

THE NATIONAL HEART, LUNG, AND BLOOD INSTITUTE STRATEGIC VISION IMPLEMENTATION FOR HEALTH EQUITY RESEARCH

George A. Mensah, MD¹; Catherine M. Stoney, PhD²;
Michelle M. Freemer, MD, MPH³; Sharon Smith, PhD⁴;
Michael M. Engelgau, MD, MS¹; W. Keith Hoots, MD⁴;
James P. Kiley, PhD³; David C. Goff, MD, PhD²

The National Heart, Lung, and Blood Institute (NHLBI) provides global leadership for a research, training, and education program to promote the prevention and treatment of heart, lung, and blood diseases and enhance the health of all individuals so that they can live longer and more fulfilling lives. Inherent in this mission is the commitment to advance health equity research as an avenue for enhancing the health of all individuals. Additionally, the four goals and eight research objectives of the NHLBI Strategic Vision directly support the commitment to health equity. In this article, we present selected examples of the NHLBI Strategic Vision implementation approaches for advancing health equity research in our mission areas of heart, lung, and blood diseases. Examples of diseases for which the burden of health inequities and our strategic vision implementation approaches are discussed include hypertension, heart failure, vascular dementia, asthma, and sickle cell disease. Examples are provided of new avenues of Institute-solicited research to stimulate and address compelling scientific questions and critical challenges to advance health equity. We also highlight the emerging fields of implementation science and predictive analytics as important opportunities to accelerate the translation of discovery science into health impact for all and to advance health equity. *Ethn Dis.* 2019;29(Suppl1):57-64; doi:10.18865/ed.29.S1.57.

Keywords: NHLBI; Health Equity; Implementation Science; Predictive Analytics

¹ Center for Translation Research and Implementation Science (CTRIS), National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD

INTRODUCTION

The NHLBI Strategic Vision has four goals and eight objectives that provide a framework for advancing research in heart, lung, blood, and sleep (HLBS) disorders.¹ An important part of this Strategic Vision is research to understand health inequities and stimulate the development and testing of interventions to advance health equity. For example, Strategic Objective 3 addresses investigation of factors that account for population health differences while Strategic Objective 4 focuses on the identification of factors that underlie individual differences in pathobiology and in responses to treatments.¹

Since its founding in 1948, the NHLBI has supported basic, translational, clinical, and population science studies that have advanced our understanding of HLBS disorders. Several of these studies have also shed

light on the burden of inequities by race, ethnicity, gender, geography, educational level, income, and other social and environmental factors.²

This article presents the NHLBI strategic vision implementation approaches for advancing health equity research in our mission areas of HLBS disorders. We provide selected examples of the burden and trends in health inequities and identify concrete examples of past or currently funded research initiatives that address these inequities. Importantly, we highlight how we are stimulating new research to address compelling scientific questions and critical challenges. We also highlight the importance of implementation science as a strategy to accelerate turning discovery science into health at the individual and population levels for improving health overall, reducing inequities, and charting the future for advancing health equity research.

² Division of Cardiovascular Sciences, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD

³ Division of Lung Diseases, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD

⁴ Division of Blood Diseases and Resources, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD

Address correspondence to George A. Mensah, MD, Center for Translation Research and Implementation Science (CTRIS), National Heart, Lung, and Blood Institute, National Institutes of Health, One Rockledge Center, 6705 Rockledge Drive, Suite 6070; Bethesda, MD 20892. 301.496.1051; George.Mensah@nih.gov

Diseases of the Heart and Blood Vessels

Although significant overall decreases in cardiovascular mortality were apparent by the end of the 20th Century, cardiovascular mortality rates are no longer declining and cardiovascular health inequities for many segments of the population remain important. Cardiovascular health inequities by geography, race and ethnicity, age, and socioeconomic status are persistent in the United States,

This article presents the NHLBI strategic vision implementation approaches for advancing health equity research in our mission areas of HLBS disorders.

and are related to a complex interaction of individual, community, policy and social factors. Among the most prevalent are cardiovascular health inequities found in African American, Hispanic/Latino, and American Indian/Alaskan Native (AI/AN) individuals. For example, African Americans have a higher incidence of myocardial infarction and, among those aged >75 years, heart failure.³ They are twice as likely to experience a stroke, and are 30% more likely to die from heart disease, relative to non-

Hispanic Whites. They are also 40% more likely to have hypertension, and less likely to have their hypertension well-controlled.³ Although Hispanic/Latinos have a lower risk of atherosclerotic cardiovascular disease than non-Hispanic Whites, the prevalence of heart failure, obesity, metabolic syndrome and diabetes is higher in this group than among most other ethnic groups, suggesting an overall excess burden of cardiometabolic risk. Geographic inequities are also significant for stroke morbidity and mortality, obesity, hypertension, and CVD in general. The rate of US CVD morbidity and mortality varies substantially by state, with the highest incidence of stroke, CVD, and obesity occurring in the southeastern portion of the United States and in rural areas. Mortality rates are significantly associated with socioeconomic status.

The Division of Cardiovascular Sciences (DCVS) at NHLBI has a long history of supporting research investigators in their efforts to better understand and address health inequities, including initiating and funding longitudinal population-based studies, clinical trials, and training opportunities. Cohort studies such as the Atherosclerosis Risk in Communities Study (ARIC) and the Multi-Ethnic Study of Atherosclerosis (MESA) include diverse participants, and several additional studies are specifically examining populations with significant cardiovascular health inequities. The Strong Heart Study (SHS) follows CVD risk factors among 13 American Indian tribes in the United States and is the largest epidemiological study of American Indians ever conducted. The Jackson

Heart Study (JHS) is a large, community-based, prospective study of cardiovascular disease risk among 5,301 African Americans adults specifically examining inequities in cardiovascular diseases. The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) has demonstrated significant variation in cardiovascular risk by individuals with different Hispanic/Latino backgrounds, suggesting a more tailored research and public health approach is most appropriate.⁴ The REasons for Geographic And Racial Differences in Stroke (REGARDS) Study⁵ was designed to uncover the reasons for the excess mortality due to stroke in African Americans and in the southeastern United States. Although the longitudinal study was funded by the National Institute of Neurological Disorders and Stroke, NHLBI provided additional funding for several ancillary studies. Finally, the Coronary Artery Risk Development in Young Adults Study (CARDIA) is uniquely focused on young adults and is prospectively examining determinants of cardiovascular disease development among more than 5,000 African American and White men and women. Especially important in these cohort studies is the inclusion and measurement of a range of biologic, genetic, behavioral, and environmental risk factors that can help to identify key targets for intervention.^{6,7}

Clinical investigations are increasingly utilizing new and emerging technologies to understand the impact of geography, neighborhood, and the built environment on cardiovascular health inequities. Such tech-

nologies, which include wearable sensors and devices, mobile health, and data science, are also useful as tools for making interventions more accessible to broader populations. In addition, clinical trials of novel interventions and implementation strategies to narrow the inequities gap have focused on community-based interventions to improve outreach and outcomes. For example, improving access to care by incorporating pharmacists into the care team has been shown to significantly improve blood pressure control among those with uncontrolled hypertension, including among low socioeconomic status individuals in a primary care setting⁸ and among African American men in a community setting.⁹ Modeling studies are also helpful in estimating how population-wide changes could lead to decreases in inequities. A recent comparative risk analysis predicted that providing subsidies for heart-healthy foods, in conjunction with implementing taxes on sugar-sweetened beverages and processed meats, might lead to a reduction in cardiometabolic disease mortality, particularly among individuals eligible for the Supplemental Nutrition Assistance Program.¹⁰

The Strategic Vision Implementation Plan for the Division of Cardiovascular Sciences (DCVS) directly addresses health equity research in the identification of six areas of scientific focus that are coordinated with the overall NHLBI Strategic Vision. Three of these areas are focused on specific CV conditions for which there are significant inequities: hypertension, heart failure, and vascular dementia. The additional three areas of focus are cross-cutting

themes that significantly impact the burden of these and other cardiovascular conditions, including addressing social determinants of health and health equity, enhancing resilience, and promoting CV health across the lifespan. These cross-cutting themes are especially relevant to health equity research. Because a large portion of inequities in the burden of CVD can be attributed to social determinants of health that operate at multiple levels, including social, economic, environmental, geographic, health care-related, and behavioral, developing effective intervention strategies to address social determinants of health and health equity and enhance resilience across the lifespan are particularly important to the DCVS mission to reduce CVD inequities.

Diseases of the Lungs

Among Americans in 2016, asthma prevalence was similar in children (0-18 years) and adults (≥ 18 years) at 8.3% yet long-standing differences persisted when comparing Americans based on race, ethnicity, and income level. Prevalence exceeded 10% in non-Hispanic Blacks (11.6%), Puerto Ricans (14.3%), and those below the poverty level (11.8%).¹¹ Asthma mortality in non-Hispanic Blacks (23.3 per million) approached triple the rate in non-Hispanic Whites (8.2 per million).¹¹ Moreover, the disparity in prevalence between Black and White children increased from 2001 to 2010.¹² Accounting for prevalence differences, inequities in asthma mortality were stable over the same period and health care utilization (hospitalizations and ER visits) inequities were reduced.

These inequities represent opportunities for investigators to understand and intervene. NHLBI's Strategic Vision provides a useful framework to review its research that addresses asthma inequities. Strategic Objective 1 focuses on understanding normal biologic function and resilience, with a critical challenge to advance methods to assess and characterize exposures to improve research. In Detroit, an Electronically Activated Recorder (EAR) worn by youth with asthma records interpersonal interactions, including conflicts, to assess the relationship between conflicts and children's asthma symptoms.¹³ Biologic (biomarker) data will be added to the clinical and social data in the same population. NIH also developed Pediatric Research using Integrated Monitoring Systems to support "sensor-based, integrated health monitoring systems for measuring environmental, physiological, and behavioral factors in pediatric epidemiological studies of asthma."¹⁴ Other research efforts address Objective 3 to investigate factors that account for differences in health among populations. Two of the critical questions related to this objective require consideration of community-based implementation research strategies to address health inequities and recognize the importance of adequate representation of disadvantaged populations in research to ensure findings are applicable to those most in need of novel approaches to understanding disease biology and management. While multiple NHLBI-supported studies¹⁵⁻¹⁸ show the efficacy of school-based asthma management programs, NHLBI developed the Asthma Em-

powerment Collaborations to Reduce Childhood Asthma Disparities program to emphasize the importance of community based asthma care that is comprehensive, well-integrated, and addresses the specific needs of the relevant community.^{19,20} Participants will assess both the efficacy and implementation of evidence-based interventions in new communities. Objective 4 highlights the importance of identifying factors that account for individual differences in pathobiology and response to treatments. NHLBI's AsthmaNet, a clinical trial network assessing asthma management, recently completed a randomized, controlled trial, Best African American Response to Asthma Drugs (BARD), to assess if current asthma guidelines are appropriate for African Americans and to understand the impact of genetics on treatment responses.

The NHLBI Strategic Vision also provides a framework for identifying important understudied areas for researchers to explore to address health inequities. Objective 6 highlights the importance of optimizing clinical and implementation research to improve health and reduce disease. A critical question within this objective encourages the identification of methods to improve research participation. Through the recently published Management of Asthma in Primary Care (MAP) program, investigators will use a network of primary care providers, patients, and practice settings that represent the spectrum of disease and care that exist in the United States, including the majority of asthma patients who have never participated in research.^{21,22} Retrospective analysis of electronic health records from

the network will allow the discovery of the most effective "interventions" that some primary care providers already use. Subsequent prospective comparison of these interventions may improve the uptake of effective practices more broadly as suggested in a critical challenge related to Objective 6. NHLBI's leadership role on the Asthma Disparities subcommittee of the President's Task Force on Environmental Health Risks and Safety Risks to Children allows partnerships and communication among federal agencies to address asthma inequities, as reflected in a critical question on engaging stakeholders to improve clinical research.

In summary, the NHLBI Strategic Vision provides a robust framework to highlight some of the NHLBI-supported research to address asthma inequities. Some notable progress has been made in reducing asthma disparities. However, a number of additional critical questions and challenges remain. NHLBI encourages investigators to continue to pursue research questions that will ultimately eliminate these disparities.

Blood Diseases and Resources

Sickle cell disease (SCD) is the most prevalent genetic blood disorder worldwide and an important contributor to health inequity. Globally there are more than 300,000 affected births annually, with greater frequencies in sub-Saharan Africa, India, Caribbean, Central and South America, and the Mediterranean countries.²³ The Centers for Disease Control and Prevention estimates that approximately 100,000 Americans are affected by SCD.²⁴

Historically, SCD has had a high mortality rate in childhood. In recent decades, childhood survival has improved greatly, with 95% of children with SCD reaching adulthood. This improved survival is a result of newborn screening, penicillin prophylaxis, immunizations for pneumonia and influenza, hydroxyurea use and education about SCD complications. Although life expectancy for children has improved markedly, the average lifespan for adults has not seen the same increase.²⁵

The sickle shape of erythrocytes results in vaso-occlusion in small blood vessels leading to ischemia, inflammation and acute severe pain crises, which is the most common acute symptom of SCD. Most persons with SCD will experience a vaso-occlusive crises (VOC) at some point at varying intervals. The NHLBI Expert Panel on the Management of Sickle Cell Disease found VOC serious enough to strongly recommend rapid treatment with parenteral opioid administration.²⁶ However, frequently when patients present at the emergency department (ED) with VOC, they are treated as drug-seeking or abusing and not believed regarding their level of pain. This results in longer wait times to treatment,²⁷ which may hinder their health.²⁸

Complex diseases, such as SCD, require comprehensive coordinated care between primary and multidisciplinary specialty care. For other complex genetic disorders, such as hemophilia and cystic fibrosis, there are effective national networks of specialty clinics that reach large proportions of these patient populations. However, for SCD, there are

fewer specialty clinics, these clinics are less likely to be networked, and they do not cover a large proportion of the SCD population.²⁹

Improving the health and quality of care of individuals with SCD is a major research priority for NHLBI. NHLBI has funded several clinical trials that have influenced the standard of care for patients living with SCD. Currently, NHLBI is funding a consortium to use implementation science to identify and address barriers to optimal comprehensive care for adolescents and adults with SCD. The consortium includes a

registry, a needs assessment to identify barriers, and implementation studies that will be informed by the needs assessment. The implementation studies will address barriers to treating with hydroxyurea, managing pain, and engaging more patients in comprehensive care. In addition to our domestic efforts, NHLBI is supporting four programs in nine sub-Saharan African countries that focus on building a registry, infrastructure development, clinical trial research (hydroxyurea use), training, clinical management guidelines and building capacity for genomic research.

SCD is a complex chronic disease that requires comprehensive coordinated specialty care. This is further confounded by the fact that SCD is a condition with marked inequities, by geography, urbanicity, and socioeconomic status, in care and outcomes, including pain management and access and use of comprehensive specialty clinics.^{28,29} With these challenges in mind, the NHLBI plans to identify and test implementation strategies to address inequities in pain management and treatment of SCD and other HLBS diseases for which such inequities exist.

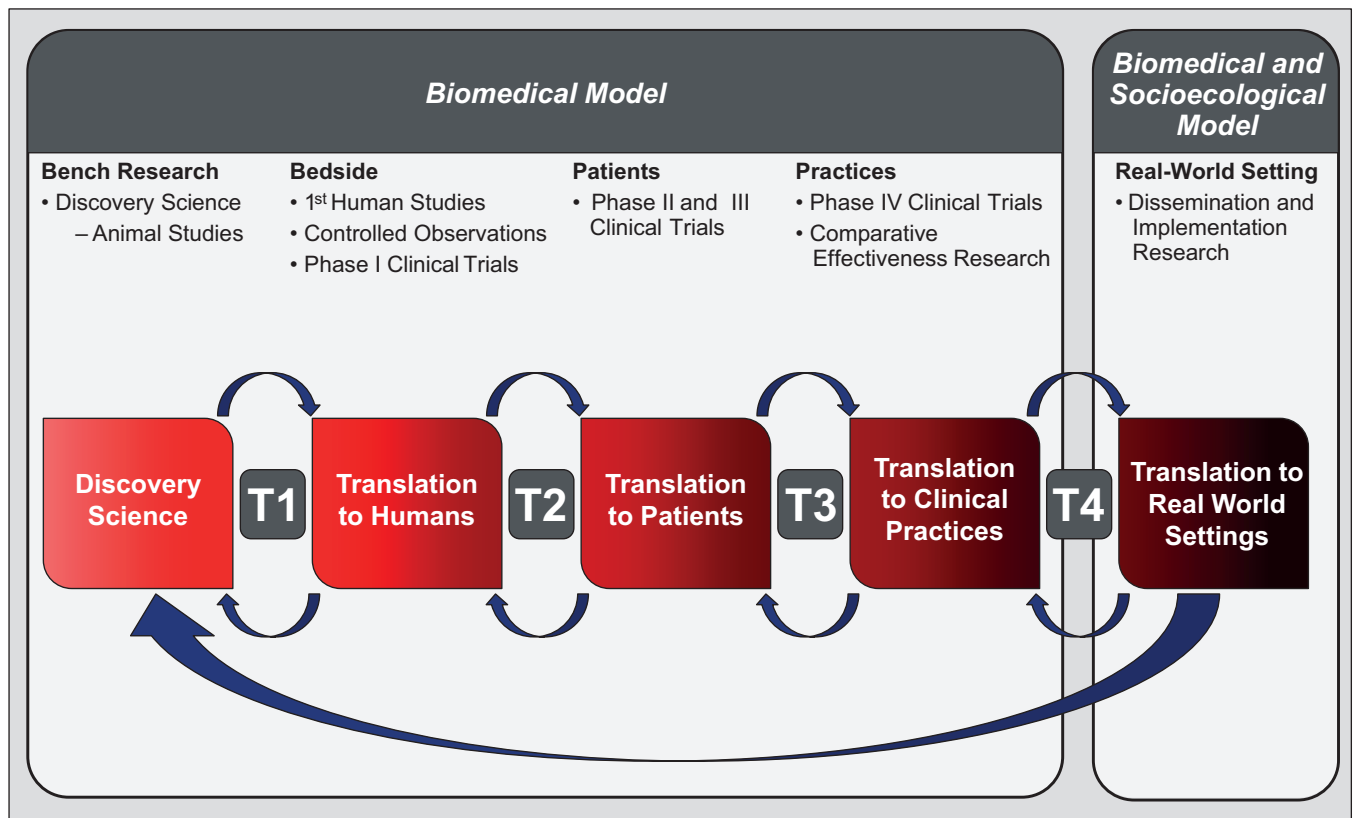


Figure 1. The four steps (T1, T2, T3, and T4) involved in the translation of fundamental discovery science into clinical and public health impact in real-world settings.

T1, the first translational step: bench to bedside or animal studies to humans; T2, the second translational step: translating science discovery to patients with specific diseases; T3, the third translational step: translating clinical insights to service delivery in clinical practices; T4, the fourth translational step: translating effective interventions to real-world settings. Reproduced with permission from Mensah GA. A New Global Heart Series. *Glob Heart*. 2013 Sep;8(3):283-284.

IMPLEMENTATION SCIENCE AND HEALTH EQUITY RESEARCH

Addressing health inequities requires understanding how to optimally and sustainably deliver proven-effective interventions to affected populations. Late-stage T4 translation research and implementation science (Figure 1) represent the final

Late-stage T4 translation research and implementation science (Figure 1) represent the final step in turning discovery science into health impact and focus on understanding key strategies for intervention delivery in the local context.

step in turning discovery science into health impact and focus on understanding key strategies for intervention delivery in the local context. Findings from this field of research are critical to addressing health equity; hence, the NHLBI Strategic Vision includes a compelling question: What community-based effectiveness and implementation research strategies

can help address HLBS health inequities? In 2017, the NHLBI convened a workshop with a multidisciplinary group of experts with the purpose of developing and prioritizing themes and strategies to reduce inequities for CVD and its risk factors through community engagement and implementation research.³⁰ The workshop identified challenges, including identifying high-burden communities and best practices in community engagement, implementing evidence-based interventions, aligning community partners and care networks, incorporating novel research methods and milestones, and training the next generation of health inequities researchers. Additional challenges in scaling-up an effective intervention also include complexity and costs among under-resourced setting.³¹ Potential solutions to these challenges were considered and included: providing appropriate support for community-based participatory projects; advancing innovative improvements in care delivery within complex, multi-entity, community-serving health systems; and addressing social determinants of health and structural barriers in the community's built environment.

These concepts informed the development of a new NHLBI research initiative targeting health inequities in high-burden communities.³² Disparities Elimination through Coordinated Interventions to Prevent and Control Heart and Lung Disease Risk (DECIPHeR) proposes to test strategies for delivering proven-effective, evidence-based, community-level interventions for reducing or eliminating cardiovascular and/or pulmonary health inequities, while pro-

moting improved population health in high-burden communities.³²

Incorporating data science approaches offers an additional avenue to enhance health equity. Data science is an interdisciplinary field of inquiry in which quantitative and analytical approaches, processes, and systems are developed and used to extract knowledge and insights from increasingly large and complex sets of data.³³ Predictive analytics is the use of data, statistical algorithms and machine learning techniques to identify the likelihood of future outcomes based on historical data, and is a type of data science.³⁴ Predictive analytics for health involves efforts assessing complex systems at the local level in communities where implementation of HLBS interventions are being delivered. In high-burden communities, many of these interventions are now being sub-optimally delivered – the reasons attributable to barriers potentially across the whole socio-ecological spectrum, including those from individual, family, and community, along with social determinants, health system characteristics, and geography as it relates to local health care facilities, local and regional health policy.

For a data science approach, NHLBI has joined the National Institute on Minority Health and Health Disparities (NIMHD) and other NIH institutes for an initiative using simulation modeling and system science to support investigative and collaborative research focused on developing and evaluating simulation modeling and systems science to understand and address minority health and health equity.³⁵ These approaches are also highly relevant

to implementation research because they integrate information and evidence from various sources such as epidemiology, clinical guidelines, sociology, behavioral science, psychology, neuroscience, and economics, to formulate complex predictive models. These models can inform implementation research designs that will better focus on the key facilitators or barriers to delivering interventions in the complex community context.

The NHLBI Strategic Vision has another compelling question: How can we foster diversity among trainees so that our research community reflects the makeup of the population at large and has ample participation of individuals from disadvantaged and medically underserved communities? In response to this key question, the NHLBI participates in the NIH Research Supplements to Promote Diversity in Health-Related Research program.³⁶ This program is designed to improve the diversity of the research workforce by recruiting and supporting students, post-doctoral fellows, and eligible investigators from diverse backgrounds, including those from groups that have been shown to be underrepresented in health-related research. In addition, in 2017, NHLBI partnered with several other NIH components and the HHS Office of Minority Health to conduct the workshop *Training the Next Generation of Implementation Researchers for Health Equity*.³⁷ At the workshop, more than 30 experts addressed best practices for designing training programs, enhancing participation, and identifying mentors.

Success in tackling health inequities will require strategic partner-

ships across the disciplines we have discussed including: implementation researchers, community engagement experts, burden of disease assessment experts, data science experts, social scientists, and others. Implementation researchers and scientists are critically important for this effort to demonstrate success in implementing effective programs that can be sustained in diverse and under-resourced clinical and community settings. Additionally, strategies that lead to more rapid adoption of effective interventions with sustained clinical, public health, and policy impact are needed.³⁸ Collectively these efforts should help accelerate late-stage T4 translation research and implementation science for health equity.

CONCLUSIONS

NHLBI has an enduring commitment to the promotion of health and health equity across the spectrum of heart, lung, and blood, diseases. To this point, great attention has been focused on describing the landscape of health equity, and substantial attention has been placed on understanding the barriers that contribute to health inequities. Much less attention has been placed on developing and testing scalable and sustainable approaches to enhancing health equity in diverse communities. To this end, we are committed to supporting rigorous research to test the effectiveness of promising community-relevant interventions and the scalability and sustainability of new strategies to implement proven approaches to enhance health and health equity.

CONFLICT OF INTEREST

No conflicts of interest to report.

AUTHOR CONTRIBUTIONS

Manuscript concept and design: Mensah, Stoney, Freemer, Smith, Engelgau, Hoots, Kiley, Goff; Acquisition of data: Freemer, Smith, Engelgau; Manuscript draft: Mensah, Stoney, Freemer, Smith, Engelgau, Hoots, Kiley, Goff

REFERENCES

1. National Heart, Lung, and Blood Institute. *Charting the Future Together: The NHLBI Strategic Vision*. Bethesda, MD: NHLBI; 2016.
2. National Heart, Lung, and Blood Institute. *Scientific Focus Area: Health Disparities and Inequities*. 2018. Last accessed December 19, 2018 from <https://www.nhlbi.nih.gov/science/health-disparities-and-inequities>.
3. Benjamin EJ, Virani SS, Callaway CW, et al; American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics-2018 update: a report from the American Heart Association. *Circulation*. 2018;137(12):e67-e492. <https://doi.org/10.1161/CIR.0000000000000558> PMID:29386200
4. Daviglus ML, Pirezada A, Talavera GA. Cardiovascular disease risk factors in the Hispanic/Latino population: lessons from the Hispanic Community Health Study/ Study of Latinos (HCHS/SOL). *Prog Cardiovasc Dis*. 2014;57(3):230-236. <https://doi.org/10.1016/j.pcad.2014.07.006> PMID:25242694
5. Howard VJ, Cushman M, Pulley L, et al. The reasons for geographic and racial differences in stroke study: objectives and design. *Neuroepidemiology*. 2005;25(3):135-143. <https://doi.org/10.1159/000086678> PMID:15990444
6. Spahillari A, Talegawkar S, Correa A, et al. Ideal cardiovascular health, cardiovascular remodeling, and heart failure in Blacks: The Jackson Heart Study. *Circ Heart Fail*. 2017;10(2):e003682. <https://doi.org/10.1161/CIRCHEARTFAILURE.116.003682> PMID:28209767
7. Kamimura D, Cain LR, Mentz RJ, et al. Cigarette smoking and incident heart failure: insights from the Jackson Heart Study. *Circulation*. 2018;137(24):2572-2582. <https://doi.org/10.1161/CIRCULATIONAHA.117.031912> PMID:29661945
8. Anderegg MD, Gums TH, Uribe L, Coffey CS, James PA, Carter BL. Physician-Pharmacist Collaborative Management: Narrowing the Socioeconomic Blood Pressure Gap. *Hypertension*. 2016;68(5):1314-1320. <https://doi.org/10.1161/HYPERTENSIONAHA.116.08043> PMID:27600181

9. Victor RG, Lynch K, Li N, et al. A cluster-randomized trial of blood-pressure reduction in Black barbershops. *N Engl J Med*. 2018;378(14):1291-1301. <https://doi.org/10.1056/NEJMoa1717250> PMID:29527973
10. Wilde PE, Conrad Z, Rehm CD, et al. Reductions in national cardiometabolic mortality achievable by food price changes according to Supplemental Nutrition Assistance Program (SNAP) eligibility and participation. *J Epidemiol Community Health*. 2018;72(9):817-824. <https://doi.org/10.1136/jech-2017-210381> PMID:29748418
11. Centers for Disease Control and Prevention. Most Recent Asthma Data. 2018; Last accessed December 20, 2018 from https://www.cdc.gov/asthma/most_recent_data.htm.
12. Akinbami LJ, Moorman JE, Simon AE, Schoendorf KC. Trends in racial disparities for asthma outcomes among children 0 to 17 years, 2001-2010. *J Allergy Clin Immunol*. Sep 2014;134(3):547-553 e545.
13. Tobin ET, Kane HS, Saleh DJ, et al. Naturally observed conflict and youth asthma symptoms. *Health Psychol*. 2015;34(6):622-631. <https://doi.org/10.1037/hea0000138> PMID:25222090
14. National Institute of Biomedical Imaging and Bioengineering. Pediatric research using integrated sensor monitoring systems. Last accessed December 20, 2018 from <https://www.nibib.nih.gov/research-funding/prisms>.
15. Noyes K, Bajorska A, Fisher S, Sauer J, Fagnano M, Halterman JS. Cost-effectiveness of the School-Based Asthma Therapy (SBAT) program. *Pediatrics*. 2013;131(3):e709-e717. <https://doi.org/10.1542/peds.2012-1883> PMID:23400614
16. Eakin MN, Rand CS, Bilderback A, et al. Asthma in Head Start children: effects of the Breathmobile program and family communication on asthma outcomes. *J Allergy Clin Immunol*. 2012;129(3):664-670. <https://doi.org/10.1016/j.jaci.2011.10.013> PMID:22104603
17. Bruzzese JM, Sheares BJ, Vincent EJ, et al. Effects of a school-based intervention for urban adolescents with asthma. A controlled trial. *Am J Respir Crit Care Med*. 2011;183(8):998-1006. <https://doi.org/10.1164/rccm.201003-0429OC> PMID:21139088
18. Gerald JK, Grad R, Bailey WC, Gerald LB. Cost-effectiveness of school-based asthma screening in an urban setting. *J Allergy Clin Immunol*. Mar 2010;125(3):643-650 <https://doi.org/10.1016/j.jaci.2009.12.984>
19. Department of Health and Human Services. Creating Asthma Empowerment Collaborations to Reduce Childhood Asthma Disparities. 2014. Last accessed December 20, 2018 from <https://grants.nih.gov/grants/guide/rfa-files/RFA-HL-15-028.html>.
20. Department of Health and Human Services. *Asthma Empowerment Collaborations to Reduce Childhood Asthma Disparities*. 2014; Last accessed December 20, 2018 from <https://grants.nih.gov/grants/guide/rfa-files/RFA-HL-17-001.html>.
21. Department of Health and Human Services. *Management of Asthma in Primary Care - Clinical Center*. 2018. Last accessed December 20, 2018 from <https://grants.nih.gov/grants/guide/rfa-files/RFA-HL-19-005.html>.
22. Department of Health and Human Services. *Management of Asthma in Primary Care - Bioinformatics Group 2018*. Last accessed December 20, 2018 from <https://grants.nih.gov/grants/guide/rfa-files/RFA-HL-19-006.html>.
23. Alrayyes S, Baghdad D, Haddad RY, et al. Sickle cell disease; An overview of the disease and its systemic effects. *Dis Mon*. 2018;64(6):283-289. <https://doi.org/10.1016/j.disamonth.2017.12.003> PMID:29395106
24. Centers for Disease Control and Prevention. Data & statistics on sickle cell disease. Last accessed December 20, 2018 from <https://www.cdc.gov/ncbddd/sicklecell/data.html>.
25. Ware RE, de Montalembert M, Tshilolo L, Abboud MR. Sickle cell disease. *Lancet*. 2017;390(10091):311-323. [https://doi.org/10.1016/S0140-6736\(17\)30193-9](https://doi.org/10.1016/S0140-6736(17)30193-9) PMID:28159390
26. Yawn BP, Buchanan GR, Afenyi-Annan AN, et al. Management of sickle cell disease: summary of the 2014 evidence-based report by expert panel members. *JAMA*. 2014;312(10):1033-1048. <https://doi.org/10.1001/jama.2014.10517> PMID:25203083
27. Tanabe P, Myers R, Zosel A, et al. Emergency department management of acute pain episodes in sickle cell disease. *Acad Emerg Med*. 2007;14(5):419-425. <https://doi.org/10.1197/j.aem.2006.11.033>
28. Zempsky WT. Treatment of sickle cell pain: fostering trust and justice. *JAMA*. 2009;302(22):2479-2480. <https://doi.org/10.1001/jama.2009.1811> PMID:19996405
29. Grosse SD, Schechter MS, Kulkarni R, Lloyd-Puryear MA, Strickland B, Trevathan E. Models of comprehensive multidisciplinary care for individuals in the United States with genetic disorders. *Pediatrics*. 2009;123(1):407-412. <https://doi.org/10.1542/peds.2007-2875> PMID:19117908
30. Mensah GA, Cooper RS, Siega-Riz AM, et al. Reducing cardiovascular disparities through community-engaged implementation research: A National Heart, Lung, and Blood Institute Workshop Report. *Circ Res*. 2018;122(2):213-230. <https://doi.org/10.1161/CIRCRESA-HA.117.312243> PMID:29348251
31. Glasgow RE, Emmons KM. How can we increase translation of research into practice? Types of evidence needed. *Annu Rev Public Health*. 2007;28(1):413-433. <https://doi.org/10.1146/annurev.publ-health.28.021406.144145> PMID:17150029
32. National Institutes of Health. Notice of intent to publish a funding opportunity announcement for disparities elimination through coordinated interventions to prevent and control heart and lung disease risk (DECIPHrR). Notice Number: NOT-HL-18-632. Last accessed December 20, 2018 from <https://grants.nih.gov/grants/guide/notice-files/NOT-HL-18-632.html>.
33. National Institutes of Health. *NIH Strategic Plan for Data Science*. Last accessed December 20, 2018 from https://datascience.nih.gov/sites/default/files/NIH_Strategic_Plan_for_Data_Science_Final_508.pdf.
34. SAS. Predictive Analytics: What it is and why it matters. Last accessed December 20, 2018 from https://www.sas.com/en_us/insights/analytics/predictive-analytics.html.
35. National Institutes of Health. simulation modeling and systems science to address health disparities (R01 Clinical Trial Not Allowed). 2017. Last accessed December 20, 2018 from <https://grants.nih.gov/grants/guide/pa-files/PAR-18-331.html>.
36. National Institutes of Health. Research supplements to promote diversity in health-related research (Admin Supp - clinical trial not allowed). 2018. Last accessed December 20, 2018 from <https://grants.nih.gov/grants/guide/pa-files/PA-18-906.html>.
37. National Institutes of Health, NIH Record. *NHLBI Hosts Training Workshop for Health Equity Researchers*. Last accessed December 20, 2018 from https://nihrecord.nih.gov/newsletters/2017/12_15_2017/story9.htm.
38. Kessler R, Glasgow RE. A proposal to speed translation of healthcare research into practice: dramatic change is needed. *Am J Prev Med*. 2011;40(6):637-644. <https://doi.org/10.1016/j.amepre.2011.02.023> PMID:21565657