Journal of the American Heart Association

EDITORIAL

American Heart Association Focusing Research Rigor on Digital Health

James A. Weyhenmeyer, PhD; Eric D. Peterson, MD, MPH; Craig Beam, BA; Patrick Wayte, MBA; Francoise A. Marvel, MD; Suzanne Bakken, PhD; Alex Sandhu, MD, MS; Brahmajee Nallamothu, MD, MPH; Seth Martin, MD, MHS; Andrea Beaton, MD; Rhoda Au, PhD; Nancy A. Brown

The American Heart Association (AHA) has had a long-standing interest in promoting health technology and digital health to provide all Americans with access to high-quality health care and promote health equity as a strategic priority. This was formalized through the creation of the AHA's Network for Health Technology and Innovation in 2016. AHA has sought to encourage the use of technology to reduce health delivery problems, provider shortages, and challenges in access.

This is only 1 part of an array of initiatives that the AHA has embarked upon to promote the expansion and implementation of health technology across the spectrum of health care services. This not only includes AHA's Center for Health Technology and Innovation but also the AHA's Center for Telehealth as well as new initiatives planned around artificial intelligence and other digital health modalities.

Although technology platforms and solutions are likely to be imperative to improving care at scale, outside of the traditional brick and mortar settings, many patients have difficulty engaging with technology solutions for a variety of reasons including trust, relevance, and ease of use. Additionally, patient-focused technology solutions do not always rely on the best and latest evidence-based science.

These gaps presented an opportunity for the research community to validate (or create) scalable, engaging health-tech solutions up and down the health continuum with the potential to improve health for people across the socioeconomic spectrum. This Strategically Focused Research Network (SFRN) provides the AHA with a mechanism to enhance the understanding of the ability for digital technology to improve health metrics and lower health care costs by engaging patients in self-care and self-prevention. These grants were intended to support the validation of scalable digital solutions to cardiovascular disease, examine their ability to improve upon connectivity to clinicians, and supply evidence-based health management tools such as those available through AHA's Network for Health Technology and Innovation.

SUMMARY AND DESCRIPTION OF THE NETWORK

- The network consists of 5 academic centers, although the Figure shows only 3.
- Each center has expanded its capabilities through inclusion of other institutions as part of their research for patient recruitment and fellows (Figure).
- The SFRN grant has provided them with funds to conduct a collaborative award project. The network stage will last for 4 years.
- The network is planned to continue beyond the fourth year as a Tech Research Collaborative that will conduct future health technology and innovation focused research.

Key Words: Editorials ■ cardiovascular disease ■ clinical trials ■ digital health ■ mobile health

The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

Correspondence to: James A. Weyhenmeyer, PhD, Auburn University, 560 Devall Drive, #266H, Auburn, AL 36832. Email: jaw0155@auburn.edu

This article was sent to Pamela N. Peterson, MD, Deputy Editor, for editorial decision and final disposition.

JAHA is available at: www.ahajournals.org/journal/jaha

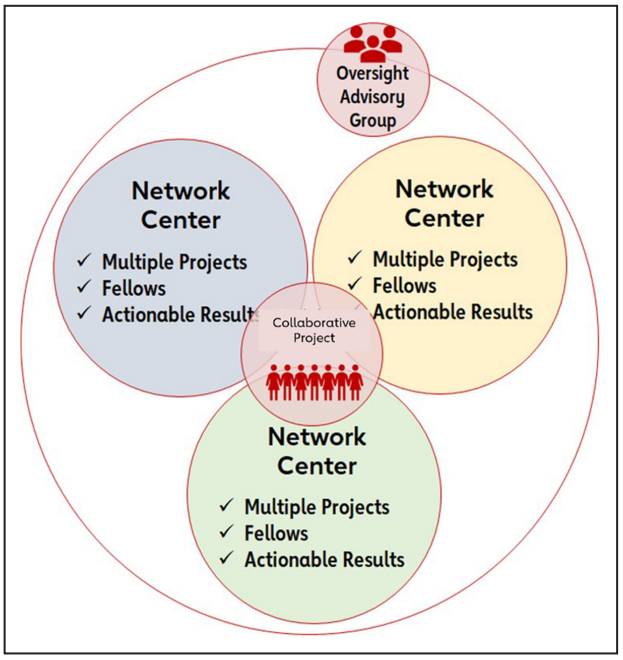

Figure. American Heart Association Strategically Focused Research Network structure.

AHA provides guidance in the form of an expert-led Advisory/Oversight Group to ensure specific aims of the projects are met.

AWARD OBJECTIVE

The AHA's purpose in offering the Health Technologies and Innovation SFRN was to:

1. Research the role and value of innovative technology solutions to improve health outcomes, optimize costs, and increase health engagement and patient/provider connectivity. It is anticipated that the SFRN will also serve to enhance research collaboration across disciplines and may further validate the value of existing health technology solutions or establish new and novel technology approaches.
2. Build a robust collaborative research team across the SFRN by providing the SFRN with structures and funds to conduct a high-impact joint research project.
3. Incubate and nourish, at the completion of the 4 years of SFRN funding, an enduring AHA Health Tech Research Collaborative Platform, consisting of the 5 elected centers. This platform infrastructure would serve as an AHA research think tank to assist in identifying, creating, testing, and bringing to scale future innovative health technologies.

IMPLEMENTATION

To initiate the request for applications for prospective research centers, the AHA provided the following guidance, which was intended to be illustrative but not limiting to those centers that wanted to propose for funding:

- Development of predictive analytics to facilitate clinical decision-making for the benefit and ease of patients or providers including but not limited to those using machine learning, artificial intelligence or both.
- Creation of or improvement to health technologies (eg, health applications, remote patient monitors, wearables/sensors, telehealth or telemedicine solutions, singly or in combination) to enable or enhance information sharing and data sharing between patients and providers for actionable health improvement.
- Improvement and enhancement of clinical trial processes for digital health.
- Best methods for consumer-friendly interfaces and health dashboards that enhance the consumer's ability to be active partners in their own and their families' care.
- Development, validation, or creation of health technologies and applications that can meaningfully affect and drive behavior change (evidence-based coaching, artificial intelligence, digital therapeutics, and related areas).
- Improvement or creation of new analytics and pathology detection capabilities (eg, valves, biomarker phenotypes).
- Projects that address one or more of these while also addressing the equity gap in care and access.

REQUEST FOR APPLICATIONS RESPONSE AND SELECTIONS

The request for applications was issued in 2019 and received numerous responses. From the responses, 5 were selected for funding. The following is a list of the awardees and a summary of the funded research:

Center: Cincinnati Children's Hospital

Active Detection and Decentralized Dynamic Registry to Improve Uptake of Rheumatic Heart Disease Secondary Prevention (ADD-RHD)

Center Director: Andrea Beaton, MD

Training Director: Elaine Urbina, MD

Population Project Principal Investigator: Andrea Beaton, MD

Coinvestigators: Ryan Moore, MD, MSc (technology development); David Watkins, MD, MPH (scientific

oversight); Emmy Okello, MBChB, PhD (Uganda project management)

ADD-RHD

Project Summary

Rheumatic heart disease (RHD) is a disease of disparity. The majority of the 40 million people with RHD live in either low-income countries or marginalized populations within higher-income countries. However, global control of RHD is achievable. The passing of the World Health Assembly RHD in 2018 mandates a coordinated global response.

Although we understand how to achieve global RHD control, broad dissemination and implementation of these practices in low-resource populations have not occurred. Innovative strategies for decentralized care delivery are urgently needed to improve the outcomes of people living with RHD.

Given this opportunity, we designed the ADD-RHD Center to develop and refine a technology-enabled approach to facilitate uptake of secondary prevention that is sustainable and replicable. Three innovations form the core of our approach: (1) a dynamic cloud-based RHD platform to facilitate active case management, (2) automated echocardiographic view-finding technology to enable sustainable and scalable active case finding programs, and (3) a novel framework for uptake of technology in low-resource settings.

The ADD-RHD Center brings together our foundational collaborative, the Rheumatic Heart Disease Research Collaborative in Uganda, with the innovative health delivery expertise of Cincinnati Children's Digital Experience and Bioinformatics Centers, industry partnership with Caption Health, and a rich collaboration with Northern Kentucky University's Biostatistics Department, Health Innovation Center, and Health Sciences Institute. This network will develop and deploy low-cost technology solutions that will rapidly improve uptake of secondary prevention and train the next generation of technologically minded cardiovascular scientists focused on reducing health disparity.

Center: Johns Hopkins University

Center for Mobile Technologies to Reduce Disparities in Cardiovascular Health

Center Director: Seth Martin, MD, MHS

Co-Center Director: David Newman-Toker, MD, PhD

Training Director: Erin Michos, MD, MHS, FACC, FAHA, FASE

Co-Training Director: Najila Nassery, MD

Clinical Project Principal Investigator: Seth Martin, MD, MHS

Co-Project Principal Investigators: David Newman-Toker, MD, PhD and Ali Tehrani, MD, PhD

Advancing Mobile Technologies to Reduce Disparities in Cardiovascular Health

Project Summary

Our team seeks to establish a new Center for Mobile Technologies to Reduce Disparities in Cardiovascular Health. The center would be based in Johns Hopkins Medicine and be a part of the AHA's Health Technology and Innovation SFRN. The center's mission is to leverage mobile and wearable technologies to empower patients and clinicians, enhance quality of care, increase value, and reduce health care disparities in the diagnosis and management of heart diseases and stroke.

To accomplish this goal, our center will combine existing strengths of current institutional centers and schools by sparking new collaborations across the Center for Health Equity, Armstrong Institute Center for Diagnostic Excellence, Ciccarone Center for the Prevention of Cardiovascular Disease, Malone Center for Engineering in Healthcare, Center for Population Health Information Technology, Welch Center for Prevention, Epidemiology, and Clinical Research, Trial Innovation Center, and the School of Nursing. Aligned with the intent of the AHA SFRN award to drive integration, collaboration and high impact, we have integrated 2 previously separate projects and interwoven team leadership and investigators into 1 cohesive unit in the development of this application. We are ready to join together with other centers in an SFRN to advance leading approaches in health technologies and innovation in support of the AHA's mission to be a relentless force for a world of longer, healthier lives.

Center: Stanford University

Center for Heart Health Technology (H2T): Innovation to Implementation

Center and Training Director: Alex Sandhu, MD, MS

Clinical Project Principal Investigator: Paul Wang, MD

Technology-Enabled Management of Hypertension in Underrepresented Communities and in the Gig Economy

Project Summary

Stanford University has been at the forefront of innovation, health technologies, and digital health through its expansion and impact of this rapidly evolving space. The vision of our proposed center, Heart Health Tech Center (H2T): Innovation to Implementation, is the culmination of a gap analysis to determine leading unmet needs in the development, evaluation, and implementation of health technology that can help to fulfill the AHA mission to be a relentless force for a world of longer, healthier lives. Our center vision is to (1) enable technology development related to heart health based on disciplined needs-finding and engineering approaches; (2) quickly and inexpensively test early versions for proof

of concept and efficacy; (3) implement at scale using pragmatic approaches to generate evidence with large-scale deployment; and (4) train and develop the cardiovascular health technology leaders of tomorrow. Our project will be the first use case to follow this approach, and the goals of our training program, architected from Stanford Biodesign, the Center for Digital Health, and other mature programs at Stanford, will translate our center vision into training objectives.

The H2T framework leverages the many resources, centers, programs, and faculty that have allowed Stanford to excel across the entire health technology life cycle, from ideation to implementation. Our team members and core center groups have a strong track record of experience in thought leadership, operations, execution, and collaboration. Our governance structure includes stakeholders from the AHA, American Medical Association, patients, caregivers, and our technology partners.

Our project addresses major gaps in improving blood pressure control at scale. Routine care for blood pressure treatment has high treatment variation, and timely medication adjustment is resource intensive and is not scalable. We aim to first develop an integrated, technology-based, solution for semiautomated management of hypertension that addresses technology gaps and unmet needs. We will then test the efficacy of this solution in a low-cost, randomized trial that includes a Black and Latino population in urban New Jersey, rideshare drivers from Uber, and patients recruited from Stanford Health Care. The gig economy workforce, including rideshare drivers, is an emerging underserved population that has a high expected risk of hypertension and untreated cardiovascular risk but often with limited health care contact.

Center: University of Michigan

Wearables In Reducing Risk and Enhancing Daily Lifestyle (WIRED-L)

Center Director: Brahmajee Nallamothu, MD, MPH

Training Director: Bhramar Mukherjee, PhD

Project Principal Investigator: Lesli Skolarus, MD, MSc (Health Equity)

Co-Project Principal Investigators: Michael Dorsch, PharmD (clinical trial) and Mark W. Newman, PhD (intervention design)

Wearables In Reducing risk and Enhancing Daily Life-style (WIRED-L) Project

Project Summary

Use of smartphones and wearables for mobile health is growing rapidly. However, evidence supporting their use is limited with many studies showing poor user engagement and a mixed impact on outcomes. A major reason is that mobile health apps frequently fail to leverage rich digital data streams on user behavior (eg, recent steps) and context (eg, weather) in designing interventions. Just-in-time adaptive interventions are novel approaches that account for such limitations, but these have been difficult to develop, deploy, and evaluate in cardiovascular disease. The Wearables in Reducing Risk and Enhancing Daily Life-style (WIRED-L) Center is designed to study just-in-time adaptive interventions at scale across diverse conditions and populations. We focus initially on hypertension, a leading cause of disability and death, the predominant driver of cardiovascular race disparities and a high priority for the AHA. We are committed to promoting health equity and believe our community-engaged approach combined with our innovative technology development will result in a scalable and sustainable program. We will build WIRED-L as a platform on an existing digital ecosystem along with our partnering institution, the University of Michigan-Flint. WIRED-L will bring together multidisciplinary experts with a focus on reusability, such that others can test just-in-time adaptive interventions on the WIRED-L platform, overcoming a major barrier in just-in-time adaptive interventions science. Finally, WIRED-L will train a diverse and inclusive set of future leaders in mobile health through a highly integrated program that focuses on the key and complementary areas of clinical trials, data science, and health equity research.

Center: Boston University

Integrated Digital Technology Platform for Optimization of Precision Brain Health

Center Director: Rhoda Au, PhD

Training Director: Vijaya Kolachalama, PhD

Clinical Project Principal Investigators: Rhoda Au, PhD *(digital phenotyping of brain health)*, Honghuang Lin, PhD *(futurizing brain health monitoring platform)*, Vijaya Kolachalama, PhD (*discovery and validation of digital biomarkers)*

Project Summary

The AHA/American Stroke Association equates optimal brain health with cognitive health and recognizes that modifying cardiovascular risk factors provides a prevention pathway for dementia, including the subtype of Alzheimer's disease. However, current cognitive symptom monitoring depends on sporadic measures that are imprecise, time consuming, and costly. These approaches have also led to health disparities that translate into poorer clinical outcomes because of lack of racial and ethnic mediated factors. But there is a way out of this maze of interrelated problems. Internet connected devices and smartphone applications allow tracking of health-related behaviors that are universal to all common chronic diseases including Alzheimer's disease, and advanced computational and artificial intelligence analytics enable profiling and precision stratification at unprecedented levels of accuracy. The proposed center will leverage an existing multisector, multidisciplinary effort to build a robust brain health monitoring platform that collects health-related behaviors and brain-related outcomes

securely, more continuously, and remotely and will do so with existing longitudinal and clinical cohorts that include historically underrepresented populations. A key innovation in our approach will be to craft solutions that move away from the presumption of a patient motivated to use active engagement technologies that require a fair amount of effort (eg, wear, respond, upload). Instead, we will rely on technologies that require little to no effort and make sustained monitoring achievable, particularly in those at risk but still asymptomatic. Given the short technology life cycle, another objective is to develop the infrastructure necessary for ongoing assessment and testing of new technologies to replace outdated/obsolete ones and continuously search for emerging software applications that provide better data security, more accurate automated solutions to processing digital data and deriving novel metrics, electronic health records stratification, longitudinal digital data harmonization, and data deidentification to enable widespread data sharing. We will deploy novel data science analytic methods to develop and validate health- and brain-related metrics from digital data streams collected from ambient technologies.

Further, we will capitalize on a separate but related effort to inform the building of a digital data-sharing platform to accelerate discovery of digital biomarkers.

NETWORK-WIDE COLLABORATIVE PROJECT

Subsequent to the issuance of the awards, an additional aim for the network was for all the participants to create a novel collaborative project and for all the funded centers to contribute to the project.

The following collaborative project was submitted for review and then refined before funding was approved. The collaborative project was approved by the Oversight Advisory Committee and began July 1, 2021.

DEVELOPMENT AND IMPLEMENTATION OF A DIGITAL OPTIMIZATION TOOLKIT FOR MANAGEMENT OF HEART FAILURE AFTER DISCHARGE

Center Director: Alex Sandhu, MD, MS

Project Summary

In this collaborative AHA SFRN Health Technology and Innovation Network Project, we will have 1 centralized study focused on postdischarge heart failure (HF) disease management. We will harness the skills/capabilities of the centers to design a postdischarge HF digital toolkit and then test its effectiveness. We will engage AHA stakeholders (Get With The Guidelines, Care Plans, Center for Health Technology and Innovation, Health Tech Advisory Group) in the design, testing, and implementation of the toolkit. Our project will be conducted in three phases: (1) develop postdischarge digital toolkit for HF management, (2) optimize the clinician and patient experience with a focus on equity, and (3) test and scale the technology through the Get With The Guidelines and international network.

These 3 phases align with the aims as outlined here:

Aim 1: Develop a postdischarge HF assessment and management digital toolkit, anchored in AHA guideline-based care, to (1) optimize guideline- directed medical therapy and (2) improve medication adherence. The toolkit will have clinician- and patient-facing components and will include features to assess HF symptom severity, medication adherence, and functional measures of brain health such as cognition.

Aim 2: Optimize the clinician and patient digital toolkit experience, with an intentional focus on including hard-to-reach users inside and outside of the United States, (eg, low socioeconomic status, older with mild cognitive impairment) guided by user-centered design approaches.

Aim 2A: Conduct virtual cross-center human-centered design sessions engaging diverse end users in optimization of the digital toolkit.

Aim 2B: Incorporate human-centered design insights into the digital toolkit so that it can more completely meet the needs of end users.

Aim 3: Test and scale the postdischarge HF assessment and management digital toolkit to Get With The Guidelines-HF hospitals inside and outside of the United States, using a formative evaluation approach and rapid analysis design to efficiently move through tests of efficacy and scale.

Aim 3A: Determine the efficacy of the HF assessment and management digital toolkit.

Aim 3B: Test implementation of the HF assessment and management digital toolkit at scale, using the RE-AIM Qualitative Evaluation for Systematic Translation framework to understand successes and challenges.

MIDSTAGE FINDINGS AND OBSERVATIONS

Challenges

The 5 digital health SFRN centers each set out with ambitious goals for their individual centers as well as the unique cross-center collaborative research initiative in heart failure. Soon after funding, however, the world was essentially shut down with the COVID-19 pandemic. Each site needed to pivot their research teams to virtual homebound modes. Although the sites showed significant ingenuity, delays in project/tool development were unavoidable. However, post

pandemic most of the sites have successfully modified their timelines and are hitting or exceeding their project milestones and enrollment numbers. This is a testament to the fortitude and creativity of these sites.

Additionally, the boom in digital health also directly affected sites. Specifically, at least 2 of the centers lost key members of their research team who transitioned to digital companies. Although there is always a challenge to retain talent within the academic world, digital technologies are particularly hard hit given their fast pace, need for capital to scale, and lucrative rewards. Despite these losses to industry, the team matrix structure of the individual centers and their deep bench of talent have allowed these institutions to persist despite losses of individuals.

A third hurdle for this particular SFRN was to design and conduct a collaborative project from scratch. Several previous AHA SFRNs had argued for funds to support collaborative research initiatives. Through generous external funding in addition to internal funds, AHA set aside $3.5 million to support the 5 SFRN centers coming together to conduct a collaborative research project. Yet as noted, the centers had diverse interests and domain expertise. Thus, even deciding on a single project and technology to develop took compromise and a collaborative spirit. They were also challenged with decisions about roles and responsibilities for each participant and how to divide these designed funds. Despite these challenges the groups came together to both design and now currently execute an important technology (a mobile clinical decision support tool) in an important medical condition (HF).

Successes

Despite the aforementioned challenges, our SFRN centers are not only surviving but thriving. Each has succeeded in traditional academic terms: publishing papers on their findings and using these funds to garner additional research grant funding based on their work. Beyond this, each of the teams has been highly successful in training and mentoring the next generation of digital health researchers. This is particularly key as the field is in its infancy and there is a paucity of well-trained and dedicated digital health researchers.

Beyond these research and education successes, the SFRNs are also succeeding in other nontraditional manners. Given the need for making digital technologies accessible to patients, several of the SFRNs have developed close bonds to their participant populations. For example, the Michigan center has from its inception relied on a diverse community-based participant core group to help review, prioritize, and evaluate their digital health technologies. These connections with the community ensure that the technologies they develop will address real needs of the community and be both understandable and usable by these diverse populations. Similarly, the Boston center is collaborating closely with older participants in their project who typically struggle with use and acceptance of novel digital technologies. The combined work of this SFRN is helping narrow the digital divide and in the process use these technologies to improve health and health care for all.

A final marker of the success of these programs will be measured in their ability to sustain and scale their solutions beyond the funding periods of their projects. Although it is still relatively early to assess just how much new intellectual property and new commercial products will come from these SFRNs, early signs are positive. At least 1 of these groups (Johns Hopkins University) has already created a digital startup and currently is in its first round of capitalization.

As these research centers are still in the midst of their projects, it is premature to draw conclusions about how successful this SFRN has or will meet its objectives. The oversight committee continues to monitor and advise the research centers and will report to the AHA Research Committee and the Science Advisory and Coordinating Committee. Upon concluding the award period, the expectation is for the funded centers to publish a paper in an AHA scientific journal that showcases the successes and foundational outcomes of the SFRN and outlines the challenges and lessons learned for the benefit of others.

Additionally, the AHA will produce an executive summary and a narrative report at the conclusion of the SFRN's work. These documents will be written in nonscientific, lay-friendly terminology to appeal to diverse audiences. AHA will share these reports widely, including the Board of Directors, volunteer committees, major donors, and other key stakeholders.

ARTICLE INFORMATION

Affiliations

Auburn University, Auburn, AL (J.A.W.); The University of Texas Southwestern Medical Center, Dallas, TX (E.D.P.); Beam & Associates, Orange, CA (C.B.); American Heart Association, Dallas, TX (P.W., N.A.B.); Johns Hopkins University Medicine, Baltimore, MD (F.A.M., S.M.); Columbia University School of Nursing, New York City, NY (S.B.); Stanford University Health Care, Stanford, CA (A.S.); University of Michigan, Ann Arbor, MI (B.N.); Cincinnati Children's Hospital, Cincinatti, OH (A.B.); and Boston University, Boston, MA (R.A.).

Disclosures

EDP serves as a consultant for Janssen Global Services, LLC and Novartis, and has received research grant support from Esperion and Amgen. FAM is a founder of and holds equity in Corrie Health. AS serves as a consultant for Lexicon Pharmaceuticals, Inc. and has received research grant support from the Gordon and Betty Moore Foundation, National Institutes of Health, and American Heart Association. SM serves as a consultant for Premier Healthcare, Novo Nordisk, AstraZeneca, Novartis, NewAmsterdam Pharma, Amgen, Merck, Kaneka Pharma America LLC, Sanofi US Services Inc., and E.R. Squibb & Sons, LLC; is a founder of and holds equity in Corrie Health; and has received research grant support from the American Heart Association.

AB has received research grant support from the Thrasher Research Fund, National Institutes of Health, American Heart Association, Edwards Lifesciences, and Philips Foundation. RA serves as a consultant for Signant Health, Novo Nordisk AS, Davos Alzheimer's Collaborative, and Biogen, Inc. BN is a principal investigator or co-investigator on research grants from the National Institutes of Health, Veterans Affairs Health Services Research & Development, American Heart Association, and Janssen. He also receives compensation as Editor-in-Chief of Circulation: Cardiovascular Quality & Outcomes, a journal of the American Heart Association. Finally, he is a co-inventor on US Utility Patent Number US15/356,012 (US20170148158A1) entitled Automated Analysis of Vasculature in Coronary Angiograms, which uses software technology with signal processing and machine learning to automate the reading of coronary angiograms, held by the University of Michigan. The patent is licensed to AngioInsight, Inc., in which BN holds ownership shares and receives consultancy fees. The remaining authors have no disclosures to report.