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Differentiating Background Sources from Bioterrorism or Criminal Release using the Bioagent Transport and Environmental Modeling System

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Abstract: *The BioWatch Program is composed of a series of sensors placed in U.S. cities, laboratory response networks, law enforcement and intelligence agencies coordinated in an effort to mitigate a bioterrorist attack. Several pathogens listed on the Bioterrorist Agents/Diseases List from the U.S. Centers for Disease Control and Prevention are endemic. Several BioWatch Actionable Results (BAR) have occurred over the past 20 years although none of these has been attributed to a terrorist attack or criminal release; one of these occurred in the city of Saint Louis. The Bioagent Transport and Environmental Modeling System (BioTEMS) was used to evaluate potential sources and the direction from endemic sources in relation to BioWatch sensors and identify replication sites should bioterrorist agents be released. BioTEMS identified sites for replication of F. tularensis in the St. Louis area varying from 100 to 1,000 times. The BioTEMS output can provide information to assist public health officials in determining; 1) where to sample to identify endemic strains, 2) include risk of endemic detection in the BAR decision, 3) identifying high risk site for replication of bioterrorist agents.*

Keywords: *Fransicella tularensis, tularemia, biodefense, bioterrorism, emergency response, bioterrorist agent*

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I. Introduction

The BioWatch Program (BWP) was initiated by the U.S. Department of Homeland Security (DHS) in 2003 as a result of the anthrax mailings in 2001.[1] The BWP provides early warning of a pathogen release, using uses a series of pathogen detectors in U.S. cities to detect airborne particles onto filters that are then transported for laboratory analysis at one of the National Response Network laboratories.[2] According to the DHS the BioWatch Program "provides early detection of a bioterrorism event and helps communities prepare a coordinated response."[3] The objective of BioWatch is to alert authorities so that medical countermeasures can be taken before symptoms, illnesses and casualties occur.

Since its deployment, several dozen BioWatch Actionable Results (BARs) have been documented, although none of these releases have been declared as an intentional release; the results are not considered false positives because pathogen DNA was detected.[4] One of the pathogens listed on the US Centers for Disease Control and Prevention (CDC) Bioterrorist Agents List is *Francisella tularensis*, the etiologic agent of tularemia.[5] Tularemia is rare, but it is a naturally occurring potentially serious bacterial zoonosis that has been reported from all U.S. states except Hawaii.[6] Human infection by *F. tularensis* occurs through the bite of an infected arthropod bites (primarily ticks or tabanid flies), ingesting contaminated water and food, and by handling infected animals.[7] In 2006, the BioWatch sensors in Saint Louis, Missouri detected a possible release of *F. tularensis* near the Busch Stadium; because tularemia is common in Missouri officials discounted the detection as a terrorist attack.[8] Tularemia has also been detected by BioWatch in other cities in the U.S. several times, e.g. Ohio.[9] Because it is naturally occurring in the US, and the fact that BioWatch has detected *F. tularensis* several times over the past two decades, identifying likely sources and the direction of the source, and what strains are naturally occurring within the detection area of BioWatch would assist in planning and properly reacting to a BAR. A critical aspect of planning in the BAR should be identifying and mitigating replication of the bioterrorist agent in the environment.

The Bioagent Transport and Environmental Modeling System (BioTEMS) has been used during international training exercises for weapons of mass destruction, Significant National Events in the U.S. and to produce risk assessment maps for infectious diseases and bioterrorist agents for cities around the world.[10-13] In the present study, BioTEMS was used to identify areas where local *F. tularensis* may have served as the source of the BioWatch BAR in 2006.

II. Methods

The City of St. Louis, Missouri has a population of over 300,000 people and is located west and adjacent to the Mississippi River and further to the north lies the Missouri River. The city has many natural assets, including a large park system and nature trails.[14] BioTEMS incorporates several hundred abiotic and biotic factors to produce risk and vulnerability assessments for biological agents and infectious diseases. Examples of biotic and biotic factors include; pathogen strain, vector/host relationship, vectorial capacity, host/vector physiology, colonization ability, population dynamics of hosts and vectors, soil, shade, and weather conditions, such as wind, temperature, precipitation. Analytical methods within BioTEMS includes; artificial intelligence, fuzzy logic, niche analysis, random forests, and statistics. Abiotic and biotic factors affecting the survival, replication and distribution of F. tularensis in the environment were evaluated. ArcGIS geospatial analysis software, Statistica statistical software and the BioTEMSwere used to analyze geographic information and to conduct data analysis and produce output into Google Earth.

III. Results And Discussion

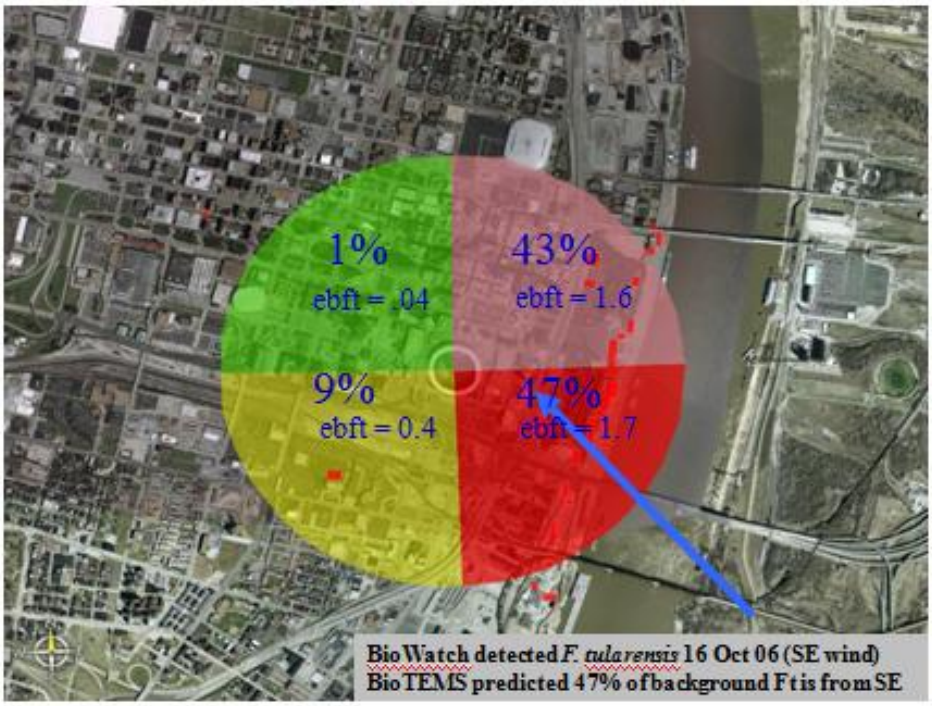
The BioTEMS identified several sites where *F. tularensis* could likely be found and isolated (Figure 1). The variation in expected level of endemic sources ranged from 1 to 47%. A high level of probable background source of *F. tularensis* (90%) was likely detected the day the BioWatch detected the wind was blowing from the southeast towards Busch Stadium. Knowing the probability of detecting endemic *F. tularensis* provides valuable information for public health and law enforcement officials. For example, if the wind was blowing from the northwest quadrant towards the Busch stadium the likelihood of this being an endemic source of tularemia for the BAR would be one percent, etc. With confirmatory sampling, addition resolution would be gained. BioTEMS has accurately predicted direction of the spread of arboviruses in the environment on several continents.

In addition to determining the geographical density and direction of endemic pathogens, BioTEMS output can identify what areas should be sampled to identify pathogen strain, reservoirs and vectors. For example, there are two subtypes of *F. tularensis* occurring naturally in the U.S., types A and B and within these two types, genetic diversity occurs geographically has led to classification of subtypes. Both *F. tularensis* types A and B, and A subtypes have been identified in Missouri[15], therefore including genotyping when sampling of endemic bioterrorist agents should be included. Testing of potential reservoir species of bioterrorist agents should be included in environmental sampling and is a factor included in the BioTEMS model. For example, rabbits, raccoons, beavers and muskrats potentially serve as reservoirs of *F. tularensis*. Physiologic state of individuals within the reservoir species is a critical factor when modeling environmental sources of bioterrorist agents. When a bioterrorist agent is a vector-borne pathogen, where and when vectors may be involved in the distribution and density of bioterrorist agents must be considered. For example, the lone star tick (A*mblyomma americanum*) is implicated as a likely vector of *F. tularensis* in Missouri.[16]

Properly modeling the deposition and replication of a release of a bioagent is critical in mitigation of a release of a bioagent. For example, medical countermeasures can be taken to mitigate civil disruption..[17,18] BioTEMS identified sites for replication of *F. tularensis* in the St. Louis area varying from 100 to 1,000 times. High risk sites for replication can be targeted my public health officials for mitigation to reduce the risk of an introduced bioterrorist agent from becoming endemic. Numerous examples of introduced infectious agents can be listed. One of the earliest known examples is *Yersinia pestis*, the etiologic agent of plague which was transported around the world inadvertently by the movement of humankind. However in 1940, Japan used plague as a biological weapon and released infected fleas into China where has now become endemic, with continued infections of the populace.[20]

In conclusion, BioTEMS was used to evaluate the environment surrounding St. Louis, Missouri, USA, where BioWatch detected *F. tularensis*, the etiologic agent of tularemia. Probable endemic sites serving as sources of *F. tularensis* and where replication is likely, should there be a bioterrorist or criminal release of F. tularensis were identified for sampling and mitigation. Direction in relation to background sources of endemic *F. tularensis* provides additional information as to the likelihood of a bioterrorist attack. The Bioagent Environmental and Modeling System can be used to supplement the BioWatch Assessment Response and to assist public health officials, law enforcement and intelligence agencies in mitigation and determining likelihood and source of a bioterrorist attack.

Figure 1. Potential sites and direction of environmental background of *Francisella tularensis* (ebft) serving as source of the BioWatch Actionable Result for tularemia in Saint Louis Missouri. The blue arrow indicates wind direction during the event.



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