HARNESSING PHYSIOLOGICAL DATA FOR EARLY WARNING OF THREAT EXPOSURE

Modeling Detection Of Anthrax Outbreak Onset Via A Novel Human Sentinel Network

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Current disease outbreak surveillance practices reflect underlying delays in the detection and reporting of disease cases, relying on individuals who present symptoms to seek medical care and enter the health care system. To accelerate the detection of outbreaks resulting from possible bioterror attacks, we introduce a novel two-tier, human sentinel network (HSN) concept composed of wearable physiological sensors capable of pre-symptomatic illness detection, which prompt individuals to enter a confirmatory stage where diagnostic testing occurs at a certified laboratory. Both the wearable alerts and test results are reported automatically and immediately to a secure online platform via a dedicated application. The platform aggregates the information and makes it accessible to public health authorities. We evaluated the HSN against traditional public health surveillance practices for outbreak detection of 80 Bacillus anthracis (Ba) release scenarios in mid-town Manhattan, NYC. We completed an end-to-end modeling and analysis effort, including the calculation of anthrax exposures and doses based on computational atmospheric modeling of release dynamics, and development of a custom-built probabilistic model to simulate resulting wearable alerts, diagnostic test results, symptom onsets, and medical diagnoses for each exposed individual in the population. We developed a novel measure of network coverage, formulated new metrics to compare the performance of the HSN to public health surveillance practices, completed a Design of Experiments to optimize the test matrix, characterized the performant trade-space, and performed sensitivity analyses to identify the most important engineering parameters. Our results indicate that a network covering greater than ~10% of the population would yield approximately a 24-hour time advantage over public health surveillance practices in identifying outbreak onset, and provide a non-target-specific indication (in the form of a statistically aberrant number of wearable alerts) of approximately 36-hours; these earlier detections would enable faster and more effective responses to support incident characterization and decrease morbidity and mortality via post-exposure prophylaxis.

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