As director of the National Heart, Lung, and Blood Institute (NHLBI), it is my privilege to be a public servant and an accountable steward of the nation’s investment in heart, lung, blood, and sleep research. The NHLBI strives to advance science that enhances human health through several enduring principles that have sustained the Institute’s legacy of excellence: value investigator-initiated fundamental discovery science; maintain a balanced portfolio across basic, translational, clinical, population, and implementation science; train a diverse new generation of scientists; support implementation science that empowers patients and partners to improve the nation’s health; and innovate an evidence-based elimination of health inequities. The pursuit of the NHLBI mission involves the collective effort of a diverse community of partners including patients, researchers, policymakers, care providers, professional organizations, and the private sector. Over the past 2 years, we engaged our partners in a process of unprecedented scope to create the NHLBI Strategic Vision, a framework of research priorities to guide the activities and initiatives that NHLBI will catalyze over the next decade.1

The Strategic Visioning process revealed an NHLBI community poised to take bold steps forward toward the prevention and preemption of cardiovascular disease. The Strategic Vision charts a future that exploits emerging disciplines and new tools and technologies in computation, imaging, and high-throughput omic analytics to further our understanding of normal biology, pathobiology, individual and population differences, precision medicine, data science, novel therapeutics and diagnostics, and workforce development. Below, I highlight 2 areas in the Strategic Vision that hold great promise for cardiovascular research and health: precision medicine and the interface with data science.

The Promise of Precision Preventive Medicine

Cardiovascular science has led the way in predictive health and precision medicine by defining the risk factors for cardiovascular disease. Twenty-first-century cardiovascular science is poised to exploit the evolution of biomedicine as a data science and take the next leap forward in precision preventive medicine. Our Strategic Vision recognizes an emerging, dynamic data landscape with a convergence of technologies that can comprehensively define molecular profiles with single-cell resolution and capture personal sensor data that transmit the status of human physiology and environmental exposures in real time. Imagine a future where health systems collect rich data from large cohorts of patients who have conditions such as hypertension, early onset myocardial infarction, or heart failure and apply deep analytics to accurately predict disease risk and prognosis and anticipate acute events and exacerbations. Envision the prospect of learning health systems, in which the conduct of clinical research is an intrinsic element of the enterprise that contributes to the continuous enhancement of patient outcomes and yields value.
as a public good. We have within our reach tools to enable the refinement of patient phenotypes that can facilitate the launch of clinical trials with predetermined eligibility and targeted-treatment profiles. The ability to integrate cellular, molecular, clinical, and environmental data to account for differences in pathobiology and unique responses to treatment could enable a new era of clinical decision making, clinical care algorithms, and medical interventions tailored to the individual patient for the best outcome.

One of the challenges for biomedicine in the digital age is how to move from data to knowledge and from knowledge to action to enhance the lives of patients in real-world contexts. Consider, for example, hypertension care in health systems.

- How can we foster learning health systems caring for diverse populations to improve hypertension control rates from the current status of 50% to >80% across a variety of populations and contexts?
- How can we enable learning health systems to identify patients with hypertension who are most likely to benefit from more intensive treatment with the lowest risk of harm and implement innovative strategies to ensure evidence-based treatment to lower target blood pressure?
- How do we enable learning health systems to discover, test, validate, and leverage new biomarkers such as the APOL1 risk variant to identify hypertensive Blacks at risk of developing renal failure?

The new tools of computation, imaging, and high-throughput molecular analysis provide unprecedented opportunities to revolutionize clinical research and practice as we know it and deepen our understanding of cardiovascular pathobiological processes, novel targets for drug discovery, variations among individuals, and refinement of patient subsets for targeted interventions.

ADVANCING NHLBI COMMUNITY COLLABORATIVE SCIENCE

NHLBI’s longitudinal cohort studies are recognized as invaluable assets that provide rich, deeply phenotyped participant populations on which to test the power of new imaging, computational, personal sensor, and omic technologies. Toward this end, the NHLBI TOPMed program (Trans-Omics for Precision Medicine) has been launched to build a large-scale genome-phenome resource based on a synthetic meta-cohort of observational studies that the research community can use to elucidate the pathobiology of heart, lung, blood, and sleep disorders; unveil novel targets for drug discovery; and usher in a new generation of therapeutics. This program is incorporating whole-genome sequencing and other omics data (eg, DNA methylation/epigenome, whole blood transcriptome signatures, metabolite profiles) with behavioral, imaging, environmental, and clinical data. To date, the TOPMed effort has generated 79,000 whole genome sequences in well-phenotyped samples that reflect the diversity of our nation.

Large-scale studies such as TOPMed, which utilize high-throughput technologies, have generated vast amounts of data with the potential to provide new insights into the prediction, prevention, and preemption of cardiovascular disease. Unfortunately, only a small portion of these data are easily findable, accessible, interoperable, reusable, or easily integrated with other big data, such as clinical, environmental, or geospatial data. As the scale and scope of big data grow, it will become imperative to leverage emerging tools of deep machine learning and artificial intelligence to discern novel patterns within datasets that enhance predictive modeling and prognostication. Developing innovative approaches to the integration, analysis, and interpretation of data of multiple types from varied sources in ways that address privacy concerns and preserve public trust is essential to advancing biomedicine as a data science and a public good to catalyze future discovery.

The NHLBI Strategic Vision anticipates the creation of a Data Commons, a communal space for investigators to engage in collaborative data and knowledge exchange utilizing emerging computational power and new analytic tools. By creating a discovery sandbox for scientific inquiry across previously siloed datasets, such as cohort studies, registries, biospecimen repositories, model organ system databases, and clinical trials, the NHLBI will enable the query, reusability, and integration of large datasets and collaborative analyses to accelerate innovation and discovery.

Imagine a future where a clinician-scientist identifies several novel loss-of-function sarcomere gene variants in young Black athletes and can seek input on how these variants may affect clinical prognosis for suspected hypertrophic cardiomyopathy. Envision this investigator can use a controlled access data science resource such as TOPMed to query whether these variants are observed in different populations or associated with abnormal findings on clinical tests such as electrocardiograms, echocardiograms, or magnetic resonance imaging scans.

Opportunities for the Future of Cardiovascular Science

To realize the potential of precision medicine and data science, the NHLBI is committed to advancing the imperative outlined in our Strategic Vision to foster a diverse and inclusive scientific workforce equipped with the skills, knowledge, and resources to tackle our future cardiovascular research and health challenges. The outlook of the cardiovascular...
lar health of our communities rests with the next generation, and my hope is that collectively we enable them to embrace the possibilities of science. I remain confident and optimistic about the future of cardiovascular science and its impact on the health of the nation.

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