

JSTO in the News

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Be Prepared: Machine Learning is Equipping Us for the Unknown

Rapid Analysis of Threat Exposure (RATE) warns of an infection up to 48 hours before overt symptoms appear.



Machine Learning.
Infection Warning.



Lead DoD science and technology to anticipate, defend, and safeguard against chemical and biological threats for the warfighter and the nation.



DEFENSE THREAT REDUCTION AGENCY

Research and Development Directorate
Chemical and Biological Technologies Department
Joint Science and Technology Office for Chemical and Biological Defense

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Front cover illustration courtesy of the Defense Threat Reduction Agency's Chemical and Biological Technologies Department.

Inside cover: Warfighters put the MEDHUB device through its paces at Fort Bragg, North Carolina. MEDHUB uses wearable sensors, accelerometers, and other technology to improve communication among patients, medics, and receiving field hospitals. Photo courtesy of the U.S. Army Medical Materiel Agency.

Back cover: A warfighter checks on the vitals of a simulated patient at the Veterans Memorial Armed Forces Center during a medical response training in Danbury, Connecticut, on June 25, 2020. Photo courtesy of the Connecticut National Guard Public Affairs Office. Photo by Timothy Koster.

HEADACHE
SORE THROAT
DRIP
SNORT
COUGH
HACK
WHEEZE
SNIFFLE
CHILL
ACHE

S

BIG DATA



A - 28.942

80%
90%
100%

MACHINE LEARNING INFECTION WARNING

DATA ANALYSIS

ANALYTICS _ G = 289 7899
HHR = 56 - 8960 - 8942 - S | 67
F = 6 | 7893 - X = 9

HEART-RATE VARIABILITY



SUBTLE PHYSIOLOGICAL CHANGES CAN
WARN OF AN INFECTION UP TO 48 HOURS
BEFORE SYMPTOMS APPEAR.

In the midst of the COVID-19 pandemic, the Department of Defense (DoD) offers a glimmer of hope: the ability to warn of an infection up to 48 hours before overt symptoms appear. This infection-warning capability is the Rapid Analysis of Threat Exposure (RATE), and its development was conceptualized and spearheaded by DoD's Defense Threat Reduction Agency's (DTRA) Chemical and Biological Technologies Department, in its role as the Joint Science and Technology Office (JSTO). RATE has the potential to disrupt the early, invisible progression of disease, and the tool has been publicized by the media. *National Public Radio* discussed the impact of the new capability



◀ Garmin Fenix 6, Multisport Smartwatch

HEART-RATE VARIABILITY



Oura Smart Ring ▶

Researchers work on a new COVID-19 detection technology. DTRA-JSTO is applying the commercial technology for early detection of the severe acute respiratory syndrome coronavirus 2, which causes the COVID-19 disease. Photo courtesy of Philips Research North America.

on the military. *Federal News Network* focused on the global, public health effects of learning presymptomatic signs of an infection 48 hours in advance.¹ *The Wall Street Journal* highlighted the significance of RATE in identifying infections due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2),² the virus that causes COVID-19; and *Fox 5 Good Day DC* explored the commercial potential of RATE.

RATE is a machine-learning algorithm that can explore a large set of data for patterns in how the human body changes when it acquires an infection. RATE is threat agnostic by design, which means the algorithm can identify signs of an infection regardless of the type of pathogen (bacterium or virus) causing the infection. The algorithm is demonstrating that it can analyze data collected by wearable technologies, such as smart watches, to identify individuals who are about to develop overt symptoms due to an exposure to SARS-CoV-2. If military personnel were outfitted with a wearable

Scientists vetted the multimillion hospital-patient interactions and selected 41,000 to develop the infection-warning algorithm.

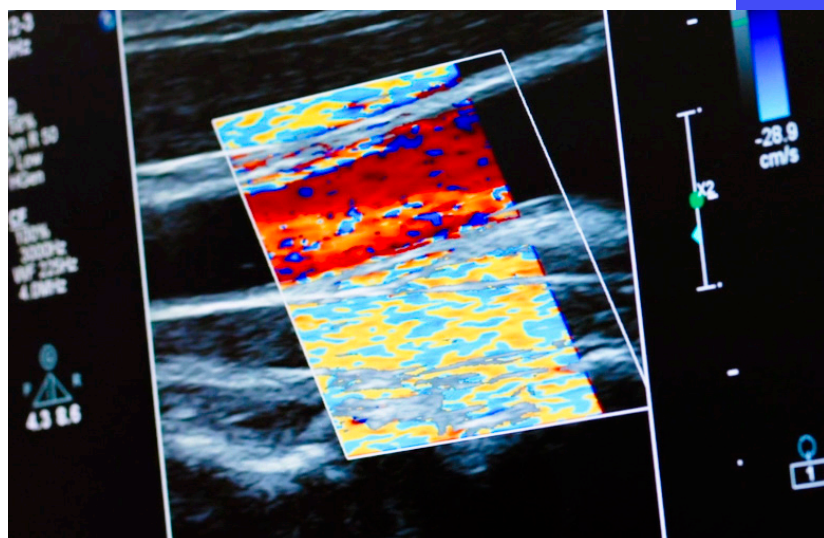
Data selected were from patients who acquired infections during their hospital stay.

technology, then RATE's threat-agnostic, infection-warning capability could help DoD better prepare for surprises in biological warfare.

DTRA-JSTO sought to develop an early infection-warning system that is grounded on the clinical fact that when a person is exposed to a pathogen, that person undergoes certain measurable changes in the body before symptoms

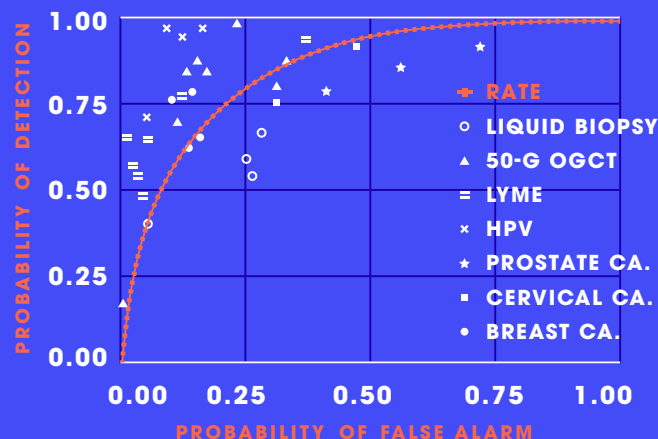
1. Temin T. 2020. DoD components team with industry partner on AI project for an infectious disease warning system. *Federal News Network* website. <https://federalnewsnetwork.com/artificial-intelligence/2020/09/dod-components-team-with-industry-partner-on-ai-project-for-an-infectious-disease-warning-system/>. Accessed November 6, 2020.
2. Kesling B, Youssef NA. 2020. Thousands of American troops to take part in COVID-19 early-detection study. *Wall Street Journal* website. <https://www.wsj.com/articles/thousands-of-american-troops-to-take-part-in-covid-19-early-detection-study-11600772402>. Accessed November 6, 2020.

DTRA-JSTO is applying the commercial technology for early detection of the severe acute respiratory syndrome coronavirus 2, which causes the COVID-19 disease. Photo courtesy of Philips Research North America.



RATE Warns 48 Hours Before Clinical Suspicion

RATE predictive algorithm compared to diagnostics approved by the Food and Drug Administration; RATE has the ability to indicate a healthcare-acquired infection or better than the sensitivity and specificity of market diagnostics.



NOTE: 50g oral glucose challenge test (50-G OGCT); human papillomavirus (HPV)

appear (fever, cough, swelling, fatigue, etc.). These measures of individual physiological variables may be subtle, but when measures from multiple variables are grouped, patterns emerge. For example, elevations in variables such as resting heart rate and body temperature, when coupled with decreases in blood-oxygen levels and heart-rate variability (“the variation in time between each heartbeat”³), can represent early signs of an infection. To better understand these group-based patterns, DTRA-JSTO needed to employ a large data set (big data) and machine learning. Machine learning enables scientists to explore big data, a feat that could take years, perhaps decades, to do by human minds alone.

Through a funding pathway called an Other Transaction Authority (OTA), which enables government agencies to work with industry or academia to quickly develop prototypes of needed capabilities, DTRA-JSTO engaged the help of Defense Innovation Unit and Philips Health to develop RATE, the early infection-warning system. Philips Health provided the big data — seven million hospital-patient interactions — so that machine learning could identify patterns in presymptomatic, physiological

changes that human bodies undergo when exposed to infection-causing pathogens.

The RATE project launched in March 2018, and by October 2019, scientists had vetted the multimillion hospital-patient interactions and selected 41,000 to develop the infection-warning algorithm. Data selected were from patients who acquired infections during their hospital stay. For each of the 41,000 hospital-patient interactions, the algorithm looked for changes in the measures of over 100 variables; the measures had been obtained noninvasively. The algorithm evaluated changes in measures, from one day to the next, until the patient developed symptoms of the hospital-acquired infection. Through this exploration, changes in specific variables, such as blood-oxygen saturation levels, resting heart rate, heart-rate variability, body temperature, and blood pressure, were determined to be the most significant early indicators of an impending illness. Then, using machine learning, scientists trained the RATE algorithm on these data, resulting in the ability to identify pattern changes signaling the beginnings of an infection 48 hours before symptoms appeared — a eureka moment with

3. Campos M. 2017. Heart rate variability: A new way to track well-being. *Harvard Health Blog*. Harvard Health Publishing website. <https://www.health.harvard.edu/blog/heart-rate-variability-new-way-track-well-2017112212789>. Accessed November 6, 2020.



the potential to change behavior to mitigate the effects of a disease. For example, military personnel armed with this knowledge can seek medical help and self-quarantine to prevent disease transmission. “While RATE isn’t preventing disease, it informs of an illness about to overwhelm the body, in turn promoting behavior that can assure a quicker return to wellness,” says Dr. John Hannan, Chief of Digital Battlespace Management Division at DTRA-JSTO.

Although RATE was developed using data from patients who developed hospital-acquired infections, it is now being assessed for its ability to indicate early signs of infection in active and otherwise healthy military personnel. The assessment is making use of wearable devices and SARS-CoV-2 as the infection-causing pathogen of interest, the latter because the assessment coincided with the COVID-19 pandemic. As mentioned earlier, RATE uses biomarkers that are collected noninvasively, which are also the type of data gathered by readily available, commercial wearable devices. Through the ongoing RATE COVID-19 Demonstration, DTRA-JSTO is evaluating the algorithm’s ability to utilize data gathered in nonclinical settings from wearable

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technologies, such as the Garmin Fenix 6 smart watch and the Oura Ring, to warn of an infection while maintaining confidentiality of personal identity and physical location.

RATE is the first machine-learning, infection-warning algorithm of its kind, offering DoD a novel opportunity to get ahead of illness among its military personnel. A 48-hour warning of an infection, regardless of the type of pathogen causing it, enables military personnel to initiate self-care, seek medical help, and self-quarantine. After all, with knowledge, action is possible. As the current pandemic continues to incite fear, RATE offers the hope of good health, even after an infection has begun. ●



Within the Defense Threat Reduction Agency's Research and Development Directorate resides the Chemical and Biological Technologies Department. The department serves as the Joint Science and Technology Office for Chemical and Biological Defense. This publication highlights the department's advancements in protecting warfighters and citizens from chemical and biological threats through the innovative application of science and technology. [DTRA.mil](https://dtra.mil)