Leveraging Implementation Science to Address Health Disparities in Genomic Medicine: Examples from the Field

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The integration of genomic data into screening, prevention, diagnosis, and treatment for clinical and public health practices has been slow and challenging. Implementation science can be applied in tackling the barriers and challenges as well as exploring opportunities and best practices for integrating genomic data into routine clinical and public health practice. In this article, we define the state of disparities in genomic medicine and focus predominantly on late-stage research findings. We use case studies from genetic testing for cardiovascular diseases (familial hypercholesterolemia) and cancer (Lynch syndrome and hereditary breast and ovarian cancer syndrome) in high-risk populations to consider current disparities and related barriers in turning genomic advances into population health impact to advance health equity. Finally, we address how implementation science can address these translational barriers and we discuss the strategic importance of collaborative multi-stakeholder approaches that engage public health agencies, professional societies, academic health and research centers, community clinics, and patients and their families to work collectively to improve population health and reduce or eliminate health inequities. *Ethn Dis*. 2019;29(Suppl 1):187-192; doi:10.18865/ed.29.S1.187.

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Introduction

In the era of precision medicine, genomic discoveries are slowly being translated to improve clinical care and population health. However, the rate (and quality) of translation has lagged relative to the rate of genomic discovery.[1] Translational genomic research can be differentiated into four phases from initial discovery to population health impact.[2] While phase one (T1) research includes pre-clinical research, phase two (T2) focuses on evidence-based evaluation leading to practice guidelines.[3] Subsequent phases of translational research include research that moves evidence-based guidelines into practice (T3) and evaluates real world outcomes of a genomic application into practice and population health impact (T4).[3] Three genomic applications have been identified by the Centers for Disease Control and Prevention (CDC) as being ready for implementation; these applications have significant potential to improve public health based on existing clinical guidelines and recommendations.[4] These applications include genetic testing for hereditary breast and ovarian cancer syndrome (HBOC), Lynch Syndrome (LS), and familial hypercholesterolemia (FH) among individuals at high risk of these genetic conditions. In this article, we use these applications to illustrate principles of implementation science, especially in relation to health disparities.

These three genetic disorders (HBOC, LS, and FH) significantly increase risk of: breast, ovarian, and other cancers; colorectal, endometrial and other cancers; and cardiovascular disease, respectively. It is estimated that approximately two million people in the United States are affected by these genetic conditions.[4] Identification of individuals with these hereditary syndromes through genetic testing is important; evidence-based guidelines have been developed for the management of these high-risk individuals and thus, reduce morbidity and mortality.[5-7]

However, implementation of these genomic applications in high-risk populations has been suboptimal.[1] Due to multiple factors, including low rates of early detection through genetic counseling and testing uptake, a large proportion of affected individuals remain

unaware that they carry genetic mutations. These rates are even lower among medically underserved populations[8-11] that historically have inadequate access to, or reduced utilization of, high-quality health care.[12] These populations include racial/ethnic minority populations, socioeconomically disadvantaged populations, underserved rural populations, and sexual and gender minorities.[12] Disparities in uptake of evidence-based guidelines for HBOC[10], LS[9] and FH[8,11] have been documented and demonstrate a critical challenge in the implementation of genomic medicine.

In this article, we: 1) describe the state of disparities in genomic medicine using examples from the literature on cancer (HBOC and LS) and cardiovascular diseases (FH) genetic testing; 2) address the importance of implementation research in addressing these disparities; and 3) discuss the strategic importance of collaborative multi-stakeholder approaches to work collectively to improve population health and reduce health inequities.

Current Barriers and Disparities Identified in T3 and T4 Genomic Research

Disparities in genomic medicine have been documented.[8-11] For example, African American women with breast cancer[10] and family history of breast or ovarian cancer[13] are less likely than White women to receive related genetic testing. Such disparities likely originate from socioeconomic and cultural factors that are associated with health care disparities more broadly.[14] However, unique social, ethical and legal issues associated with genetic testing in underserved populations may compound challenges in the translation of genomic applications, calling for tailoring based on the socio-cultural context of each population.[15,16] Disparities in access to and use of genetic testing are exacerbated by differential participation in translational research, in which we find lower inclusion of racial/ethnic minority populations in pre-clinical and clinical genomic research (T1-T2), calling into question the utility of genetic testing and the effectiveness of implementation in these populations.[14,17] Moving forward, the inclusion of diverse populations is needed across preclinical, clinical and public health research settings in order to promote health equity.

Reported barriers to the implementation of genetic testing include low patient awareness and knowledge,[18-20] stigma,[21] concerns about cost,[19,22] fear and distress,[23] patient education level,[24] family concerns,[21] medical mistrust (including fear of misuse of genetic test results[18,20]), lack of a provider recommendation,[24] low provider knowledge,[22] and limited access to genetic services (eg, rural geography),[14] among others. A recent review[16] demonstrated low awareness and knowledge about genetic testing for hereditary cancer among ethnic minority groups, despite generally positive attitudes and perceived benefits of testing, including test results' positive implications for personal and family health.[16] However, concerns about confidentiality, stigma, and discrimination were noted in the review, and in some cases these concerns were more common among ethnic minority groups.[16,20,21] For example, in a population-based sample of African Americans, one third expressed concerns that genetic testing for colon cancer risk could lead to discrimination.[25] Of note, Olaya et al found that among those who received genetic counseling, African American women were as likely as Whites to move forward with genetic testing for HBOC,[26] suggesting that research to reduce access issues may do well focusing on access to genetic counseling as an important outcome of interest. Another recent review[27] identified major barriers to identifying and testing relevant family members (ie, cascade screening) once an individual is diagnosed with a genetic condition. State variation in genetic privacy laws, family communication, and geography were noted as major barriers to cascade screening, and a paucity of T4 research was identified that focused on disparities or that included underserved study populations.[27]

Not only is variation in knowledge, attitudes, and benefits notable between racial/ethnic groups, but also within minority populations. Among studies in racial/ethnic minority populations, knowledge about genetic testing varied by sub-ethnic group,[28,29] acculturation,[28] nativity,[29] education,[28] and language skills.[28,29] For example, in one study, increasing acculturation was associated with being more familiar with genetic tests for cancer risk, being more likely to cite perceived benefits of testing, and being less likely to cite perceived barriers among Latinas.[30] Another study found that ethnic identity was positively associated with perceived benefits of genetic testing for cancer risk among African American women.[21] Of note, many of the current studies have focused on HBOC, and while barriers and facilitators may

generalize to LS and FH, unique barriers to these hereditary conditions warrant additional research in relation to equitable implementation of genetic testing. Additional studies that seek to understand barriers for men, who have demonstrated lower rates of genetic testing,[31] will also be important.

Addressing Health Disparities through Implementation Science

The current body of literature demonstrates the complex, multilevel (eg, patient, provider, policy levels) array of barriers that contribute to disparities in the implementation of guidelines recommended for genetic testing of HBOC, LS, and FH. However, we need more T3 and T4 research to optimize the equitable translation of these lifesaving genomic applications into clinical care and public health practice. Implementation science (IS) is the study of methods to promote the translation of evidence-based practices into routine health care and public health practice.[32] IS may provide the frameworks needed for reducing/eliminating existing disparities in access to genomic medicine as well as emerging disparities in genomic medicine.[3] IS can identify barriers to effective implementation of practices, measure important outcomes related to translation, and test strategies to optimize or adapt implementation within a given clinical or public health context.[33] IS frameworks highlight multilevel constructs that impact the implementation of evidence-based care,[34] such as the Consolidated Framework for Implementation Research, which highlights constructs related to the intervention, the individual, inner (eg, clinic level), and outer settings, as well as processes that influence implementation.[35] In other words, IS frameworks acknowledge the importance of patient (eg, knowledge), interpersonal (eg, family or provider communication), organizational (eg, health systems), community (eg, geographic access to genetic services), policy (eg, genetic privacy laws), and socio-cultural (eg, mistrust of medical system) levels, which influence disparities and are critical to implementation of genetic testing, and genomic medicine more broadly.

Indeed, others have called for the use of IS to reduce health disparities[3,36-38] and increase the impact of health research.[39] The Centers for Population Health and Health Disparities program included implementation research as a requisite skill for researchers in cardiovascular disease and cancer in order to address the complexity of observed disparites.[37] Within public health genomics, the Genomics and Public Health Action Collaborative has identified objectives and metrics for HBOC and LS that include an IS framework and implementation outcome measures.[40] Moreover, systematic reviews of the literature[41] and an National Institutes of Health research portfolio[41] have demonstrated an ongoing need to incorporate implementation science into genomic medicine research. Efforts such as Implementing Genomics in Practice (IGNITE),[42] Clinical Sequencing Evidence-Generating Research (CSER),[43] and other funding announcements,[44] attempt to facilitate this movement.

In the current health disparities literature, implementation science frameworks have been used to address disparities in underserved populations.[45-47] This work could be extended to T3 and T4 genomic research to help researchers and practitioners systematically measure disparities in genetic services use, evaluate interventions to reduce disparities, adapt interventions to the unique socio-cultural needs of racial/ethnic minority populations, and measure population impact of evidence-based genomic medicine. For example, researchers in a 2015 study examined the implementation of a screening tool to identify underserved women at high risk for HBOC within a community-based hereditary cancer screening program. The study used mixed methods to measure the acceptability and utilization of this tool among non-genetic clinicians in the community. From this, an education module was developed to improve clinician knowledge of cancer genetics and self-efficacy for connecting clients to genetic counseling and testing for HBOC; this module was then implemented and evaluated.[48] In the end, the education module was effective in improving knowledge and confidence among clinicians. Using implementation frameworks,[34] strategies[49] and measures[50] will further strengthen health disparities research in genomics, by providing standardized metrics and strategies for assessing use of genomic medicine across clinical and public health settings.

However, the use of implementation research to reduce health disparities in genomic medicine, specifically, remains a major gap in the current literature.[41] A review of implementation research in translational genomics found that study populations were primarily White, non-Hispanic, and often authors did not report race or ethnicity.[27] Findings were similar

in a review of the NIH portfolio in implementation science in genomic medicine research.[41] Taken together, these findings demonstrate limited research within racially/ethnically diverse populations in this area, which has implications for our understanding of disparities in implementation of genomics as well as the generalizability of study findings to diverse populations.

Collaborative Multi-stakeholder Approaches to Address Health Disparities

As researchers engage in work that falls at the intersection of health disparities, implementation science, and genomic research, the use of collaborative, multi-stakeholder approaches will be imperative. Inherent in IS approaches, researchers must account for multilevel factors by incorporating stakeholders across multiple levels, including patients, family members, patient advocates, providers, health administrators, community leaders, industry leaders, and policy makers (Table 1).[51] Without consideration of all levels, implementation may fail. For example, even if patients and providers have bought into the importance of genomic medicine to their health, patients, particularly those who are underserved, may still not have access to genetic services due to policies (eg, insurance coverage of follow up care for Tier 1 applications) or geography (eg, low access to genetic counselors) despite individual level buy-in. Given the complexity of implementing genomics, multiple perspectives across these levels (Table 1) will be needed to address disparities in translation.

Recently, the National Heart, Blood, and Lung Institute convened a think tank meeting and recommended collaborative research to reduce health inequities.[38] By including stakeholders (such as community organizations) in translational genomic research, research teams can bring understanding to the complexity of reducing disparities and enhance the reach of genomic medicine by engaging the key stakeholders who are ultimately the end users of genomic medicine. In addition, capacity building will be important for health systems to effectively implement evidence-based genomic medicine.[52] Provider training and resources will be

Table 1. Multilevel factors and key stakeholders influencing diagnosis, treatment and cascade screening for hereditary breast and ovarian cancer syndrome (HBOC), Lynch Syndrome (LS) and familial hypercholesterolemia (FH) in the United States (Adapted from Khoury et al[48])

Level/stakeholder	Examples of factors
Persons with HBOC, LS, FH	Knowledge about genetic conditions and genetic testing; family dynamics; communication with providers and relatives; access to genetic services; medical mistrust; cultural beliefs
Relatives of HBOC, LS, FH patients	Knowledge about genetic conditions and genetic testing; family dynamics; communication with providers and relatives; access to genetic services; medical mistrust; cultural beliefs
Providers	Knowledge about FH, HBOC, LS screening recommendations; communication about genetic conditions with patients and relatives; reimbursement for diagnosing and reporting genetic conditions; reimbursement of initiating contact with relatives of patients; competing demands in a clinic visit; knowledge of genetics and genetic counseling referral patterns; ability to interpret genetic findings and recommend appropriate care (eg, variants of unknown significance)
Laboratories	Different methods and approaches for screening for genetic conditions (eg, in LS, microsatellite instability and IHC as well as DNA sequencing); different laboratory systems (eg, centralized versus local) to undertake screening
Health care organizations	Coordination between various specialties (primary care, oncology/cardiology, genetics); policies and standard practices for screening cases and returning results; integration of genetic information into electronic health records; presence of decision support tools for genetic testing and subsequent guideline recommendations; standardized informed consent for genetic testing; training, tools and resources related to genetic testing for providers and patients
Community/state leaders	Socio-cultural contexts of genetic screening; insurance coverage and reimbursement; existence of state guidelines for recording genetic data; state efforts to promote adoption of guidelines; state certification policies for laboratories/personnel; state laws about genetic privacy; state public health programs to improve access to genetic testing
National health policymakers	Medicare and Medicaid benefits for genetic testing; national policies and regulation of laboratories and genetic testing; professional societies standards; public health efforts to address disparities in implementation of genetic testing and cascade screening

needed for practitioners to keep up with the rapid pace of translational genomic research. Incorporating infrastructure for research will allow health systems to learn from implementation successes and failures:[32] a core function of this learning health care system could be assessing, monitoring and addressing disparities in the use of genetics services.

As the era of precision medicine marches forward, it is imperative that we address disparities in genomic research and genomic medicine. By using implementation science and incorporating key stakeholders in T3 and T4 research, we can begin to address existing disparities in genomics. Through this transdisciplinary research, investigators open the opportunity to develop and implement precision public health to improve population health and reduce disparities. Strategic collaborative engagement of all stakeholders across multiple sectors in approaches that place the patient and family at the center of genomic medicine implementation will be critical for success.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

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References

1. Manolio TA, Chisholm RL, Ozenberger B, et al. Implementing genomic medicine in the clinic: the future is here. *Genet Med*. 2013;15(4):258-267. https://doi.org/10.1038/gim.2012.157 PMID:23306799
2. Schully SD, Benedicto CB, Gillanders EM, Wang SS, Khoury MJ. Translational research in cancer genetics: the road less traveled. *Public Health Genomics*. 2011;14(1):1-8. https://doi.org/10.1159/000272897 PMID:20051673
3. Sampson UK, Mensah GA, Narula J. Implementation research: an imperative for improving global health and health inequities. *Glob Heart*. 2015;10(1):1-2. https://doi.org/10.1016/j.gheart.2014.12.002 PMID:25754560
4. Centers for Disease Control and Prevention. *Tier 1 Genomics Applications and their Importance to Public Health: Genomic Application Toolkit.* 2014. Last accessed January 9, 2019 from https://www.cdc.gov/genomics/implementation/toolkit/tier1.htm.
5. US Preventive Services Task Force. *Final Recommendation Statement: BRCA-Related Cancer: Risk Assessment, Genetic Counseling, and Genetic Testing.* December 2013. Last accessed January 8, 2019 from https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/brca-related-cancer-risk-assessment-genetic-counseling-and-genetic-testing.
6. Evaluation of Genomic Applications in Practice and Prevention (EGAPP) Working Group. Recommendations from the EGAPP Working Group: genetic testing strategies in newly diagnosed individuals with colorectal cancer aimed at reducing morbidity and mortality from Lynch syndrome in relatives. *Genet Med*. 2009;11(1):35-41. https://doi.org/10.1097/GIM.0b013e31818fa2ff PMID:19125126
7. Goldberg AC, Hopkins PN, Toth PP, et al; National Lipid Association Expert Panel on Familial Hypercholesterolemia. Familial hypercholesterolemia: screening, diagnosis and management of pediatric and adult patients: clinical guidance from the National Lipid Association Expert Panel on Familial Hypercholesterolemia. *J Clin Lipidol*. 2011;5(3)(suppl):S1-S8. https://doi.org/10.1016/j.jacl.2011.04.003 PMID:21600525
8. Amrock SM, Duell PB, Knickelbine T, et al. Health disparities among adult patients with a phenotypic diagnosis of familial hypercholesterolemia in the CASCADE-FH™ patient registry. *Atherosclerosis*. 2017;267:19-26. https://doi.org/10.1016/j.atherosclerosis.2017.10.006 PMID:29080546
9. Lee J, Gubernick LR, Brodsky AL, et al. Missed opportunities: genetic counseling and testing among an ethnically diverse cohort of women with endometrial cancer. *Gynecol Oncol*. 2018;151(1):153-158. https://doi.org/10.1016/j.ygyno.2018.07.023 PMID:30077346
10. Levy DE, Byfield SD, Comstock CB, et al. Underutilization of BRCA1/2 testing to guide breast cancer treatment: black and Hispanic women particularly at risk. *Genet Med*. 2011;13(4):349-355. https://doi.org/10.1097/GIM.0b013e3182091ba4 PMID:21358336
11. Zafrir B, Jubran A, Lavie G, Halon DA, Flugelman MY, Shapira C. Clinical Features and Gaps in the Management of Probable Familial Hypercholesterolemia and Cardiovascular Disease. *Circulation J*. 2017;82(1):218-223. https://doi.org/10.1253/circj.CJ-17-0392 PMID:28701632
12. National Institute on Minority Health and Health Disparities. *Overview.* Last accessed January 8, 2019 from https://www.nimhd.nih.gov/about/overview/.
13. Armstrong K, Micco E, Carney A, Stopfer J, Putt M. Racial differences in the use of BRCA1/2 testing among women with a family history of breast or ovarian cancer. *JAMA*. 2005;293(14):1729-1736. https://doi.org/10.1001/jama.293.14.1729 PMID:15827311
14. Hall MJ, Olopade OI. Disparities in genetic testing: thinking outside the BRCA box. *J Clin Oncol*. 2006;24(14):2197-2203. https://doi.org/10.1200/JCO.2006.05.5889 PMID:16682739
15. Allford A, Qureshi N, Barwell J, Lewis C, Kai J. What hinders minority ethnic access to cancer genetics services and what may help? *Eur J Hum Genet*. 2014;22(7):866-874. https://doi.org/10.1038/ejhg.2013.257 PMID:24253862
16. Hann KEJ, Freeman M, Fraser L, et al; PROMISE study team. Awareness, knowledge, perceptions, and attitudes towards genetic testing for cancer risk among ethnic minority groups: a systematic review. *BMC Public Health*. 2017;17(1):503. https://doi.org/10.1186/s12889-017-4375-8 PMID:28545429
17. Landry LG, Ali N, Williams DR, Rehm HL, Bonham VL. Lack of diversity in genomic databases is a barrier to translating precision medicine research into practice. *Health Aff (Millwood)*. 2018;37(5):780-785. https://doi.org/10.1377/hlthaff.2017.1595 PMID:29733732
18. Suther S, Kiros GE. Barriers to the use of genetic testing: a study of racial and ethnic disparities. *Genet Med*. 2009;11(9):655-662. https://doi.org/10.1097/GIM.0b013e3181ab22aa PMID:19752639
19. Gammon AD, Rothwell E, Simmons R, et al. Awareness and preferences regarding BRCA1/2 genetic counseling and testing among Latinas and non-Latina white women at increased risk for hereditary breast and ovarian cancer. *J Genet Couns*. 2011;20(6):625-638. https://doi.org/10.1007/s10897-011-9376-7 PMID:21691939
20. Peters N, Rose A, Armstrong K. The association between race and attitudes about predictive genetic testing. *Cancer Epidemiol Biomarkers Prev*. 2004;13(3):361-365. PMID:15006909
21. Sussner KM, Edwards TA, Thompson HS, et al. Ethnic, racial and cultural identity and perceived benefits and barriers related to genetic testing for breast cancer among at-risk women of African descent in New York City. *Public Health*

Genomics. 2011;14(6):356-370. https://doi.org/10.1159/000325263 PMID:21540561
22. Kinney AY, Simonsen SE, Baty BJ, et al. Acceptance of genetic testing for hereditary breast ovarian cancer among study enrollees from an African American kindred. *Am J Med Genet A*. 2006;140(8):813-826. https://doi.org/10.1002/ajmg.a.31162 PMID:16523520
23. Sussner KM, Jandorf L, Thompson HS, Valdimarsdottir HB. Barriers and facilitators to BRCA genetic counseling among at-risk Latinas in New York City. *Psychooncology*. 2013;22(7):1594-1604. https://doi.org/10.1002/pon.3187 PMID:22987526
24. Cragun D, Bonner D, Kim J, et al. Factors associated with genetic counseling and BRCA testing in a population-based sample of young Black women with breast cancer. *Breast Cancer Res Treat*. 2015;151(1):169-176. https://doi.org/10.1007/s10549-015-3374-7 PMID:25868867
25. Satia JA, McRitchie S, Kupper LL, Halbert CH. Genetic testing for colon cancer among African-Americans in North Carolina. *Prev Med*. 2006;42(1):51-59. https://doi.org/10.1016/j.ypmed.2005.10.004 PMID:16297974
26. Olaya W, Esquivel P, Wong JH, et al. Disparities in BRCA testing: when insurance coverage is not a barrier. *Am J Surg*. 2009;198(4):562-565. https://doi.org/10.1016/j.amjsurg.2009.07.003 PMID:19800469
27. Roberts MC, Dotson WD, DeVore CS, et al. Delivery of cascade screening for hereditary conditions: a scoping review of the literature. *Health Aff (Millwood)*. 2018;37(5):801-808. https://doi.org/10.1377/hlthaff.2017.1630 PMID:29733730
28. Heck JE, Franco R, Jurkowski JM, Sheinfeld Gorin S. Awareness of genetic testing for cancer among United States Hispanics: the role of acculturation. *Community Genet*. 2008;11(1):36-42. PMID:18196916
29. Vadaparampil ST, Wideroff L, Breen N, Trapido E. The impact of acculturation on awareness of genetic testing for increased cancer risk among Hispanics in the year 2000 National Health Interview Survey. *Cancer Epidemiol Biomarkers Prev*. 2006;15(4):618-623. https://doi.org/10.1158/1055-9965.EPI-05-0378 PMID:16614100
30. Sussner KM, Thompson HS, Valdimarsdottir HB, Redd WH, Jandorf L. Acculturation and familiarity with, attitudes towards and beliefs about genetic testing for cancer risk within Latinas in East Harlem, New York City. *J Genet Couns*. 2009;18(1):60-71. https://doi.org/10.1007/s10897-008-9182-z PMID:18686019
31. Childers KK, Maggard-Gibbons M, Macinko J, Childers CP. National distribution of cancer genetic testing in the United States: evidence for a gender disparity in hereditary breast and ovarian cancer. *JAMA Oncol*. 2018;4(6):876-879. https://doi.org/10.1001/jamaoncol.2018.0340 PMID:29710084
32. Chambers DA, Feero WG, Khoury MJ. Convergence of implementation science, precision medicine, and the learning health care system: a new model for biomedical research. *JAMA*. 2016;315(18):1941-1942. https://doi.org/10.1001/jama.2016.3867 PMID:27163980
33. Bauer MS, Damschroder L, Hagedorn H, Smith J, Kilbourne AM. An introduction to implementation science for the non-specialist. *BMC Psychol*. 2015;3(1):32. https://doi.org/10.1186/s40359-015-0089-9 PMID:26376626
34. Nilsen P. Making sense of implementation theories, models and frameworks. *Implement Sci*. 2015;10(1):53. https://doi.org/10.1186/s13012-015-0242-0 PMID:25895742
35. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implement Sci*. 2009;4(1):50. https://doi.org/10.1186/1748-5908-4-50 PMID:19664226
36. Mueller M, Purnell TS, Mensah GA, Cooper LA. Reducing racial and ethnic disparities in hypertension prevention and control: what will it take to translate research into practice and policy? *Am J Hypertens*. 2015;28(6):699-716. https://doi.org/10.1093/ajh/hpu233 PMID:25498998
37. Golden SH, Ferketich A, Boyington J, et al. Transdisciplinary cardiovascular and cancer health disparities training: experiences of the centers for population health and health disparities. *Am J Public Health*. 2015;105(S3)(suppl 3):S395-S402. https://doi.org/10.2105/AJPH.2014.302489 PMID:25905828
38. Sampson UKA, Kaplan RM, Cooper RS, et al. Reducing Health Inequities in the U.S.: Recommendations From the NHLBI's Health Inequities Think Tank Meeting. *J Am Coll Cardiol*. 2016;68(5):517-524. https://doi.org/10.1016/j.jacc.2016.04.059 PMID:27470459
39. Chinman M, Woodward EN, Curran GM, Hausmann LRM. Harnessing implementation science to increase the impact of health equity research. *Med Care*. 2017;55 Suppl 9 Suppl 2:S16-S23. https://doi.org/10.1097/MLR.0000000000000769
40. Doyle DL, Clyne M, Rodriguez JL, et al. Proposed outcomes measures for state public health genomic programs. *Genet Med*. 2018;20(9):995-1003. https://doi.org/10.1038/gim.2017.229 PMID:29300382
41. Roberts MC, Kennedy AE, Chambers DA, Khoury MJ. The current state of implementation science in genomic medicine: opportunities for improvement. *Genet Med*. 2017;19(8):858-863. https://doi.org/10.1038/gim.2016.210 PMID:28079898
42. National Human Genome Research Institute. Implementing Genomics in Practice (IGNITE). September 2018. Last accessed January 8, 2019 from https://www.genome.gov/27554264/implementing-genomics-in-practice-ignite/.
43. Clinical Sequencing Evidence-Generating Research. Last accessed January 8, 2019 from https://cser-consortium.org/.
44. Department of Health and Human Services. Dissemination and Implementation Research in Health (R01). May 2016. Last accessed January 8, 2019 from https://grants.nih.gov/grants/guide/pa-files/PAR-16-238.html.
45. Glasgow RE, Askew S, Purcell P, et al. Use of RE-AIM to address health inequities: application in a low-income community health center based weight loss and hypertension self-management program. *Transl Behav Med*. 2013;3(2):200-210. https://doi.org/10.1007/s13142-013-0201-8 PMID:23750180
46. Krist AH, Aycock RA, Etz RS, et al. MyPreventiveCare: implementation and dissemination of an interactive preventive health record in three practice-based research networks serving disadvantaged patients—a randomized cluster trial. *Implement Sci*. 2014;9(1):181. https://doi.org/10.1186/s13012-014-0181-1 PMID:25500097
47. Friedman DB, Brandt HM, Freedman DA, et al. Innovative and community-driven communication practices of the South Carolina cancer prevention and control research network. *Prev Chronic Dis*. 2014;11:E127. https://doi.org/10.5888/pcd11.140151 PMID:25058673
48. Greenberg S, Yashar BM, Pearlman M, Duquette D, Milliron K, Marvin M. Evaluating and improving the implementation of a community-based hereditary cancer screening program. *J Community Genet*. 2018. https://doi.org/10.1007/s12687-018-0357-5 PMID:29508367
49. Powell BJ, Waltz TJ, Chinman MJ, et al. A refined compilation of implementation strategies: results from the Expert Recommendations for Implementing Change (ERIC) project. *Implement Sci*. 2015;10(1):21. https://doi.org/10.1186/s13012-015-0209-1 PMID:25889199
50. Lewis CC, Fischer S, Weiner BJ, Stanick C, Kim M, Martinez RG. Outcomes for implementation science: an enhanced systematic review of instruments using evidence-based rating criteria. *Implement Sci*. 2015;10(1):155. https://doi.org/10.1186/s13012-015-0342-x PMID:26537706
51. Khoury MJ, Coates RJ, Fennell ML, et al. Multilevel research and the challenges of implementing genomic medicine. *J Natl Cancer Inst Monogr*. 2012;2012(44):112-120. https://doi.org/10.1093/jncimonographs/lgs003 PMID:22623603
52. Leeman J, Birken SA, Powell BJ, Rohweder C, Shea CM. Beyond "implementation strategies": classifying the full range of strategies used in implementation science and practice. *Implement Sci*. 2017;12(1):125. https://doi.org/10.1186/s13012-017-0657-x PMID:29100551