PREPARED STATEMENT OF PATRICIA FLATLEY BRENNAN, RN, PhD
DIRECTOR, NATIONAL LIBRARY OF MEDICINE

Madam Chairwoman and Members of the Subcommittee: I am pleased to have this opportunity to speak to you about the exciting work taking place at the National Library of Medicine of the National Institutes of Health (NIH).

ACCELERATING BIOMEDICAL DISCOVERY & DATA-POWERED HEALTH

The National Library of Medicine (NLM) plays an essential role in catalyzing basic biomedical science through its cutting-edge data science and informatics research, comprehensive information systems, and extensive research training programs. As the world's largest biomedical library, NLM acquires, organizes, and delivers up-to-date biomedical information across the United States and around the globe. NLM operates some of the most heavily used Federal websites. Millions of data scientists, health professionals, and members of the public use NLM's electronic information sources every day to translate research results into new treatments, products, and practices and provide the foundation for clinical decision making by health professionals and patients.

Leveraging its 180-year history of organizing and disseminating biomedical literature, NLM is committed to the application of emerging data science capabilities to challenges in biomedical research and public health. It does this by enhancing its data and information resources and providing leadership in both the acquisition and analysis of data for discovery. It continues to expand its core biomedical literature and genomic collections to include a broad array of health, clinical, and biological data types. It makes these data findable, accessible, interoperable, and reusable (FAIR) for research. NLM is investing in new research programs to systematically characterize and curate data describing complex health phenomena and to devise new methods to uncover the knowledge held in data. It has restructured its 16 biomedical informatics training programs to address data science as they continue to foster excellence and support a diverse workforce. NLM is in the process of developing an efficient organizational structure to accommodate emerging directions in research and services.

RESEARCH IN BIOMEDICAL INFORMATICS AND DATA SCIENCE

NLM's research programs support pioneering research and development to advance knowledge in biomedical informatics and data science. Its research portfolio spans such areas as artificial intelligence, computational biology, clinical decision support, public health surveillance, visualization, and discovery mining in digital data sets. This research encompasses areas of high importance to NIH and society at large, and for audiences ranging from clinicians and scientists to consumers and patients.

Research in data science produces novel analytical approaches and visualization tools that help scientists accelerate discovery from data and translate these findings to clinical solutions. It also aims to solve problems consumers face in accessing, storing, using, and understanding their own health data and to produce tools that make precision

medicine discoveries available and more understandable to patients. Biomedical informatics research is yielding advanced analytical methods and tools for use against large scale data generated from clinical care, leading to fuller understanding of the effects of medications and procedures as well as individual factors important in the prevention and treatment of disease processes.

Recognized as a leader in clinical information analytics, NLM supports and conducts research in areas such as medical language processing, high-speed access to biomedical information, analysis and use of high quality imaging data, health data standards; and analysis of large databases of clinical and administrative data to predict patient outcomes and validate findings from clinical research studies. Leveraging extensive machine learning experience and field-based projects, NLM is now advancing analytical tools and deep learning techniques for application in image analysis research.

NLM's biomedical informatics research also addresses issues in computational biology. Research creates new ways to represent and link together genomic and biological data and biomedical literature and produces analytic software tools for gaining insights in areas such as genetic mutational patterns and factors in disease, molecular binding, and protein structure and function.

Last year, NLM established a new partnership with the National Science Foundation to support research on advanced analytical methods specifically applied to health.

BIOMEDICAL INFORMATION SYSTEMS FOR RESEARCH AND HEALTH

NLM develops and operates a set of richly linked databases that promote scientific breakthroughs and play an essential role in all phases of research and innovation. Every day, NLM receives up to 15 terabytes of new data and information, enhances their quality and consistency, and integrates them with other NLM information. It responds to millions of inquiries per day from individuals and computer systems, serving up some 115 terabytes of information. This includes genomic data, such as that contained in the Sequence Read Archive, as well as citations to more than 30 million journal article records in PubMed.

On any given day, more than 2.5 million people use NLM's PubMed Central (PMC) to retrieve more than 5 million full-text biomedical journal articles. PMC serves as the repository for NIH's Public Access Policy and includes more than one million articles summarizing the results of NIH-funded research. Additionally, ten other federal agencies use PMC as the repository for publications collected under their public access policies.

Recently, NLM enhanced the ability to connect articles in PMC to openly available datasets that support reported research findings. Currently, more than 300,000 articles in PMC include datasets as supplemental materials. Others link to datasets

hosted in other trusted repositories. The addition of this information has resulted in a 30 percent increase in daily downloads of supplementary material from PMC.

NLM also offers sophisticated retrieval methods and analysis tools to mine this wealth of data, many of which grow out NLM's research and development programs. For example, NLM tools are used to mine journal articles and electronic health records (EHRs) to discover adverse drug reactions, analyze high throughput genomic data to identify promising drug targets, and detect transplant rejection earlier so interventions to help clinical research participants can begin more quickly. Data analysis tools also support complex analyses of richly annotated genomics data resources, yielding important molecular biology discoveries and health advances for applications to clinical care. Such applications demonstrate how the benefits of big data critically depend upon the existence of algorithms that can transform such data into information.

As a major force in health data standards for more than 30 years, NLM's investments have led to major advances in the ways high volume research and clinical data are collected, structured, standardized, mined, and delivered. In close collaboration with other HHS agencies, NLM develops, funds, and disseminates clinical terminologies designated as essential for demonstrating meaningful use of EHRs and health information exchange. The goal is to ensure that clinical data created in one system can be transmitted, interpreted, and aggregated appropriately in other systems to support health care, public health, and research. NLM produces a range of tools to help EHR developers and users implement these standards and makes them available in multiple formats, including via application programming interfaces or APIs. NLM is now providing support to develop tools to facilitate research use of the Fast Healthcare Interoperability Resource, or FHIR, standard that is being widely adopted for use in electronic health records.

ENGAGING THE PUBLIC WITH HEALTH INFORMATION

NLM uses multiple channels to reach the public with health information, including development of consumer-friendly websites, direct contact, and human networks that reach out to communities. Direct-to-consumer information is made available in lay language through MedlinePlus, which covers more than 1000 health topics. EHR systems can connect directly with MedlinePlus to deliver information to patients and health care providers at the point of need in healthcare systems. In collaboration with other NIH Institutes and Centers and other partners, NLM produces the print and online *NIH MedlinePlus* magazine, and its Spanish counterpart, *NIH Salud*.

The National Network of Libraries of Medicine (NNLM) engages more than 7,000 academic health sciences libraries, hospital libraries, public libraries, and community-based organizations as valued partners in conducting outreach to ensure the availability of health information and efficient access to NLM services. The NNLM provides a community-level resource for NIH's *All of Us* program, ensuring a point of presence in almost every county in the US. The NNLM provides a robust network that reaches communities that are often underrepresented in biomedical research.

NNLM partners with local, state, and national disaster preparedness and response efforts to promote more effective use of libraries and librarians and ensure access to health information in disasters and emergencies. NNLM also plays an important role in increasing the capacity of research libraries and librarians to support data science and improve institutional capacity in management and analysis of biomedical data.

CONCLUSION

To conclude, through its research, information systems and public engagement, NLM supports discovery and the clinical application of knowledge to improve health. Its programs provide important foundations for the field of biomedical informatics and data science, bringing the methods and concepts of computational, informational, quantitative, social, behavioral, and engineering sciences to bear on problems related to basic biomedical and behavioral research, health care, public health, and consumer use of health-related information.

Patricia Flatley Brennan, RN, PhD
Director, National Library of Medicine

Patricia Flatley Brennan, RN, PhD, is the Director of the National Library of Medicine (NLM) at the National Institutes of Health (NIH). NLM is the world's largest biomedical library and producer of digital information resources used by scientists, health professionals, and members of the public. Since becoming director in August 2016, Dr. Brennan has positioned the Library to be the epicenter for biomedical data science at NIH and across the biomedical research enterprise globally. Her leadership has led to the development of a new strategic plan that refocuses and enhances NLM's research, development, training, and information systems. By leveraging NLM's heavily used data and information resources and programs, Dr. Brennan is strengthening and advancing NLM's data infrastructure to accelerate data-driven discovery and health, engage new users in new ways, and develop the workforce for a data-driven future.

Prior to joining NIH, Dr. Brennan was the Lillian L. Moehlman Bascom Professor in the School of Nursing and College of Engineering at the University of Wisconsin–Madison. She also led the Living Environments Laboratory (now the Virtual Environments Group) at the Wisconsin Institute for Discovery, which develops new methods for the effective visualization of high-dimensional data.

Dr. Brennan is a pioneer in the development of innovative information systems and services, and her professional accomplishments reflect her background, which unites engineering, information technology, and clinical care to improve public health and ensure the best possible experience in patient care.

Dr. Brennan received a Master of Science in Nursing from the University of Pennsylvania and a PhD in industrial engineering from the University of Wisconsin–Madison. Following seven years of clinical practice in critical care nursing and psychiatric nursing, she held academic positions at Marquette University, Case Western Reserve University, and the University of Wisconsin–Madison.

A past president of the American Medical Informatics Association, Dr. Brennan was elected to the National Academy of Medicine in 2001. She is a fellow of the American Academy of Nursing, the American College of Medical Informatics, and the New York Academy of Medicine.