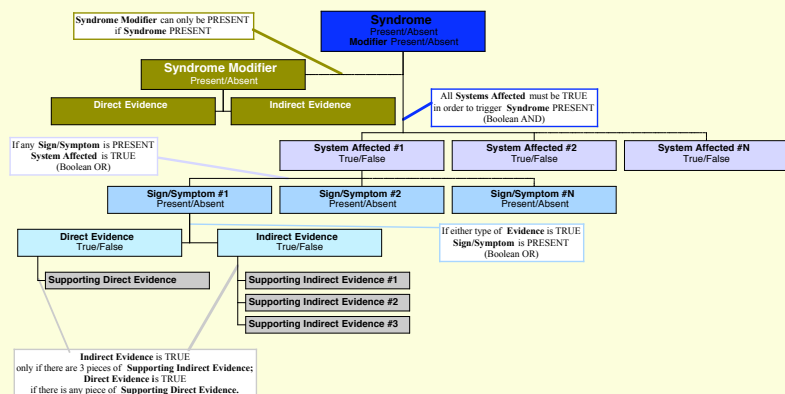


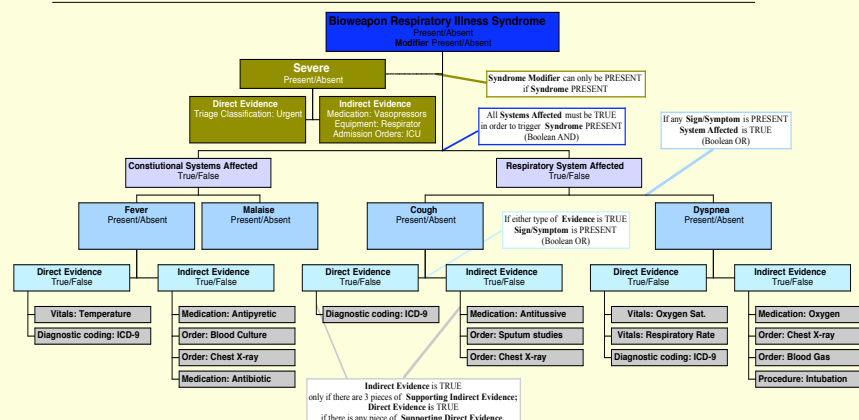
# A Knowledge-Based Approach to Defining Syndromes

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## Generic Syndrome Ontology & Inference Heuristic



## Bioweapon Respiratory Illness Example



## Background

- Syndromic surveillance can only produce meaningful results if there is a common understanding of what observations constitute a syndrome, and consequently how a syndrome relates to diseases that may cause those observations.
- However, the constituent elements of syndromes, such as "flu-like illness," are poorly characterized and rarely explicitly defined by surveillance system developers.

## Conceptual Heterogeneity

- We recently identified extensive conceptual heterogeneity among 15 syndromic surveillance systems, including 8 unique case definitions for syndromic surveillance for acute bioweapon respiratory illness
- All 15 surveillance approaches used different criteria for enumerating and tallying illness syndromes attributable to biological weapons, with little or no evidence of a coordinated or evidence-based approach.

## Knowledge-Based Approach

- We describe here a preliminary ontology for the creation of bioterrorism syndrome knowledge bases that will facilitate sharing and comparison of knowledge, independent of a particular system or research group.
- Additionally, we have created an inference heuristic problem-solving method that can relate indirect measurements of disease, such as antibiotic prescriptions, to diseases of interest.
- Other groups have used similar knowledge-based techniques successfully to overcome the problem of conceptual heterogeneity in healthcare guidelines and clinical trial design.

## Ontology

- Our ontology enables precise enunciation of forms of evidence required to diagnose a syndrome.
- The ontology contains 6 major categories: Syndrome, Syndrome Modifier, System Affected, Sign/Symptom, Direct Supporting Evidence, and Indirect Supporting Evidence.
- We have instantiated the ontology for the syndrome "Bioweapon Respiratory Illness."

## Inference Heuristic

- The inference heuristic can use the elements of this ontology to combine direct measurements into meaningful abstractions.
- Each sign and symptom has a defined, explicit relationship to supporting direct and indirect evidence, like measured temperature or a patient's chief complaint.
- Similarly, the presence of a syndrome can only be inferred if illness within requisite body systems can be substantiated by the presence of symptoms.
- The heuristic currently uses deterministic reasoning, but could easily be extended to perform probabilistically.

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# Conceptual Heterogeneity Complicates Automated Syndromic Surveillance for Bioterrorism

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Routine infectious disease surveillance has traditionally relied on aggregation of multiple disease indicators, such as laboratory-based reporting and notifications from sentinel healthcare providers. Several authorities have recently endorsed the concept of **syndromic surveillance** as a means of enhancing the timeliness and sensitivity of bioterrorism surveillance systems.

Despite the widespread interest in syndromic surveillance, there are few data to support the assertion that it will enhance the timeliness and sensitivity of detection of bioterrorism. Furthermore, it is unclear if the syndromes being monitored are truly representative of the prodrome of illness due to biological weapons.

We identified 15 different syndromic surveillance systems currently in use. From these, we found 8 different case definitions for acute respiratory illness due to intentional release of biological weapons. All 15 surveillance approaches we identified used different criteria for enumerating and tallying illness syndromes attributable to biological illness, (**Table 1**) with little or no evidence of a coordinated or evidence-based approach.

There was also substantial conceptual heterogeneity amongst the 8 case definitions for acute respiratory bioweapon illness. For instance, the Lightweight Epidemiology Advanced Detection and Emergency Response System (LEADERS) defined it as “upper or lower respiratory tract infection with fever.” By contrast, the Rapid Syndrome Validation Project (RSVP) asked clinicians to report “influenza-like

illness” and “Adult Respiratory Distress Syndrome (ARDS).” The systems displayed no clear agreement on what signs and symptoms are necessary or sufficient for detection of bioterrorist attack.

The developers of these systems deserve plaudits for creating these surveillance approaches rapidly, under immense political pressure, to respond to a new and evolving public health threat. Nevertheless, conflicting and subjective case definitions greatly complicate the quest to develop automated surveillance systems and make use of a variety of routinely collected medical data elements, such as diagnostic codes, test orders, and medication prescriptions. We advocate the creation of standardized, evidence-based disease knowledge models that will easily allow sharing and comparing different modalities of syndromic surveillance.

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ESSENCE	LEADERS	RDSS	RSVP
Respiratory (common cold, sinus infection)	Upper or lower respiratory tract infection with fever	Respiratory	Influenza-like illness
Gastrointestinal (vomiting, diarrhea, abdominal pain)	Diarrhea or gastroenteritis, including vomiting, abdominal pain, or any other GI distress	GI, infectious	Adult respiratory distress syndrome (ARDS)
Dermatologic, infectious	Rash with fever	Dermatologic	Acute bloody diarrhea
Dermatologic, hemorrhagic	Meningitis, encephalitis, or unexplained delirium	Ophthalmologic	Hepatitis
Neurologic (headache, meningitis)	Botulism-like syndrome, including cranial nerve impairment and weakness	Fever, unexplained	Fever with skin findings
Fever/malaise/sepsis	Sepsis or non-traumatic shock		Fever and altered mental status
Coma/sudden death			

**Table 1: Syndrome groups from four representative surveillance systems.**