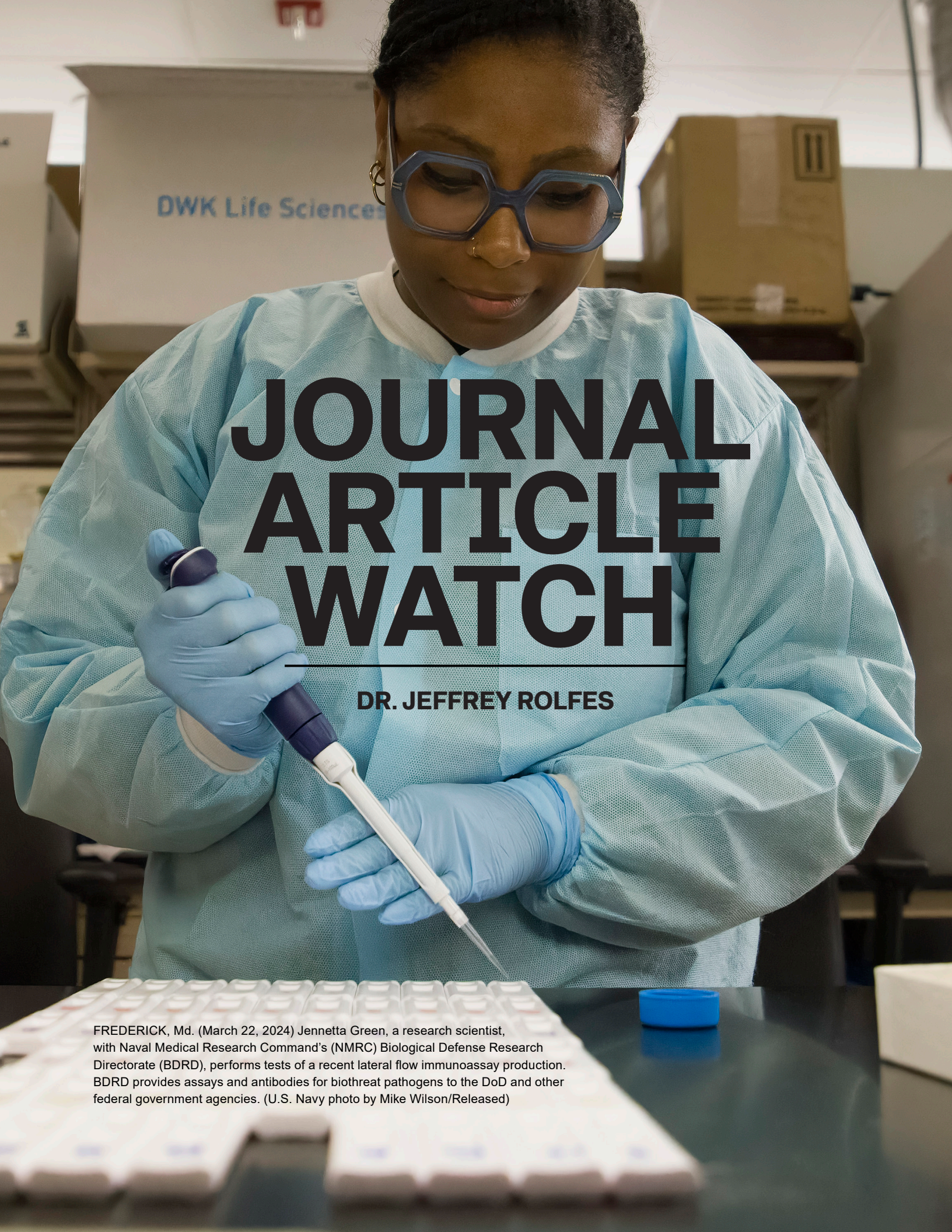

JOURNAL ARTICLE WATCH

DR. JEFFREY ROLFES

FREDERICK, Md. (March 22, 2024) Jennetta Green, a research scientist, with Naval Medical Research Command's (NMRC) Biological Defense Research Directorate (BDRD), performs tests of a recent lateral flow immunoassay production. BDRD provides assays and antibodies for biothreat pathogens to the DoD and other federal government agencies. (U.S. Navy photo by Mike Wilson/Released)

For this issue, the CWMD Journal Article Watch will focus on new research and technologies in the biological arena. Whether the topic is emerging diseases or novel treatments, the pace of new discoveries in this science is exponentially accelerating. Because of the breakneck speed of this inventive force, it is important to stay abreast of all the foundational paradigm shifts that are occurring. Read on for in-depth analysis of ongoing initiatives and thought-provoking pieces that explore the challenges and opportunities related to countering WMDs.

RECENT ADVANCES AND CHALLENGES: TRANSLATIONAL RESEARCH OF MINIMALLY INVASIVE WEARABLE BIOCHEMICAL SENSORS

Summary of research:

Wearable biosensors, which track critical biomarkers, hold great promise for enhancing treatment outcomes. However, the current market lacks widespread availability of wearable biochemical monitors, and many existing options are primarily focused on detecting physical parameters rather than comprehensive biomarker analysis. Despite progress in emerging minimally invasive wearable biochemical sensors (WBS), several challenges hinder their real-world implementation. In this review, the authors focus on studies that have assessed in vivo sensors at technology readiness level (TRL) 4. Their goal is to identify and understand the crucial technological factors and strategies necessary for the practical realization of wearable biosensors, characterized by transducers and target biofluids. Comparative analysis reveals that sensor performance is highly reliant on the design of the detection component. Aspects that affect analysis and operation of the sensor are the choice of bioreceptor, incorporation of nanomaterials, and surface area modifications, which can significantly impact sensitivity, linear range, and stability. While the in vitro sensor method is efficacious for examining biofluids, adapted standardization that relates sensor information to reference techniques is the most accurate technique for measuring biomarker concentrations.

Why it matters to CWMD:

Wearable biochemical sensors have gained significant attention due to their potential in personalized medicine and continuous monitoring of human health. As the materials science and mechanical engineering fields advance, wearable biochemical sensors have been developed to detect various biomarkers such as sweat, saliva, and tears, making them practical for monitoring soldier's health on base and on the battlefield. Such tech could provide early warning of infections and inform commanders on the real-time health of individuals.

Reference:

Irfani R. Ausri, Yael Zilberman, Sarah Schneider, Xiaowu (Shirley) Tang, "Recent advances and challenges: Translational research of minimally invasive wearable biochemical sensors," *Biosensors and Bioelectronics: X*, 15 (December 2023): 100405, https://doi.org/10.1016/j.biosx.2023.100405.

PRECISION MEDICINE IN THE ERA OF MULTI-OMICS: CAN THE DATA TSUNAMI GUIDE RATIONAL TREATMENT DECISION?

Summary of research:

Precision medicine in cancer is swiftly advancing, embracing a holistic strategy that accounts for various facets of biological complexity to understand cancer progression mechanisms for individual patients. However, this strategy encounters difficulties because of the identification of numerous factors within each tumor. These varied factors make medical decision-making more complex, particularly when considering different treatment choices.

Medication responsiveness relies on the feasibility of specific objectives, their clonal or subclonal origin, and concurrent genomic changes. Recent sequencing endeavors have revealed a broad spectrum of influential factors arising during treatment inefficacy, which might serve as potential targets for clinical trials or drug adaptation. To efficiently prioritize treatments, ranking genomic modifications based on their established feasibility becomes crucial. Beyond primary influencers, the future of personalized medicine necessitates recognizing the spatial and temporal diversity inherent in cancer. Copious intricate biological data mandates leveraging artificial intelligence (AI) algorithms for comprehensive analysis.

Effective personalized medicine cases often rely on identifying core drivers and optimizing drug selection. Additionally, alterations in drug resistance and smaller-scale influential factors have emerged as promising therapeutic targets. Beyond individual contributors, advancing precision medicine necessitates acknowledging the complex spatial and temporal heterogeneity inherent in cancer. Integrating data from various sources provides valuable insights into functional targets and regulatory processes, which are essential for clinical applications. Furthermore, thorough data analysis sheds light on oncogenic mechanisms, enhancing our overall understanding of tumor biology and facilitating the development of comprehensive tumor models.

Why it matters to CWMD:

Precision medicine research not only benefits cancer patients but also informs drug development strategies to mitigate the effects of traditional and novel CBRN WMDs. By leveraging personalized approaches and cutting-edge technologies, the Army can enhance its ability to respond effectively to these complex threats. This field aligns with this multidimensional approach by customizing treatments based on genetic profiles and disease mechanisms.

Reference:

M. Aldea, L. Friboulet, S. Apcher, F. Jaulin, F. Mosele, T. Sourisseau, J.-C. Soria, S. Nikolaev, and F. André, "Precision medicine in the era of multi-omics: can the data tsunami guide rational treatment decision?" *ESMO open* 8, no.5 (October 2023): 101642, https://doi.org/10.1016/j.esmoop.2023.101642.

CONFLATING RACE AND ANCESTRY: TRACING DECISION POINTS ABOUT POPULATION DESCRIPTORS OVER THE PRECISION MEDICINE RESEARCH LIFE COURSE

Summary of research:

The utilization of race in genetic research has been a topic of uneven progress. However, previous research highlights challenges in mobilizing genetic concepts of difference due to broader contextual factors and racialization. These studies hold significant implications within the context of precision medicine research (PMR), which investigates how individual variations in genetics, environments, and behaviors relate to health outcomes. PMR faces a well-recognized deficiency in genomic diversity within biobanks and databases. Studies positioning racial diversity as inherent to their study sites underscore the challenge of moving beyond race and/or ethnicity in genomics research, which can only be resolved by confronting how beliefs about fundamental human differences have long been embedded in practices across the research life course.

Why it matters to CWMD:

Precision medicine research that accounts for racial diversity enhances our ability to respond effectively to CBRN WMDs. As the Army is more racially diverse that the general population, more data needs to be included into these data sets to properly understand the genetic factors that influence a patient's reported race. Another issue to consider is racial populations themselves have a variety of heterogeneity that may be racially different from person to person. Understanding those genetic variations within the population will give scientists and medicine professionals the knowledge to give the correct tailored treatment that is based on an individual's actual genetics and biochemistry, rather than that individual's perceived racial group.

Reference:

Michael Bentz, Aliya Saperstein, Stephanie M. Fullerton, Janet K. Shim, and Sandra Soo-Jin Lee, "Conflating race and ancestry: Tracing decision points about population descriptors over the precision medicine research life course" *Human Genetics and Genomics Advances* 5, no. 1 (September 2023): 100243, https://doi.org/10.1016/j.xhgg.2023.100243.

AN EMERGING HEALTH CRISIS IN TURKEY AND SYRIA AFTER THE EARTHQUAKE DISASTER ON 6 FEBRUARY 2023: RISK FACTORS, PREVENTION AND MANAGEMENT OF INFECTIOUS DISEASES

Summary of research:

On February 6, 2023, earthquakes struck both Turkey and Syria, causing significant structural harm to buildings and infrastructure in densely populated regions of Anatolia. Data collected in the field during this time indicated the existence of risk factors that could lead to the emergence of infectious diseases in the affected residential areas from the very onset of the emergency.

The simultaneous collapse of healthcare facilities, severe winter weather, destruction of critical infrastructure, overcrowding in emergency shelters, substandard sanitation, and adverse socio-economic conditions, compounded by ongoing crises (such as conflicts, pandemics, and epidemics), further worsened the already delicate public health situation. The devastation of local healthcare infrastructure, combined with inadequate emergency preparedness plans, impeded timely management and effective treatment of serious health issues. To address these risks, efficient disease surveillance at local and regional levels became essential for identifying infectious disease outbreaks and managing these crises promptly with medical treatment and supplies.

Why it matters to CWMD:

Natural disasters are apt analogues for WMD events, and the lessons learned from managing the treatment and recovery of people and infrastructure can be applied to similar catastrophic outcomes. Understanding the effects of earthquakes helps in designing resilient infrastructure that can withstand both natural disasters and potential WMD attacks. Earthquakes disrupt sanitation, water supply, and healthcare access; these disruptions mirror challenges faced during WMD incidents. Strengthening infrastructure resilience ensures continuity of essential services during emergencies. This type of recent research provides valuable insights into disaster management, infrastructure resilience, and public health.

Reference:

Maria Mavrouli, Spyridon Mavroulis, Efthymios Lekkas, and Athanassios Tsakris, "An Emerging Health Crisis in Turkey and Syria after the Earthquake Disaster on 6 February 2023: Risk Factors, Prevention and Management of Infectious Diseases ," *Healthcare* 11, no. 7 (April 2022): 1022), https://doi.org/10.3390/healthcare11071022.

EVALUATION OF ARTIFICIAL INTELLIGENCE TECHNIQUES IN DISEASE DIAGNOSIS AND PREDICTION

Summary of research:

Medical conclusions heavily depend on the analysis of images captured by high-tech medical equipment. The incorporation of artificial intelligence (AI) in the examination of medical imagery has led to automated and accurate assessments. As a result, the burden on doctors has lessened, diagnostic inaccuracies and response times have diminished, and the overall efficacy in forecasting and identifying various ailments has increased. Investigations into AI methodologies for medical image processing are pivotal, employing complex computer algorithms for prognosis, diagnosis, and treatment strategies. Machine Learning (ML) and Deep Learning (DL) are the main AI branches used for disease diagnosis, drug discovery, and pinpointing patient risk elements. The recent progress in digital health records and big data solutions have aided the effectiveness of ML and DL algorithms. ML includes neural networks and fuzzy logic algorithms, automating prediction and diagnostic procedures. DL algorithms, in contrast to conventional neural networks, do not depend on expert feature extraction. Their high-performance computations produce encouraging outcomes in medical image evaluation, encompassing fusion, segmentation, documentation, and categorization. Support Vector Machine (SVM) and Convolutional Neural Network (CNN) are the most utilized methods for disease examination and diagnosis. This review research looks at recent AI methodologies for diagnosing and predicting diseases like cancers, cardiac issues, pulmonary conditions, skin ailments, genetic abnormalities, and neurological disorders. These AI techniques exhibit superior accuracy compared to human experts, while also tackling obstacles and restrictions in the healthcare sector.

Why it matters to CWMD:

In the event of a WMD attack or outbreak, the healthcare system may be overwhelmed with many patients requiring medical attention. AI can assist in triaging patients, prioritizing critical cases, and managing resources efficiently during emergencies. During this event, physicians and radiologists may face fatigue or cognitive biases when interpreting medical images manually. AI systems, on the other hand, can process vast amounts of data without fatigue and provide consistent, objective assessments. By reducing human error, AI enhances the accuracy of WMD-related diagnoses and predictions. It is important to note, however, machine and deep learning techniques would struggle to initially process this information if these events were based on novel pathogens due to the lack of data that the system needs to accurately diagnose those pathogens.

Reference:

Nafiseh Ghaffar Nia, Erkan Kaplanoglu, and Ahab Nasab, "Evaluation of artificial intelligence techniques in disease diagnosis and prediction," *Discover Artificial Intelligence* 3, no. 5 (January 2023), https://doi.org/10.1007/s44163-023-00049-5.

A THREE-DIMENSIONAL LIQUID DIODE FOR SOFT, INTEGRATED PERMEABLE ELECTRONICS

Summary of research:

Scientists from Hong Kong have created wearable electronics that are lightweight, stretchable, and exhibit a remarkable 400-fold increase in sweat permeability. These innovative devices enable reliable long-term monitoring of biosignals for biomedical applications. Led by a team from CityUHK's Department of Biomedical Engineering (BME), the research team addressed a critical issue faced by wearable biomedical devices: maintaining stable signal quality over extended periods. Sweat accumulation and air permeability can affect the longevity of signal stability. To overcome this challenge, the team developed a structured material based on a nature-inspired three-dimensional liquid diode (3D LD) configuration that unidirectionally channels sweat away from the adhesion point between the skin and electronics. This novel approach allows for the spontaneous flow of liquids in a specific direction, ensuring seamless monitoring even under sweating conditions.

Why it matters to CWMD:

This new material will now allow for longer term cycles of physiological monitoring. Military uniforms and gear can be equipped with integrated, stretchable wearable electronics, enabling unobtrusive health monitoring for longer time periods and at higher levels of physical activity without compromising mobility or comfort. This new breathable electronic ensures that soldiers can focus on their mission without having to worry about the placement and discomfort of their biosensor.

Reference:

Binbin Zhang, Jiyu Li, Jingkun Zhou, Lung Chow, Guangyao Zhao, Ya Huang, Zhiqiang Ma, Qiang Zhang, Yawen Yang, Chun Ki Yiu, Jian Li, Fengjun Chun, Xingcan Huang, Yuyu Gao, Pengcheng Wu, Shengxin Jia, Hu Li, Dengfeng Li, Yiming Liu, Kuanming Yao, Rui Shi, Zhenlin Chen, Bee Luan Khoo, Weiqing Yang, Feng Wang, Zijian Zheng, Zuankai Wang, and Xinge Yu, "A three-dimensional liquid diode for soft, integrated permeable electronics," *Nature* 628, (2024): 84-92, https://doi.org/10.1038/s41586-024-07161-1.

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