# The Social Component of Diabetes Health Disparities:
## New Directions in Analyses and Interventions Through Social Networks and Structures

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**National Institute of Diabetes and Digestive and Kidney Diseases**

**Division of Diabetes, Endocrinology, and Metabolic Diseases**

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# List of Acronyms

| Acronym | Definition |
|---------|------------|
| ABM | agent-based modeling |
| AIAN | American Indian and Alaska Native |
| BIPOC | Black, Indigenous, and people of color |
| BMI | body mass index |
| CBO | community-based organization |
| CVD | cardiovascular disease |
| DHD | diabetes health disparities |
| DPP | Diabetes Prevention Program |
| DSME | diabetes self-management and education |
| EHR | electronic health record(s) |
| HD | health disparities |
| HRR | hospital referral region |
| NIDDK | National Institute of Diabetes and Digestive and Kidney Diseases |
| SDOH | social determinants of health |
| SES | socioeconomic status |
| SN | social network(s) |
| SNA | social network analysis |
| SNI | social network intervention |
| T1D | type 1 diabetes |
| T2D | type 2 diabetes |

# Day 1 Session Summaries

## Welcome Session and Meeting Charge

Dr. Griffin P. Rodgers, Director of the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), provided opening and welcome remarks. Dr. Rodgers first thanked the workshop co-chairs, speakers, panelists, and discussants for their service and noted that the NIDDK relies on experts from the community to keep its programs relevant and current. Dr. Rodgers further pointed out that extensive diabetes health disparities (DHD) exist in disease prevalence, control, and rates of complications and that he considered this workshop very much aligned toward the goals of the NIDDK strategic plan. Dr. Rodgers anticipated that presentations and discussions of the state of the science and key research gaps will inform the NIDDK in promising and actionable directions in reducing DHD and promote health equity.

Dr. Will Cefalu, Director of the Division of Diabetes, Endocrinology, and Metabolic Diseases, NIDDK, then joined Dr. Rodgers in welcoming all attendees and thanking the organizing committee. Dr. Cefalu echoed Dr. Rodgers in noting that addressing DHD is a priority of the NIDDK in its ongoing programs and in its strategic plan for the future. Dr. Cefalu shared some numbers that showed that obesity and type 2 diabetes (T2D) are not only common, consequential, and costly, but they also are associated with significant disparities in this country. He then noted that the application of social network analysis (SNA) to obesity and diabetes has been somewhat limited, and interventions focusing on social structures and networks as social forces of change have not been explored adequately. He wished the workshop success and expects its outcome to inform the NIDDK on actionable steps.

After the welcome remarks from the NIDDK leadership, Drs. Edwin Fisher and Ann McCranie, representing the workshop co-chairs, laid out the workshop charge. Dr. Fisher started with a brief review of the importance of social influences and the fundamental role of social connections and support. The pioneer work by H.F. Harlow and M. Harlow more than half a century ago put forward the notion that social connection and contacts are fundamental to primates, not learned or developed [1], and subsequent work by Jim House showed that social isolation is lethal [2]. These works, together with another landmark paper by Holt-Lunstad et al. [3], established that human beings are more effective and happier when they have someone with whom they can talk about personal matters, who cares about them, and who can help them when they need help.

Dr. Fisher further reviewed the major types of health behavior interventions that currently are conducted and the survey questions that are asked. He pointed out that although many studies contain a "social" component, many questions could be asked in light of social network (SN) concepts and methods, as summarized in Table 1, but are not being asked; they may represent missed opportunities. He challenged attendees to ponder and discuss during the workshop these questions, as well as places in studies of social influence and DHD where SNA can be leveraged to speed innovation and advances (Figure 1).

Table 1. Questions not typically asked in diabetes health disparities research even when it includes "social" components

| Intervention Type | Questions that Might Be Asked |
|---|---|
| **Worksite**<br>Usually organized by work unit, division | • How many of your coworkers do you know outside of work?<br>• With how many of your coworkers are you comfortable talking about personal matters? |
| **Community**<br>Usually organized geographically or by governmental boundaries | • With how many others in your community are you friendly?<br>• With how many are you comfortable talking about personal matters?<br>• How many of your family members live in the community?<br>• How many of your friends live in the community? |
| **Group Program**<br>Often organized around anonymity—"My name is Ed"—to minimize linkages outside the group itself | • How many of the group members do you know outside the group?<br>• How many of the group members know friends of yours or others you know?<br>• How many of the group members come from communities (e.g., churches, neighborhoods) with which you are familiar? |
| **Peer Support or Community Health Worker**<br>Often matched according to clinical characteristics (e.g., cancer type/stage/treatment, type 1 diabetes) rather than social characteristics | • Did you know your peer supporter before the program?<br>• How many of your friends know your peer supporter?<br>• How many of the peer supporter's friends or family members do you know?<br>• Do you and your peer supporter interact outside of formal meetings? |

Dr. McCranie then explained the workshop agenda and structure and laid out overarching questions: How can SNA improve understanding of the roles that social relationships have in the prevention and treatment of DHD? How can interventions focused on SNs and structures accelerate efforts to reduce or eliminate DHD? She shared plans and structures for breakout group discussions, as well as a candidate list of topics, and encouraged attendees to discuss and provide feedback to the co-chairs.
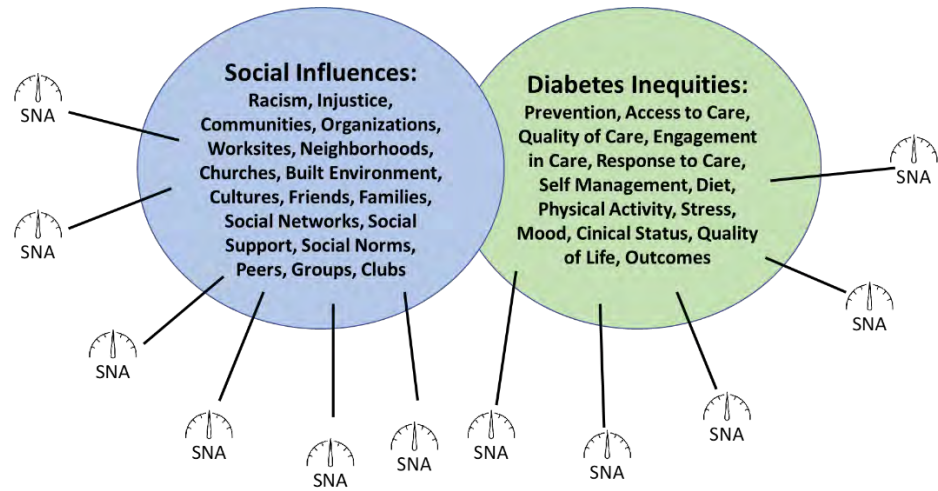
Figure 1. Main topics in social influence and diabetes health disparities, as well as where and how social network analysis could help.

# Keynotes

The workshop started with keynote talks from two physician-scientists who are leaders in DHD research.

Dr. Leonard E. Egede from the Medical College of Wisconsin presented on "Addressing Health Disparities in Diabetes: Intersection of Structural Racism, Social Determinants, and Racial/Ethnic Disparities." Dr. Egede first provided an overview of health disparities (HD); the intersection of structural racism, social determinants, and HD; and structural racism as a driver of HD. Using examples, he showed that structural inequalities arise when discriminatory practices in one sector (e.g., education, employment, housing, credit market, health care, justice system) reinforce discriminatory practices in other sectors, thereby creating an interconnected system that embeds inequalities into laws and policies (e.g., redlining, housing segregation). Emerging evidence indicates that structural racism (i.e., "the ways in which societies foster discrimination through mutually reinforcing inequitable systems") is antecedent to social determinants that result in social risks and is a strong driver of health care disparities. Structural racism affects both mental and physical health through a number of pathways, such as chronic social deprivation, risks, and stress. However, existing studies of social determinants of health (SDOH) paid little attention to upstream antecedent structural factors; as a result, they often found themselves out of power when trying to address the downstream factors. He noted that one possible reason studies often overlook structural factors is that they tend to focus on one individual level (e.g., personal behavior). Dr. Egede expressed optimism that as an increasing number of investigators work on SDOH with increasingly sophisticated analyses that can incorporate multiple levels, HD will be tackled more effectively.

Using examples from programs he leads, Dr. Egede discussed how to push the boundary and start analyzing the upstream factors by extending to neighborhoods and using hierarchical models. One example is a study his group conducted in Milwaukee, WI, aimed at addressing how multidimensional adversity and social risks cause chronic stress, which subsequently lead to poor health and disability. Dr. Egede further shared several tailored interventions his group is conducting to reduce disparities in clinical outcomes for diabetes. Their guiding principles include the World Health Organization and National Institute on Minority Health and Health Disparities models as an organizing framework, consideration of the multidimensional adversities due to poverty and chronic stress, engagement and incorporation of lived experience of stakeholders, the building of focus groups, and focus on evidence that will change national policy. Dr. Egede commented that in their programs, SNs were used as a covariant; however, how to capture the SN measures is a common question, and he is excited to learn from discussion in this workshop.

To really push the envelope and the size of studies, Dr. Egede noted that the community needs sustained support to build infrastructure in reducing HD that goes beyond focused testing of specific hypotheses, pathways, and models, and he recommended that federal funding agencies consider this need.

The keynote from Dr. Elbert Huang of The University of Chicago, titled "A Brief History of Social Network Interventions and the Scientific Road Ahead," built on Dr. Egede's presentation. Dr. Huang first briefly reviewed studies of SNA and social network interventions (SNIs) in human behavior and health. He pointed out that the general interest in this field has dramatically increased over the past several decades because of a variety of factors, including increases in available data, computational power, and statistical applications. Presently, such research concentrates more heavily in such clinical areas as infectious diseases and substance abuse, with a smaller body of research in chronic diseases like diabetes [4]. It is now well established that SNs "matter"—they are causally related to disease and

mortality risks. More specifically, it is known that people with fewer friends have a higher risk for developing diabetes, and SNs play a role in risk for diabetes and complications, as well as in diabetes management [5].

If SN matters, the natural big question is whether and how to design SNI that target one's SNs instead of individuals and that benefit the individual by modifying and changing one's SN. Dr. Huang noted that several conceptual and theoretical works in social influence, social learning, and SNI shed light on and are increasingly serving as a basis for designing SNI. Dr. Huang highlighted the work by Dr. Tom Valente from the University of Southern California, another panelist during this workshop. Dr. Valente previously developed a taxonomy of SNI that includes four categories: (1) individuals (i.e., engaging individuals based on their network properties, (2) segmentation (i.e., engaging certain groups), (3) induction (i.e., encouraging or enhancing peer–peer interactions), and (4) alteration (i.e., changing the network by adding or deleting members) [6]. Dr. Huang then described several studies that he led or participated in that used the induction and segmentation mechanisms.

On the topic of diabetes, Dr. Huang reviewed the SNI trials. He pointed out that although a 2017 systematic review found 19 randomized clinical trials [7], the number of trials in diabetes that conducted and are conducting SNI is much higher, but the trials are not always labeled as SNI. He summarized that these trials are mostly designed to influence the behavior of an individual patient by engaging with and/or altering a patient's existing network, such as adding peer support, a community health worker, or a group visit model of diabetes care. They generally found that SNIs improve social support, which, in turn, is associated with improved A1C levels. He noted that because most often the trials were not explicitly designed using SNA concepts, it is not always clear what elements of the SNI taxonomy are being deployed, and it is not always possible to discern the unique contributions of the SNs.

Moving forward, to address DHD, Dr. Huang argued that results from existing efforts suggested that SNI can be a promising tool to manage diabetes and reduce DHD. Many opportunities to intentionally study specific SNIs in diabetes prevention/care exist—for instance, comparative effectiveness trials of SNIs to assess which SNI mechanism is optimal under what circumstances, as well as studies of independent network effects of interventions. He commented on the need to think beyond the egocentric patient networks that typically have been the focus of trials so far. In particular, he recommended also examining the provider and organizational networks, as their behaviors are critical to delivery of diabetes prevention and care. Studies have shown that they are a critical factor of structural inequalities and HD. Presently, a proportionally lower percent of doctors are serving African American patients, and their numbers and locations are heavily influenced by structural racism and historic public policy, which perhaps can be studied and addressed using the network segmentation approach. Providers and health care organizations work in networks that frequently need to collaborate, but they also compete with each other [8], and they can be studied and better understood using SNA. As an example, Dr. Huang shared an infused agent-based modeling (ABM) study he recently conducted with collaborators [9] that modeled, analyzed, and predicted the dissemination behaviors of a T2D guideline that recommends individualizing glycemic (A1C) goals. Dr. Huang proposed that ABM is a promising approach to harness SNs in interventions and reduce DHD for larger populations. Outcomes from such studies may inform policymaking to address the structural inequalities that Dr. Egede discussed.

The keynote talks inspired many questions from the audience and in-depth discussions. Regarding structural racism's being upstream of SODH, as well as if and how SNs can be incorporated in interventions to reduce it, Dr. Egede expressed hope and optimism and also cautioned the audience to be patient and persistent, making efforts to promote awareness using evidence, as many still do not see the connection. Regarding SNI, it was generally agreed that very often, structural and financial

interventions do not pay attention to the SN component, and sometimes conflicting processes may be inflicted as a result; therefore, SNI opens new opportunities. The attendees also generally agreed that many questions remain to be resolved in leveraging SNI, such as metrics to assess SNs; how to capture not only the quantity of one's social links but also the quality and nature of the links; how to translate results from complex studies to simplicity in delivery to patient care; and the challenge in balancing efficacy and scalability, given that social interventions are expensive.

Discussions also touched on the current limitations in SN studies and potential gaps in applying it to DHD. Dr. Huang pointed out that many open questions still remain, such as how much of the SN is geographic versus physical versus behavioral. Dr. Egede warned that an implicit bias applying conventional SNI designs to minority communities may exist, as minority communities may have not been adequately tested. He noted that from his own experiences, assumptions behind existing models often do not hold for minority communities or for all environments, and he challenged the SN field to apply existing concepts and frameworks across cultural and ethnic groups and to appreciate and characterize how SNs may work very differently. Regarding the application of SNI to reduce DHD, several attendees, including Drs. Egede and Fisher, commented on the need to move beyond linear or single-level analysis, as all the contextual factors are connected and could reinforce one another, and more structures and models additional to SNs should be explored, including that of social support.

# Special Session: Lived Experiences of Stakeholders

When it comes to the social component of HD, the research community has much to learn from the lived experiences of stakeholders. This workshop was fortunate to have four stakeholders attend and lead a panel discussion, moderated by Dr. Marissa Lightbourne from the NIDDK, who herself once had gestational diabetes. These four panelists were Ms. Elena Ennis from California, Rev. Dr. Patrick Gee Sr. from Virginia, Ms. LaQuita Smith from Alabama, and Dr. Nicole Wiesen from Georgia.

Dr. Wiesen was diagnosed with diabetes on her 29th birthday. When coming back home from work, her mom noticed that she did not look right and insisted that she see a doctor right away. She did, and after the doctor checked her blood glucose, she was immediately admitted to a hospital. Her journey of life living with diabetes had been a relatively smooth one, aside from a period of 17 months when she had to deal with additional challenges in life and lack of care; she had experienced no complications, including during a pregnancy.

Dr. Gee, on the other hand, has faced significantly more challenges and adversities since being diagnosed with diabetes in 2003. He was also diagnosed in a hospital, when he was taken to the emergency room, and it was the first time he had learned about glucose. An endocrinologist informed him of stage 3B kidney disease (30% function). He then gradually lost kidney function completely to diabetes. After 4 years of being on dialysis, he had a kidney transplantation in 2017, followed by 33 days in the hospital riddled with operations and surgeries. Looking back, when he was first diagnosed with diabetes, nowhere in his diabetes education package did it inform him that kidney failure is the leading complication, with hypertension second. His personal experience revealed the painful fact that disadvantaged communities do not receive equal information, and this inspired him to establish iAdvocate, Inc., a nonprofit organization. The mission of this organization is to help the underserved, undervalued, and disenfranchised communities of color (1) stay up to date with technologies, treatments, and drugs; (2) learn how to best manage their chronic kidney disease and the morbid conditions that contribute to this disease, such as diabetes; and (3) ensure that they have a voice in their quality of life and equitable health care access.

Ms. Smith's experience is equally tumultuous. She has been living with diabetes for more than 25 years and with prediabetes for a few years before her diabetes diagnosis. The journey had been hard—she had been put on so many different medications that they were difficult to keep track of, and she gave birth to a large baby in 1985. One major challenge she experienced is the lack of communication and information from her care providers. When she was first diagnosed, she was given a brief description of diabetes and a printout of a recommended diet that was difficult to follow rigorously. She encountered many problems, including frequent diarrhea, when her doctor put her on metformin combined with a strict diet. She tried to communicate with the doctor many times but did not receive much help. It took her more than 10 years to finally find a doctor who would listen and share more information with her. Ms. Smith also shared the SN side of her story. She learned about her family history of diabetes only after being diagnosed, including that both parents and a grandparent had been diabetic. The social norms in families and the workplace could impose hurdles in following dietary restriction, given the dietary traditions in a family that is not friendly to diabetes and the lack of appreciation from coworkers of the dietary challenges faced by people living with diabetes.

Ms. Ennis was diagnosed with type 1 diabetes (T1D), a rarer form of diabetes that is more common in children, at the age of 40. Before that, she did not know T1D could happen in adults. Initially, she faced hard times, including the constant need for blood tests and the anxiety in managing blood glucose. Luckily, she had fellow church members who were also living with T1D and who helped her connect with

the T1D community. The rich information and support from social networking helped her through this strenuous, life-changing period. She now wears a continuous glucose monitoring device and has participated in 10–15 clinical trials.

Overall, the panel shared conflicting experiences with their SNs of friends, families, and coworkers, showing the complex role that SNs play in diabetes. While some experienced support that ranged from a willingness to listen and share information, connections, and tips to manage diabetes, others experienced others hiding diagnoses from each other, inflicting shame and embarrassment, and not understanding and ignoring the needs of people living with diabetes. The audience had many questions for the panel, which were generally focused on the role of the SN of friends and loved ones in diabetes management, if such SNs changed over time, and how to develop a supportive SN. The panel shared numerous valuable insights and suggestions regarding how to develop and engage supportive SNs. It was pointed out by Dr. Gee that the key to building relationships (as in SN) is to "relate" to each other, yet many hurdles stand in the way: race, gender, and sexual orientation, among others. Doctors prescribing a healthy diet to patients living in food deserts is not helpful. The panel suggested that empathy, sympathy, understanding, and patience are needed from care providers; shame is frequent and the biggest issue people experience upon being diagnosed; legislation must understand social and psychological needs to combat diabetes; and upon diagnosis, counseling needs to be part of the prescription, and perhaps an SN questionnaire and related information should be provided. The panel and the audience generally agreed that diabetes care requires a multidisciplinary team that ideally should include social workers and someone who can relate to patients.

## Session 1. Social Network Analysis Concepts and Methods

This session featured two lead scientists from the SNA field, Dr. Kayla de la Haye from the University of Southern California and Dr. Brea Perry from Indiana University, who shared basic SNA concepts and theories, as well as methods with examples, to set the stage for discussions. For more details on SNA concepts, theory, and terms, see Appendix A.

Dr. de la Haye's talk was titled "Social Network Analysis and Its Application to Health Disparities: A Brief but Useful Introduction." She first provided a brief overview of the field of SNA and how it may help in studies of behavior, health, and HD. She explained that SNs in SNA are social structures made of social actors and the relationships among these actors. SNs measure multiplicity of relationships that can occur at multiple levels, and SNs can be made up of diverse types of relationships and social actors, such as kinship among community members, friendships among students, advice-seeking among colleagues, retweets among Twitter users, collaboration between organizations, and partnership among countries, to name a few. SNs affect health behaviors and outcomes [10–13] and how health practice and policy happen and are implemented [14–16]. It is fair to say that social networks are a major determinant of health [3] and play a large role in structuring and affecting HD across many domains. However, how they interact with other SDOH is still not fully understood.

SNA is an analytic approach based on mathematical graph theory, used to study and understand social structures and patterns within the structures and how they affect behavior. SNA classifies SNs into two categories: (1) personal (egocentric) SNs that measure social ties surrounding specific individuals and (2) complete (sociocentric) SNs that measure social ties among *all* people in a bounded group (e.g., school, organization, community). The SNA field has studied a number of mechanisms through which SNs affect health, such as social contagion, social influence (e.g., through group norms, homophily), social support, social capital, and social undermining or aggression. Some emergent SN phenomena may not be intuitive, one example being the strong tie versus weak tie effect reported in a landmark paper by Granovetter [17]. Close-knit, dense, small, reciprocal networks are good for general health, but these can be homogenous and enforce strong norms, while large, more diffuse, heterogeneous networks with many weak ties may offer more diverse information and resources and can be helpful during a transition or crisis.

To leverage SNA in studies of health behaviors and in DHD, Dr. de la Haye argued that fostering transdisciplinary science where SNs are measured and better understood would be more productive and would open up more opportunities than leaving it entirely to SN scientists.

Through several decades of work, the SNA field not only developed taxonomy and theories, including those from Dr. Valente's network [6], which helped improve understanding of how social relationships affect behavior and health outcomes, but also helped design health interventions that use SN structures and processes. Dr. de la Haye described several examples of such interventions, including those from her own group on healthy diet behavior interventions [18–20]. These studies covered a range of different SNs, used a variety of SN approaches that included segmentation and alteration, and generally showed that SNs have independent contribution to intervention outcomes after controlling for confounding factors (e.g., socioeconomic status condition). Dr. de la Haye also shared several observations from these studies. Health behavior is difficult to sustain, and intervening in the social and environmental spaces so that they help to support and sustain the changes in the long term is rarely thought about. Exposure to social and environmental barriers is unequally distributed in societies; people are set up to fail in many interventions in ways that exacerbate disparities.

Dr. de la Haye ended her talk with a personal perspective of the opportunities lying ahead in leveraging SN and SNA for DHD. In observational research, much can be drawn from the literature, including the networks, structures, and mechanisms that are most important to study. Examination of SN and health dynamics can help shed light on emergent micro–macro phenomena critical to perpetuating disparities and expand understanding of SDOH. For intervention research, adding network intervention components to existing programs may be productive, and it also would be of interest to measure SN mechanisms of change and to understand if and how network mechanisms affect outcomes and for whom.

Dr. Perry's talk, titled "Personal Social Networks: What, Why, and How?" focused more on egocentric networks that describe individuals' connections to their own personal networks from the perspective of the embedded ego. Aside from the points already made by the previous speakers regarding the direct role of SN in behavior and health and its being a strong potential mechanism underlying HD and DHD, Dr. Perry pointed out that SNs also act through affecting many psychological and physiological processes [21], and means to activate social ties for desired outcomes can be designed that target such pathways. Dr. Perry noted the existing disparities in these mechanisms and how they act—for example, racial differences in chronic social stress [22]; people living in urban areas have more social bridging, while people in rural areas have less, which negatively affects their access to novel information and technologies. SNA can help identify modifiable mechanisms underlying DHD and provide insights on interaction. Regarding social intervention in diabetes care and management, and in reducing DHD, Dr. Perry proposed a number of mechanisms that can be leveraged that mainly include social bridging, social bonding, social stress, and social influence, as summarized Figure 2. The SN perspective will enable the ability to relate the observed disparities to downstream health outcomes and identify modifiable mechanisms and points of intervention.

As an expert in SNA, Dr. Perry also briefly explained how SN data are collected and how SNA is typically conducted and made several recommendations to anyone new to the field. More specifically, the egocentric network approach has several appealing features for clinical studies, which include flexibility in data collection, abundant sampling frames, and data collection strategies available; it can be easily incorporated into large-scale or nationally representative surveys, and it is ideal for studying individuals and their behavior in multiple contexts. Network measures, once obtained, can be plugged into existing statistical models and analytical frameworks, such as regression models and structural equation models. A specialized mode is not required, and learning new statistical models or new software is not needed.
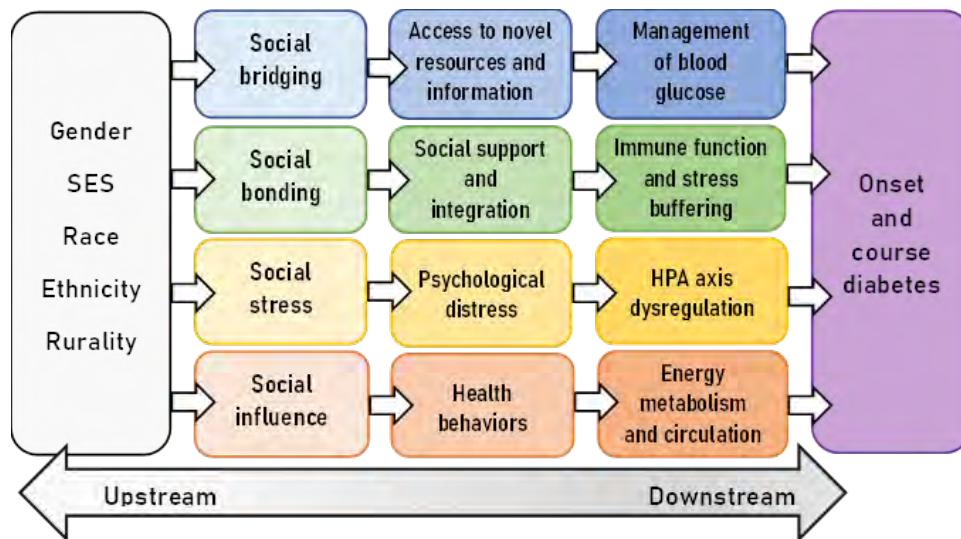
Figure 2. Pathways of how social determinants of health can affect the course of diabetes through social networks and social functions.

Discussion during the question-and-answer period covered both application and methodology development questions. Dr. Guadalupe X. Ayala asked if research had been conducted on differences in rural and minority communities regarding network multiplicity, transitivity, or complexity. Both speakers shared some data and knowledge that have come to light recently. These include differences in access to social capital and social resources in SN compositions, such as family size, and that SNs are more kinship centered and more homogeneous for immigrants from South and Central America. Both also acknowledged that much work still needs to be done—for example, little is known about how socioeconomic status (SES), race/ethnicity, and refugee status shape one's SNs. It is generally agreed that network is not the only factor that matters in intervention, but it is an ingredient that is often missing. Intervening in the social and environmental spaces so that they help to support and sustain the changes in the long term is rarely thought about. SNA approaches may lead to better measurements of social connectedness, facilitate mechanistic studies and hypothesis testing, and provide insights into points of intervention.

Both speakers also led discussions on gaps and challenges. Currently, many network studies sample some particular populations, but studies of larger networks and studies that follow networks over time are needed; however, doing so is resource intensive. One possibility is to leverage a larger existing population panel, such as The National Social Life, Health and Aging Project, and add the network questions and measures, such as a battery of questionnaire items. From such data, latent networks can be inferred, and Dr. de la Haye noted that this is already an emerging topic. Another challenge is a lack of standardization of network measures and procedures for SN studies, which makes it hard to compare across studies and findings and limits researchers to studying the mechanism. As a result, network studies often stop at the level of "SN matters."

## Session 2A. Social Interventions: Communities and Organizations

In this session, three speakers from The University of North Carolina at Chapel Hill presented examples of community- and organization-based social interventions in several chronic conditions. Dr. Fisher's talk, titled "Community-Based Peer Support in Diabetes Prevention and Management," showcased two intervention programs conducted in Asia. Kerala Diabetes Prevention Program is an international collaboration with many partners, supported by Australia National Health and Medical Research Council, NIH, and World Diabetes Foundation. The Shanghai Integration Model of Diabetes Management is a program developed and implemented in the past 30 years, led by Professor Weiping Jia, a lead diabetes researcher from China. Results from these studies showed that peer support can lead to reduced T2D risk, reduced 10-year cardiovascular disease (CVD) risk, a reduction in baseline HbA1c levels, and, in diabetes, a reduction in distress among people living with T2D. Dr. Fisher emphasized that both projects developed peer support interventions in the context of community organization and support and drew from community resources and perspectives. The results provoke further thinking about Western Individualistic Models of Behavior Change versus the Collective Care Model. The former emphasizes the individual's role as an active decision maker, risk perception, intention to change, outcome expectations, self-efficacy, individual goals and action plans, and self-regulation. The latter emphasizes collective problem solving and collective ways to pursue healthier lifestyles and support one another by leveraging the support and help of a peer group, families, and the community at large. While interest in peer-support studies has been increasing steadily since 2005, as evidenced by the PubMed articles, Dr. Fisher pointed out that more thinking and new methods would help and proposed an ecological model of social influence in health behavior where SNs and SNA are added as a distinct layer to emphasize their distinct roles, methods, and insights (Figure 3).
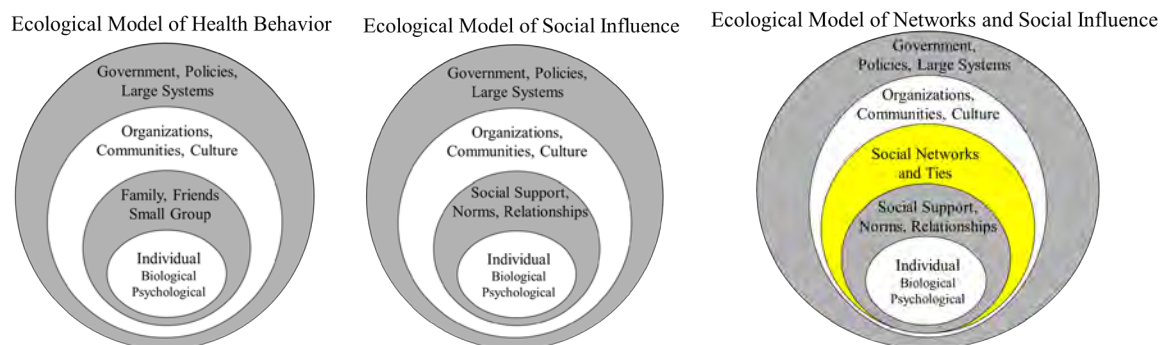


Figure 3. Dr. Edwin Fisher's ecological model of social networks, social influence, and health behavior.

In her talk titled "Health Disparities and Social Influence in the Workplace: Key Take-Aways from Workplace Interventions and Future Directions," Dr. Laura Linnan presented three worksite study examples that focused on addressing social influences around chronic-disease-related outcomes to show that workplaces are important settings for addressing chronic-disease disparities. Moving forward, changes in work, the workforce, and workplaces are happening and will drive new considerations for addressing chronic-disease disparities. Such changes have been accelerated by the COVID-19 pandemic and will be further shaped by technologies, such as robotics, digital health, artificial intelligence, and others. Dr. Linnan also noted that the research community needs support for planning, engagement, and partnership development and for pragmatic, optimized trials and mixed-method approaches to

identify the most effective interventions for low-wage and BIPOC (Black, Indigenous, and people of color) workers.

Dr. Sam Cykert gave a thought-provoking talk on "Community Partnering with Health Care: An Equity Success Story." He started by showing how the disparities in care and treatment of such chronic conditions as cancer, diabetes, and CVD persisted during the past several decades despite great scientific advances, including in precision medicine. He pointed out that race remains a causal factor for HD even after all other confounding factors, such as SES, have been adjusted for. Using the analogy of fish versus lake, he argued that while many means to treat individual fish have been developed and are very good—such as promoting a healthy diet and physical activity—more efforts are needed to improve systems-level interventions, as these treat the lake and can improve the health of many fish. He proposed three designing principles for system-level interventions—(1) transparency (in real time that can affect treatment), (2) accountability, and (3) enhanced communication—using several examples of systems-level interventions for early-stage lung cancer and breast cancer, CVD, and diabetes to demonstrate how the three principles can be implemented and how they worked. These examples showed that to remedy systematic, institutional-level racism, working with affected communities to determine appropriate outcome measures, measuring outcomes according to the target community (race or other disadvantaged populations), and being ready to iteratively measure and assess results are essential. Last, Dr. Cykert proposed a "three-legged stool" model for achieving true health equity that considers the medical system, SDOH, and physiology of racism. He pointed out that the medical system has become fairly sophisticated; together with the abundant data, pushing it for fair care is possible. The SDOH leg is trickier. However, if key factors in SDOH can be identified, it is feasible to tackle them in real time. The last leg, the physiology of racism, such as in cortisol dysfunction or epigenetic changes related to racism and injustice, has until now been frequently overlooked.

During the question-and-answer session, Dr. Valente of the University of Southern California noted that while all talks recognized the importance of opinion leaders (or champions) in community-based intervention programs, the leaders were not selected via SNA. He then further asked the speakers how such leaders were decided upon and reached. All speakers agreed that no formal network measures were collected or assessed. Instead, the leaders were chosen via a variety of different approaches, ranging from volunteers who are the most willing to serve, to candidates who emerged from participant surveys, to those who were clearly community leaders prior to intervention. Dr. Linnan commented that in the trials she presented, a post-intervention survey was conducted, which provided measures of the opinion leaders.

Dr. Cefalu from the NIDDK asked the speakers to comment on whether they see the COVID-19 pandemic and the coming of technologies, such as telemedicine, complicating intervention programs or increasing the disparities that already exist in clinical care. All three speakers generally agreed that technology like telemedicine will complement—not totally replace—low-tech, in-person interactions and peer support. They pointed out that, in fact, the two have already been used in complementary ways in trials and intervention programs. Dr. Cykert commented that telemedicine is not as effective in rural areas or in minority populations and sees the need for tiered approaches that target three groups and participants: those who self-care well, those who respond well to technologies, and those who do not respond well and need "real" person-to-person contact.

## Session 2B. Social Interventions: Channels and Culture

Part B of session 2 included two talks given by three speakers. The first talk was given by Dr. Ayala from San Diego State University and titled "Sources of Peer Support and Influence among Mexican-origin Families in the U.S: Implications for Diabetes Prevention and Control." Studies conducted by her team mainly focus on communities in San Diego County and Imperial County, California. Compared to the national average, the population has a high percentage of Latino Hispanics, predominantly of Mexican origin, is more likely to be non-English speaking and with a lower literacy level, and is more likely to live in poverty. Most of the intervention programs in her studies have a social component. During this workshop, the multilevel socioeconomical model that includes individual, interpersonal, organization, community, and policy levels was frequently cited by speakers. Within this model framework, Dr. Ayala noted that whereas many intervention programs often tend to focus on the interpersonal level, her team's approaches considered social actors and many social processes across all levels. She then went into more depth with three example social processes—families (Familismo), communities, and acculturation—to demonstrate how her team considered and intervened in social processes to promote the adoption of healthy lifestyles and disease control.

Familismo is a phenomenon specific to Mexican-origin families and is theorized as a core cultural value that requires the individual to submit to collectivistic, family-based decision-making, as well as responsibility for, and obligation to, ensuring the well-being of family members. It creates a socially constructed norm with implications for family obligations, family support, and family as a referent. When social processes act through communities, social constructs help to organize and interpret the world by focusing attention on subjective elements of the environment, such as values, norms, beliefs, and assumptions. These result in cultural syndromes, such as individualism and collectivism. Dr. Ayala noted that individualist countries show a stronger tendency to harbor "anti-fat" prejudice when they hold individuals accountable for their weight, while collectivist countries are less likely to link negative cultural values (being obese is bad) to the person (being an obese person is bad). Acculturation is a complex process in which individuals retain parts of their original culture while also adopting beliefs, values, and behaviors from the new culture they are continuously exposed to. A recent study by LeCroy et al. showed that a difference in English language use between parents and youth was identified as a risk factor for elevated body mass index (BMI) percentile among youth [23]. Their result indicates that the lack of concordance between children and parents on their English language use had the most influence on childhood obesity risk.

Dr. Ayala commented that the findings have profound implications for interventions; they offered insights to strategy designs leveraging community health workers/promotoras(es) to influence individuals, families, and communities and designs involving other sources of social influence, such as social and physical structures to support healthy eating at schools and in stores and restaurants. As for future directions, Dr. Ayala pointed out that using innovative methods to study social processes is a gap; some examples of innovation could include ecological momentary assessment and resident-driven data collection, including Photovoice, and image-based video recording and eye-tracking technologies for interventions.

The second talk focused on churches as channels for social interventions and was titled "Fostering Health Equity through Community and Peer Support in African American Churches." It was jointly presented by Drs. Gretchen A. Piatt and Cherie Conley from the University of Michigan. Dr. Piatt shared with the attendees a study titled "Sustainability through Diabetes Self-Management Support in African American Churches: The Praise Diabetes Project." It was a 33-month hybrid type II cluster randomized controlled trial (2016–2021) with 371 patient participants enrolled from 21 churches, randomly assigned

to three arms: Parish Nurse Support, Peer Leader Support, and Parish Nurse + Peer Leader Support. The premise of the study was that while much is understood about how to provide effective, initial diabetes self-management and education (DSME), less is known about who, where, when, and how to provide effective, sustained DSME. A critical need exists to develop and evaluate DSME models that are ongoing, patient-driven, and embedded in existing community infrastructures. The outcome measures included changes and sustainment of changes in HbA1c levels and diabetes stress. At the end of the study, statistically significant decreases in A1C levels and diabetes distress were observed in all arms, and the changes were sustained for the majority of the participants. The study did face several challenges, most notably parish nurse, peer leader, and participant burnout.

Dr. Conley then presented a study titled "Faithful Friends and Families Dyadic Peer Support Project," which explored the feasibility of using dyad support to augment an existing health promotion program for African American church members. The 18-week program consisted of education, matching dyad peers, and training. Eighty participants were recruited and enrolled from three churches in three different North Carolina counties; 65 participants completed the program. At the end of the study, the feasibility was validated, with five themes emerging that are informative for future studies: collaborative goal setting, multiple communication methods, experiencing challenges, hesitancy to overstep boundaries, and encouragement and presence.

During the discussion, Dr. Nadia Islam asked Dr. Ayala about the "borrowed power from communities" concept and if her studies included a way to measure and assess the "borrowed power." Dr. Ayala commented that the construct of borrowed power came during formative research, and she acknowledged that although it should have been measured or assessed, it was not. Other questions were addressed to Drs. Piatt and Conley and included the efficacy of the studies, the sustainability of changes post-study, and the composition of the participants (e.g., gender, age, SES), including if the variations in composition affected the outcome. To these questions the speakers commented that while the changes were sustained during the program, it has been challenging for many churches to sustain the program on their own after the program ended. Demographic variance in participants was low, with most participants of low SES. It was more challenging for rural churches with few financial resources to run these programs.

## End of Day 1 Discussion: Key Issues Raised during the Day

The workshop was designed to promote open interactions and discussions and to provide ample opportunities for all voices to be heard. Day 1 of the workshop ended with an open session for attendees to reflect and debate key issues raised during the day.

To open and facilitate discussions, workshop co-chair Dr. Hood of RTI International provided a personal summary and takeaways. She noted that throughout the talks and discussions during the day, several themes emerged. Regarding HD, including DHD, factors upstream to the SDOH—such as structural racism and the persistent chronic stress that results for people developing or living with diabetes—need more attention. Talks of socioecological model examples clearly implied that multilevel approaches are needed to address DHD. SN is an important component of health; SN measures can and should be included more intentionally in diabetes intervention studies. Not collecting SN data and not conducting network-level interventions or not being intentional about how an individual's SNs are incorporated and engaged when conducting interventions are missed opportunities. Numerous insights were shared by the stakeholder panel. They highlighted the importance of listening to patients and community members when thinking about and designing work, as well as the importance of collaborating with them to ensure the strategies and solutions are culturally and contextually relevant. Interventions and solutions cannot be one-size-fits-all. Another insight from the panel was that patients' emotional and mental health needs are just as important as their physical needs; ideally, the care team needs to be a multidisciplinary one that can provide multifaceted support. Opportunities exist both in leveraging individual and interpersonal networks, as well as in leveraging organizational networks, to promote sustainability. Dr. Hood noted that, as Dr. Egede pointed out during his keynote, gaps in infrastructure and resources need to be filled to capitalize organization-level networks toward promoting long-term sustainability of interventions post-delivery.

During open discussion, the first topic raised was diabetes prevention and if network approaches would be effective. Several speakers (Drs. de la Haye and Fisher) and attendees (Drs. Andrea Cherrington, Tammy Hannon, and others) commented that they have done prevention programs with a social component. Dr. Hannon noted that in pediatric diabetes prevention programs, SN work was frequently conducted without its being called that. For example, in order to engage kids to stay in programs, personal SNs need to be created for them (more often than in adult programs). She further posed a provocative question of whether outcomes have to do with this aspect versus all the other interventions that were being done. Dr. Cherrington pointed out that linking intervention participants to peers is a balancing act that depends on the outcome goal. While some types of goals can be addressed effectively by remote peer support or support mediated through telemedicine, others require peers to deeply appreciate the unique personal needs, challenges, and resources available in the particular community.

The attendees also discussed the technical issues in community-based programs, such as what the key features and considerations are in selecting and matching peers for support—for example, being in the same community, having shared interests, and being able to relate. Should participating stakeholders decide the desirable feature of their peers? Dr. Miranda Broadney from the NIDDK proposed that a national database of peers may need to be established to allow stakeholders to identify their supporting peers. Dr. Liz Tung from The University of Chicago, one of the workshop co-chairs, pointed out that SNA offers new insights that could be valuable in guiding the designs of peer selection. For example, the concept of segmentation could be useful in peer selection. While advantages exist to having peers from within one's segments (proximity, etc.), selecting peers from outside has the distinct advantage of social bridging and access to heterogeneous information, knowledge, and resources, and SNA may allow the "sweet spot" to be found. Dr. Fisher followed up by noting that in peer-support studies, the practice has

been very doctrinaire. For example, in cancer care, matches were made based on such characteristics as stage of disease and type of treatment. Lessons learned indicated that when matching participants to peers, it is important to not make preconceptions about what will be important for the participants. The conventional approaches need to be thought through, including what social aspects may be important. In that sense, this is a fascinating and clear example of how the concept of SN and SNA can open up opportunities, and a whole new dimension of people's social status in peer selection, to improve existing practice.

One attendee made an observation that much discussion has been around community engagement and peer support, which are about activating the informal care network, and asked about changing the culture of formal care and promoting the relational aspects of clinical practice. What about patients' needs in finding the right doctors and care teams, as revealed by the stakeholder panel? What evidence would need to be collected to answer these questions? In response to these questions, several ideas were shared and discussed, including to structure health care systems to critically improve the diversity in medical schools and workforce development pipelines, such as by recruiting young talent that can bring lived experience to practice and training clinicians who can genuinely relate.

Currently, electronic health records (EHR) are often designed to capture the procedures being done, which is useful determining fees and charges. They do not capture the quality of care, however, nor how patients have benefited. Many opportunities exist for improving how health care systems are structured. In the meantime, the attendees also acknowledged that changing the health care system is not easy, and Dr. Ayala provided an example where her study sought to have peer leaders enter information into the EHR, potentially to inform the conversation with care providers. However, this was not allowed because the peer leaders were volunteers. To this, Dr. Cykert suggested possibly taking a stratified approach. First, messages of health behavior (physical activity, diet, no smoking) need to reach everyone; health care systems cannot be expected to pay for these, and consideration should be given to how to use SNs to make these messages the norm. Second, for low-risk patient groups where time is available to engage peers and communities, and where it is also difficult to push for the health care systems to pay, SN and SNA can continue to be leveraged to improve the efficacy in engaging peers and communities. Last, for high-risk patient groups, the families and care providers are usually all willing to intensify their effort, and peer support will be highly needed and can make a difference that is noticeable even in the short term. Perhaps SN and SNA could be leveraged to identify such groups efficiently and focus can be put on pushing the health care system to pay for peer support for these groups.

Dr. Fisher followed by pointing out that the health care system is predicated on the premise of having a few highly skilled professionals care for all, while peer support is about lay persons helping one another. Allowing peers into the formal health care system will be disruptive for the latter. He further encouraged all to think transcendingly; one's validity as a person comes from the many social roles that they play. These social roles also help people deal with stressors. Diversity in SNs is fertile ground to think about how to help individuals deal with stress from structural racism and their health.

# Day 2 Session Summaries

## Session 3. New Approaches and Insights Leveraging SNA

Session 3 offered four talks that covered a diverse range of approaches that apply SN and SNA in different settings at different scales in care and management of chronic conditions. The wide range of topics was designed to spark discussions and imagination.

The first talk was by Dr. Amar Dhand of Harvard University and Brigham and Women's Hospital, titled "Harnessing Social Networks in a Clinical Setting." Dr. Dhand's research focuses on the effects and mechanisms of SNs on behavior, health, and well-being in neurology patients and on the translation of such knowledge into social therapeutics in the form of clinical trials. Dr. Dhand first commented that human beings are political and social animals, and yet clinical care tends to focus on individuals and, furthermore, only on the biology and etiology inside individuals' bodies. The whole body is typically ignored, as is how individuals connect to others (i.e., their SNs). The work he presented was inspired by his long-time observation that SNs regulate access to care. Apart from choking, stroke is the most time-sensitive human disease. Every minute of delay in care causes 1.09 million neurons to die and 4.2 days of disability. However, despite this reality, patients on average delay 2 hours before calling 911 during stroke.

Using the egocentric SN approach, he examined the relationship between patients' SN characteristics and risk of delayed hospital arrival after acute stroke. The study, conducted in Boston and St. Louis, found that small and close-knit personal SNs of highly familiar contacts (i.e., high-constraint bonding networks) were related to delay in hospital arrival, independent of demographic, clinical, and socioeconomic factors. More in-depth examination revealed that the slower arrivers are less likely to discuss symptoms with family members, and even when they do, they may selectively disclose or over-negotiate symptoms when disclosing. The close-knit personal networks of family members often socially confirm and, as a group, reinforce the idea of a "watch and wait" plan, almost serving as echo chambers. In contrast, fast arrivers tend to be in low-constraint bridging SNs with more heterogeneous social relationships, including weak links, where more information is being shared, alters are more ready to disrupt norms, take action, and make such comments as "Something is wrong with you; you need to go to the doctor." In conclusion, the closed network structure led to constricted information flow in which patients and close confidants, absent outside perspectives, elected to watch and wait. Dr. Dhand commented that the finding confirms the existing theories of social bonding, social bridging, and the importance of weak social ties.

Throughout the talk, Dr. Dhand shared six insights he obtained in the process of conducting this work: (1) Listen to patients. (2) SN theory and method are important together. (3) Make the significance concrete. (4) Do qualitative research to understand mechanisms. (5) SNs regulate access to care and hence are critical for HD. (6) The relationship between SNs and social interactions needs consideration. Dr. Dhand ended the presentation by posing two overarching questions to the audience: (1) Can social behavior that complements information embedded in participants' surveys be measured objectively? and (2) Can network-informed interventions be built? He also shared the efforts his group is making toward answering these questions, including development of wearables and artificial intelligence/machine learning–powered apps. Much of the work he presented was published recently in "Stroke Delay: Social Networks and Risk of Delayed Hospital Arrival after Acute Stroke" [24].

The next talk was from Dr. Erika Moen of Dartmouth University, titled "Insights into Disparities in Access to Health Care with Patient-Sharing Network Analysis." Dr. Moen first provided some background on

patient-sharing network analysis in health service research and recommended a scope review by DuGoff et al. [25]. Such analysis normally is conducted using administrative data, with a wide range of applications, such as studies of care coordination among providers and the diffusion of medical innovation.

She then presented work her team recently finished that opened a new direction of patient-sharing network analysis. It was motivated by the discrepancy between the need for people living with chronic conditions to have a team of care providers who coordinate with one another in providing care and the lack of appreciation of the relationships among the care providers in current access-to-care measures. For example, care for cancer patients requires coordinated efforts from an interdisciplinary, highly skilled team that includes at least a medical oncologist, radiation oncologist, surgeon, nurse navigator, pathologist, and other specialists. However, currently the measure of access to cancer care does not acknowledge the importance of the relationships among them in delivering care. This discrepancy provoked her team to rethink and reframe how the physician workforce should be measured. The goal of her work was to integrate interdisciplinary relationships of care teams into measures of access to care, develop measures to assess the robustness of the care provider network to a potential workforce shortage, and provide information of vulnerable regions in the network that can guide allocation of resources [26].

More specifically, Dr. Moen's team proposed a new measure to capture physician network vulnerability to specialist turnover, which was termed the physician's "Linchpin" score. For each physician, it measures ties to another physician with the same specialty. It is calculated by the number of ties that are with other physicians of other specialties to the total number of ties [26].

Applying the Linchpin score to cancer-patient sharing networks constructed using Medicare claims data, Dr. Moen's group showed that the Linchpin score offered independent information from existing, normally used network centrality measures and revealed specialty-dependency vulnerability of physician networks. More relevant to this workshop, disparities in physician network vulnerability were evident, with 15.4 percent of the physicians serving rural communities being linchpins versus 9.6 percent of those serving urban populations. They further translated this work to the hospital referral region (HRR) created by the Dartmouth Atlas of Health Care (an organization committed to studying health care markets in the United States) to capture health care delivery markets. Each physician in this nationwide network was assigned to one of the 306 HRRs. Using Poisson regression, the observed versus expected linchpins were obtained, and observed/expected oncologist ratios were compared. This allowed the identification of HRR level measures of the cancer workforce and regions with vulnerabilities.

For next steps, Dr. Moen plans to examine whether linchpin physicians and network vulnerability contribute to cancer HD. Their preliminary analysis indicated Medicare beneficiaries eligible for Medicaid may face significant higher physician network vulnerability than others. Last, she offered several takeaways that may be relevant for DHD research. First, a clear and compelling rationale for studying provider networks—a clear clinical motivation—is essential. Second, it is important to choose or develop an intuitive network measure that is easy for people not familiar with network science to appreciate. Last, many different types of data (e.g., EHR, administrative, survey) and different ways to construct physician networks exist.

Returning to the personal SNs of patients, Dr. Brittany L. Smalls from the University of Kentucky gave a talk titled "Using Social Networks to Address Diabetes Health Disparities in Rural Kentucky." Dr. Smalls' work focuses on T2D diabetes prevention and management in Appalachia in rural Kentucky. She started by sharing that the prevalence of T2D in Appalachia, at 23.4 percent (almost one in four), is significantly

higher than the national average of 10.4 percent or the Kentucky average of 13.7 percent. Additionally, T2D is often persistent and pervasive among social circles, and, therefore, understanding SNs and social support can be an important tool to better understand health behaviors that go along with having T2D and to develop interventions. Her approach was to find a balance between individual characteristics and social environmental factors and to see how the latter affect individual choice and decision-making in health behaviors.

She then presented several examples of her studies [27] aimed at understanding the role of cultural contexts and factors in diabetes self-management in rural Appalachia and why, unlike in other populations, social support shows little benefit. The results from these studies revealed that reported social support was not always positive; religiosity sentiments like "God will take care of me" reduced personal efforts. The major perceived barriers include forgetting appointments, inability to afford treatment/medication, and putting faith above medical care and above access to care. In short, these examples indicated that social support and religiosity mediate/moderate the relationship between psychosocial factors and self-care activities. Dr. Smalls then delved deeper into the unique characteristics of social roles and SNs in rural Appalachians. One feature noted is grandparent-headed households—sadly, a consequence of the opioid epidemic—which contributes to chronic stress in all family members. A significant association was evident between the number of individuals living in the home and cholesterol level and BMI [28]. In a separate study focusing on the grandchildren in such families, the type of social support and the importance of such support perceived by them affected their risk for T2D.

Last, Dr. Smalls presented an ongoing project of hers funded by the NIDDK (K01 DK116923) titled "Social Network Analysis and Social Support Intervention for Rural Dwelling Older Adults with T2DM." The project began with community surveys of sources and how people obtain trusted health information. Using the data, "trusted individuals" were identified and trained to be educators to disseminate information to reduce misinformation in the community. Using the egocentric SN approach, the project implemented quantitative value measures of the ego–alter relationship and the social support mediated through the relationship, such as the number of useful contacts, weekly frequency of contacts, frequency with which each alter provided ego with information on healthy lifestyle, and the value of the information in helping ego with healthy lifestyle. The study revealed several interesting findings. When it comes to obtaining health behavior information, people more often turn to friends over families or faith-based leaders, and they more often turn to other medical professionals over their own doctors. The SNs mapped out using data collected also revealed that the rural Appalachian communities comprise many small egocentric networks (mostly having a size of three) that are isolated from the vast majority in the community, which poses challenges for community-based interventions.

In summary, one key takeaway from Dr. Smalls' talk is that in rural environments, the SN is very important and very different, and what it means to have social support and what SNs look like are very different in rural Appalachia than other places. This again emphasizes the importance of appreciating cultural contextual factors when studying SNs. Dr. Smalls ended her talk with a comment regarding policy implications of SN and social support studies. In Kentucky, economically distressed counties are also the counties with the highest cardiometabolic rates. Potentially studying how funding flows are affecting health outcomes could offer needed information to guide policy designs to address such disparities.

The last talk of this session was given by Dr. Louise Hawkley from The University of Chicago, with the title, "Social Is Not Social Is Not Social." In this presentation, Dr. Hawkley elaborated on the specificity in

associations with health from the perspective of her decades of research on loneliness. She organized her talk into three parts: the social human, social influences, and social connection and health.

Dr. Hawkley started by laying out the basic concepts in the study of loneliness. Loneliness should not be equated to lack of social connection; it is only weakly associated with objective social isolation. Rather, it is the distress that accompanies a perception that one's actual social connections do not match one's desired social connections, whether it is in number, type, or quality [29, 30]. Social connectedness has three dimensions—intimate connectedness, relational connectedness (having someone to confide in), and collective connectedness (the sense of social belonging)—and unmatched desires in any one of them can cause loneliness. Loneliness is a human instinct acquired through evolution, and both seeking bonds with others and striking out alone helped ensure survival of the species. Chronic loneliness leads to adverse health consequences. Loneliness and chronic disease are reciprocal and can perpetuate through an individual's SNs, suggesting places to intervene.

Moving on to social influence, Dr. Hawkley commented that the distinction between loneliness spills out to many social variables discussed in this workshop, which leads to a range of various concepts of social influence, such as loneliness, social support, and social relationship quality, as well as measures like the UCLA loneliness scale, Social Network Index, social strain, and relationship stratification. Further adding complexity to the social influence framework, social connection is a multifactorial construct that includes three dimensions: structural (types of social relationships and roles, as well as the interconnections among them), functional (such as perceived support and loneliness), and qualitative dimensions (positive and negative aspects). In general, the functional dimensions of social relationships are more consistently related to health outcomes than structural social influences [31].

Delving more into the social influence on health and HD, Dr. Hawkley shared a recent report from the Foundation for Social Connection Scientific Advisory Council ([https://www.social-connection.org/scientific-advisory-council](https://www.social-connection.org/scientific-advisory-council)) titled "Systems of Cross-sector Integration and Action across the Lifespan (SOCIAL) Framework." The report laid out the landscape of how social connections can be studied within a socioecological framework and through different lenses (life span, diversity/equity, evidence/application). Dr. Hawkley then provided several examples of SN studies within the socioecological framework and offered several takeaways. First, one must measure and/or examine multiple dimensions of social connection in a single study (structure, function, quality) and contextualize studies and interventions in families, groups, communities, and neighborhoods. Social relationships and health are reciprocally related. Carefully designed interventions can address the causal question directly. Last, the life course should be taken into consideration. Social connection dimensions that have no relationship with a diabetes-related outcome in one stage of the life course may be highly related at another stage.

When the session opened for questions and answers, the first question was about data sources for patient-sharing networks and if such networks change over time. To that, Dr. Moen responded that several sources exist in addition to the Centers for Medicare & Medicaid Services, including institutional data and referral claims data, although gaps remain regarding how to extract network information from different data types. The patient-sharing networks had been relatively stable over time until the COVID-19 pandemic occurred and telemedicine was increasingly adopted, which rapidly and drastically changed the landscape. The possible reciprocal pathway between loneliness and illness was also discussed. Dr. Hawkley noted that while a reciprocal pathway is likely, as people who develop illness from loneliness may then further socially isolate—especially if loss of function occurs, such as loss of sensory functions. Studies so far suggest that loneliness's being the leader is the more robust pathway, with illnesses, such as depression, occurring as a result of loneliness.

One attendee commented that works from Drs. Dhand and Smalls showed counterintuitive effects of SNs, such as having a high number of family members delaying hospital arrival after stroke and affecting negatively on diabetes care. Both speakers acknowledged this. Dr. Dhand pointed out that while many SN phenomena may seem counterintuitive, they can be readily explained by theories in SNA, such as the "weak tie" theory [17]. Dr. Smalls added that SNs have been changing, and the patterns seen now are different from the last generation because of many factors, including culture and technology changes. Therefore, many conventions from the past that contributed to shaping our intuition are no longer relevant, and they must not be relied on to design interventions. Dr. Hawkley shared that, indeed, her own studies have found that the SNs of "Baby Boomers" are different from others; Baby Boomers are less kin oriented and have more friends of choice, and they are less lonely at the same age than the previous generation.

Questions were raised regarding the existence of general universal principles of SNs and whether the benefit of SNs depends on the type of disease or disease/health state. Dr. Dhand explained that an SN can carry many different functions with it, such as information dissemination or peer support. The type of SN that would be beneficial depends on the type of function that is beneficial for the desired outcome. Using his own study of stroke as an example, Dr. Dhand commented that prompt hospital arrival depends on heterogeneous information's being received and, therefore, benefits from having large, diffuse, heterogeneous SNs, while recovery post-stroke needs significant support; hence, large, close-knit SNs are beneficial. Therefore, indeed, types of beneficial SNs depend on the type of disease and the stage of disease.

This session ended with discussions about what the field needs to do. Suggestions included the need to promote awareness, especially among the public, insurance companies, and health organizations; the importance of SN in health; and the benefit of investing in it early on. Evidence suggests physiological and epigenetic impacts of SN; therefore, a better understanding of the underlying mechanism is needed.

## Breakout Group Discussions

Based on the discussions in Day 1 and a survey of the attendees, five breakout group discussion topics were chosen: (1) prevention, (2) intervention, (3) care teams, (4) methods/measures in intervention, and (5) upstream determinants of health. Each group was charged to answer how research in the assigned topic could help in understanding or reducing DHD. The key points reported back by each group are summarized below.

During the discussion, Groups 1 and 3, on prevention and care teams, respectively, decided to merge, and a report-back was provided by Dr. Kathryn Fantasia of Boston Medical Center. The combined group mostly focused on what prevention is and in what context prevention should be thought about. Several main gaps were identified. Currently, family systems are underutilized in prevention, and an increase in awareness of family history and understanding personal risks given that history is needed. The culture and messaging around diabetes prevention needs to be improved, especially the role of clinicians and providers in addressing prevention. Health care teams need to be best aligned to increase the likelihood that individuals will participate in T2D-preventive behaviors. Reciprocal connections between community services and health care teams can be leveraged in T2D prevention. How policy and payment systems may impede access to health care networks needs to be better understood. Regarding future directions, the team's consensus views included examination of the matrix from SN to disentangle the questions of how provider networks function and how clinicians and providers function within these networks and to link them to patient outcomes.

The report of Group 2, on intervention, was provided by Dr. Jean Lawrence of the NIDDK. She commented that the group shared many valuable ideas and discussions. In general, the group thought that SN and SNA should be a part of community assessment and part of the standardized process when developing interventions. The challenges include that collecting SN information and implementing SN approaches are time- and resource-demanding. One possible approach to getting started is building awareness of the importance of understanding where the community goes for information and where the community gathers, as well as building appreciation of the need to consider the social component as an integral part of the research and to include it in the overall timeline and milestones for studies. Community groups and organizations need to be better funded and sustained on an ongoing—not one-time—basis so that they can be an ongoing resource for the community and readily be part of the interventions. Consideration needs to be given to how community resources, such as community-based organizations (CBOs), can be leveraged to help people start trusting health care organizations when they develop or are at risk for a chronic disease, as well as to reduce HD. In the studies of family and peer support, a deeper understanding is needed of how to better engage support for people living with diabetes and how to identify the best source of support, especially for individuals and communities that are socially or geographically isolated.

Dr. McCranie chaired Group 4, on methods/measures in intervention, and provided a report of the discussions. First, the group identified a need for standardization, including the standardization of documentation of tools used in SN studies. More specifically, the survey tools, which are as important as the physical tools, currently do not receive adequate support for development, psychometric validation, improving findability, and sharing with the community. Second, procedural standardization is needed in SN studies, including standardization in designs, forms, and documentation to survey for social interactions—such the nature, number, frequency, and quality of interactions—and extraction of the SN from raw observational data. The community of SN studies needs to establish best-practice principles (such as transparency in data use) and ethics standards, which are critical in view of the technology

changes and the ability to collect a wide range of personal digital data. Last, improvements are needed in the standardization of reporting so that others can replicate analyses and reproduce findings.

Dr. Broadney of the NIDDK provided a report for Group 5, which focused on the upstream determinants of health. The group identified a list of upstream determinants that ultimately affect an individual's personal SNs and that can serve as points for intervention. The first is residence and neighborhood environment influenced by housing and loan policies, including the integration of residence, and neighborhood violence disruptions. Education is also an important and multifaceted factor. The primary education system is funded by a tax structure based on residence; education curricula shape one's social and emotional intelligence and one's approach to strengthening our social ties, which can bias our SNs, and college acceptance criteria affect the diversity of the secondary educational community. At the business level, missions and objectives of hiring institutions influence people's source of income and their integration into their community. The group noted that desegregation is a clear example of a policy's affecting SN; perhaps its SN outcomes should be studied more using SNA approaches, such as "segmentation" taxonomy. The group recommended public health policy and schools as places for intervention—by prioritizing and integrating the concept of building social ties and adding to the education curricula the practice and hiring policy for teaching healthy social/emotional intelligence and networking skills. To address any of these upstream determinants, the group noted that trans-sectoral needs are quintessential. More specifically, the group recommended that the NIH note that for studies of natural experiments and upstream determinants to health, the typical 5-year R01 mechanism is inadequate and too short.

The virtual attendees of this hybrid workshop formed a group of their own, and Dr. David Shoham from East Tennessee State University provided a report. Members in this group covered a diverse range of expertise, including epidemiology, exercise physiology, systems modeling, cutting-edge technologies (e.g., machine learning), mindfulness interventions, HIV, substance abuse disorders, and rural health. The group discussed broadly the needs in moving SN and DHD forward, mainly focusing on the need to better understand culture and cultural difference in SNs. The group thought that more research into the basics and more grounded theories and qualitative works are needed to improve our understanding of how and why SN are important for diabetes prevention and reducing DHD. Interventions need to be culturally tailored and include more underrepresented groups. More needs to be done to inform (and hence influence) policy that can help reduce SN segregation and improve social health. Trust in researchers and public health, which suffered some challenges during the COVID-19 pandemic, needs to be rebuilt. More data and additional types of data relevant to SN need to be actively collected. Possible starting points include supplementing existing studies to add additional data collection, such as egocentric network questionnaires; collection of administrative and physician data; and added or increased efforts to collect information on race, SES, and socioeconomic position. The group also recommended that funding agencies support multidisciplinary research and joined the call for a funding mechanism for such studies that provides longer and more resources than the typical R01-type of mechanism and improves the sustainability of such studies.

## Session 4. Setting the Agenda Forward—Panel Discussion

The discussion in this session was led by the following panelists, who were charged to each provide their takeaways of the workshop and recommendations for actions moving forward:

> R. Turner Goins, Ph.D., Western Carolina University
> Jeffrey Gonzalez, Ph.D., Albert Einstein College of Medicine
> Nadia Islam, Ph.D., New York University
> Monica Peek, M.D., M.P.H., The University of Chicago
> Lijun Song, Ph.D., Vanderbilt University
> Tom Valente, Ph.D., University of Southern California

Dr. Goins is a gerontologist with decades of experience studying health problems of the American Indian and Alaska Native (AIAN) people. She provided a summary of the current knowledge and the perceived gaps. AIAN people are twice as likely to have T2D and three times more likely to die from T2D complications; 60 percent of tribal members ages 65 years and older have T2D. Prior research findings indicated a strong social component. For example, studies of mental health and diabetes outcomes found that higher depressive symptomatology and psychological trauma were associated with higher A1C levels in people with low social support but not in people with high social support. In these communities, sources of support include one's formal network of care providers, family and friends, spirituality, community, and culture. Many challenges exist in social studies of AIAN people, who have unique Indigenous core culture values, such as reciprocity in caring for each other, or "Gadugi" in Cherokee. Overall, little is known of the core values, either generally or relative to T2D prevention or treatment, of the AIAN population, including the tribal community. Drawing from her studies of AIAN communities, Dr. Goins recommended collecting more data to better understand culturally dependent SN differences; SN stability and how it changes over time; and the negative aspects of SNs, such as social stress. More work is needed to identify the modifiable SN characteristics that enhance T2D management and control and to culturally tailor elements of interventions so that they are efficacious and sustainable.

Dr. Gonzalez highlighted several talks of his choice and provided a personal synthesis of takeaways. His first takeaway is that structural racism—which is based in policies, governance, culture, and social values—drives HD. Most work has focused on individuals; however, the structural root causes need to be affected. Second, SN may be a mechanism through which structural racism affects disparities; more thought needs to be given to how to harness this and work with SNA to reduce DHD. A related takeaway arose from the stakeholder panel discussion, where their experiences clearly illustrated that the problems of stigma, judgment, and shame not only cause chronic stress and affect people's mental health, but they also prevent people from building and leveraging SNs in overcoming blame and maintaining mental health. While peer interventions and the like provide social support to individuals, it would be interesting to investigate the potential of SNs in influencing cultural norms and beliefs to reduce social isolation and loneliness. As nicely captured by Dr. Gee, "How do you build relationships when no one is relational?" The fourth takeaway is related to place-based interventions, such as workplace- and church-based interventions, which could be suited for SNA and could leverage SNA to extend beyond these targeted place-based populations to benefit families, networks, and the wider community.

An active member in the Diabetes Prevention Program (DPP), Dr. Gonzalez shared that while the intervention is highly effective for individuals, the program suffers from limited reach, which is its biggest problem. Dr. Fisher echoed Dr. Gonzalez and noted that expanding the reach of DPP has been a

challenge for the past 15 years. DPP's current model of "If we build it, people will come" is able to touch only a small percent of population who need it. The program never considered targeting key members in the SNs to spread the reach of the interventions. Dr. Gonzalez did note challenges in leveraging the network approach, including the cost to lay out methodologies to measure SNs, identify influential nodes, and capture outcome.

Dr. Gonzalez last takeaway is related to the ongoing discussion of the fish versus water (lake) problem, by pointing out that some talks, most notably that by Dr. Smalls, showed promise in targeting key individuals to spread the reach and change other fish and, over time, also the "water" and its culture and norms when enough fish act.

Dr. Islam focused her recommendation around how to advance our understanding of SNs and to leverage SNs to improve equity in diabetes. While the workshop somewhat covered differences in SNs of minority populations and communities, it and the whole field so far missed the opportunity of using SNI and SNA to learn from the experiences from Asian Americans and immigrant populations. Another panelist, Dr. Lijun Song from Vanderbilt University, agreed; she has observed in her own research and teaching a lack of attention in research and a lack of mention in textbooks of racial ethic differences and disparities issues in Asian Americans.

Asian Americans face a disproportionate burden of diabetes nationwide; they face a higher prevalence of age-adjusted high BMI and diagnosed and undiagnosed diabetes [32]. Their communities have unique SN features that can be leveraged in SNI, such as living in multigenerational extended families (that include cousins), transnationalism (time split between the United States and their country of birth, hence transiting between different SNs), and living in multiunit housing. These features can affect information dissemination and behavioral changes in unintuitive ways and offer opportunities for innovative ways of diffusion of messages and interventions. During the pandemic, the critical role played by CBOs, including social service agencies and faith-based organizations, was amplified in all communities, particularly minority communities. This was particularly true in Asian communities, which were effectively left out of federal and local COVID-19-related programs, and a lot of mobilization occurred in binding together at the community level between organizations to address the crisis. Such experiences offer an opportunity to understand how connections of CBOs can foster better support for community members materially and emotionally, as well as enhance a sense of community and social capital.

Dr. Islam also echoed Dr. Egede's message of systems change as being where the power is and pointed out the need to better understand the relationships in networks and systems of power—more specifically, when it comes to interventions, how to leverage networks to enhance power and change the power structure.

Many diabetes interventions are designed to improve self-efficacy; it is important to learn from communities to enhance collective efficacy (borrowed power) among communities affected by diabetes, change upstream systems, and hold systems accountable for harms. Diabetes prevention and management is a collective effort. Much of the stigma around diabetes may be the result of the types of interventions designed and the health care systems, which are all pinned up at the individual level; such concepts have filtered through communities over generations and over time. The narrative needs to be changed, and the message that this is a community-level, multistate stakeholder effort must be conveyed. Dr. Islam's last recommendation was about opportunities from SNA to inform qualities of community health workers and peer mentors that facilitate social support and impact. Examples include how the of balance "being pushy" versus modeling behavior varies by culture, as well as how lived experiences can shed light on how to address SDOH.

Dr. Peek from The University of Chicago first commented that in diabetes interventions, much SN intervention work has been done without calling it that, and the success of these programs often relies on how social support and the social capital of people is leveraged. All four SNA taxonomies defined by Dr. Valente have been practiced unknowingly: "individual" approaches that target high-risk people, "segmentations" that identify groups of people and leaders, "inductions" through peers and community leaders, and "alternation" through adding family members of choice. Leveraging SN made a difference for diabetes intervention programs; however, these factors have not been measured as rigorously as in the SNA field. Moving forward, opportunities exist for bridging between diabetes behavioral intervention researchers and the SNA field, and they are ready for T2D and DHD, as well as for other chronic disease. Dr. Peek's second comment is related to the ongoing discussions during the workshop regarding the structural inequalities and factors upstream of SDOH. When it comes to interventions, consideration should be given not only to how structural racism may intervene in patients' behavior, but also to employing SNs as the perpetrators, through such mechanisms as social contagia, to spread messages and ideas with an aim to spark actions. Not only should the marginalized be studied, but also the oppressors and how racism from the bad person was transmitted to systems.

Dr. Song from Vanderbilt University focused on the social cost and the potential dark side of SNs. It is long known that SNs can bring both benefit (if harnessed well) and harm. However, the research field has been paying more attention to the beneficial side and less to the detrimental side, which is generally termed the social cost. Examples of the latter include social stress, social undermining, harmful social support, and relational strain. More studies of social costs and an integrated model that puts the diverse range of factors together are needed. As for future studies, the network chain and the relationship between structural forms, composition, and network content should be considered, as should antecedental factors of social relationships. For intervention, consideration should be given not only to people who lack network resources or face more social costs but also to people who suffer from both, as they are likely the most vulnerable and disadvantaged.

Dr. Valente pointed out that many of the themes that emerged during the workshop are not surprising and not new, such as that networks matter and network interventions can be promising, that opinion leaders matter and various ways exist to identify and recruit them, that dyads matter, and that peer support is critical. He provided an updated and more detailed taxonomy (Table 2) from his landmark paper published in 2012 [6]. Since he first proposed in 1999 the role of opinion leaders in either regulating, slowing, or accelerating the process of information and innovation diffusion through the SNs [33], many intervention studies explicitly designed in opinion leaders. Meta-analyses consistently show that interventions utilizing opinions leaders enjoy 10–15 percent greater uptake when compared to those that do not [34]. Overall, while a variety of ways to design network interventions exist (Table 2, right column), using opinion leaders is the most straightforward and the most frequently used in different settings.

Table 2. An updated taxonomy of network interventions, from Valente 2012 [6].

| Strategy | Tactic | Operationalization |
|---|---|---|
| Identification | Leaders<br>Bridges<br>Key players<br>Peripherals<br>Low thresholds | Degree, closeness, betweenness<br>Mediators, bridges<br>Positive, negative<br>Isolates, marginals<br>Proportions, counts |
| Segmentation | Groups<br>Positions | Components, cliques, communities<br>Structural equivalence, hierarchies |
| Induction | Word of mouth<br>Snowball<br>Matching | Random excitation<br>RDS, outreach<br>Leaders first, groups first, optimize both |
| Alteration (manipulation) | Deleting/adding nodes<br>Deleting/adding links<br>Rewiring | Vitality<br>On cohesion, other metrics<br>On network, on behavior |

During open discussion, attendees shared additional comments and insights around the topics the panel summarized. Dr. Hannon commented that although the medicine of diabetes treatment has improved dramatically during the last two decades, this has not translated to general health outcomes. Experiences from the Diabetes Control and Complications Trial, which has a strong social support system in additional to a strong medical support team, indicated that the social support system is important and needs to be an integral part, and inadequacies in it perhaps explain why the general health outcomes are lagging behind the medical advances. Dr. Linnan suggested that one future direction worth pursuing is to use SN data to bring back to communities, share with them the important findings obtained from their data, and learn from them regarding what worked or did not work, as well as to recruit more people and engage them in planning future interventions. Dr. Michelle Birkett from Northwestern University, author of the popular SNA software Network Canvas, shared her thoughts. Observed disparities are not necessarily caused by factors intrinsic to the populations; rather, most often it is the process of the systems around the populations, such as victimization and a lack of resources and support. However, our interventions and measurements in disparity studies typically target individuals. SNA is a tool that can be used to see beyond individuals to understand the complexity of disparities at the system level, such as distribution of resources. She also reminded all that approaches other than SNA are useful. Dr. Pamela Thornton asked if and how SNA can be used to promote awareness of the importance of social science and social behavioral science, as they are critically important to health outcomes but often not considered "hard" science. The importance of social behavioral science has been especially demonstrated during the COVID-19 pandemic, such as in accelerating the uptake of testing through SNs and trusted community members.

The workshop co-chairs also made several concluding remarks. Dr. McCranie pointed out that the topics in SN studies are crosscutting for many different health conditions and noted that multiple funding

agencies have expressed interest. The National Institute on Aging hosted a similar workshop just before this one. Currently, the NIH sponsors several active funding opportunity announcements on social connectedness (PAR-21-349, 350, 352). The National Institute on Drug Abuse traditionally has been interested in network studies. The basic research on methods and measures is perhaps of trans-NIH and National Science Foundation interest. Dr. Fisher concluded that the discussions during the workshop have been fundamentally revolutionary against a highly entrenched hierarchy and expert-based health care delivery system.

# Appendix A. Social Network and Social Network Analysis Concepts, Terms, Methods, and Measures

## Basic Sociometric Network Terms

- **Network:** A collection of nodes and the edges between them.
- **Node** (also called *actor* or *vertex*): This describes the entity that is connected through relationships. This could be individual people, groups of people, or institutions (e.g., agencies, nonprofit organizations, schools). One way of thinking about this is that *nodes* are nouns and *edges* are verbs—nodes are things that are connected through edges.
- **Ego:** This refers to the node one is focused on at the moment and the connections that they have. Note that in egocentric studies, this is somewhat different (below).
- **Edge** (also called *line*, *tie*, or *arc*): These describe the relationships between nodes being considered. Relationships can take on many forms: Nodes could be connected through somewhat intangible relationships, such as liking someone or nominating them as leaders. Relations can also be based on more tangible interactions, such as referring clients to one another. They could also be defined by sharing resources, such as money or information.
- **Affiliations:** This is a special kind of relationship, in which two nodes are connected through another kind of node, event, or membership in a shared group. If two agencies belong to the same coalition they could be said to have an affiliation tie. If they belong to many shared coalitions, they could be thought of as more strongly connected than two agencies that shared few such coalition memberships.
- **Edge weight** (also called *value*): Edges can have a value attached to them. A node could send 50 referrals to another node, or they could share three interactions of the same type with one another. If affiliation ties of agencies that belong to coalitions are transformed into a direct relationship, the edge weight between two agencies will be equal to the number of coalitions to which they belong.
- **Directed or undirected ties:** Ties can either be directed or undirected. If a relationship is directed, it is being sent from (i.e., is originating from) one node to another node. Node A may send some resource/referral to Node B, but Node B does not have to return anything back to Node A. Node A could give Node B something, such as resources, information, or an illness. However, in some cases, edges are defined as undirected. Two nodes that are working together on a project share an undirected edge. (Note: In some academic literature, the term *edge* is reserved for an undirected relationship, while the term *arc* is used to refer to directed ties.)
- **Graph** (also called *sociogram* or *visualization*): A graphic representation of the nodes and edges between them.
- **Multiplexity:** Refers to the different ways two nodes could be connected to one another. A multiplex set of relations between two nodes could be that they are friends or colleagues and exchange advice.
- **Attributes:** Characteristics of the nodes or ties. A node agency could be public, nonprofit, or for-profit, or it could have an annual budget of $1 million or $50 million. Attributes can also include characteristics from the network itself, such as how many ties a node has (degree centrality). Can be useful in visualization and analysis.
- **Density:** The percentage of actual ties in a network divided by the number of possible ties. A directed network of 10 nodes would have 90 possible arcs between them.

- **Centrality:** This is a way of ranking the importance of nodes within a network. Many different ways exist to measure importance, such as degree centrality, betweenness centrality, and eigenvector centrality. The meaning of the measure from a mathematical sense can be easily described, but the meaning in the context of the relationship at hand (referrals, nominations, information sharing, resource flows) varies widely.
- **Communities** (also called *clusters*)**:** A community in a network is a way of thinking about grouping, often by finding densely connected sets of nodes. A community within a network that is tightly connected to one another but not to an outside group might be seen as a faction, such as rival political groups. In this case, nodes with high *betweenness* centrality in a network with multiple factions might be some of the only points of contact between rival groups—a potentially powerful but also difficult position to be in.
- **Structural holes:** A powerful concept in network analysis (Burt 1992) is that there sometimes are ties missing (structural holes) in a network between more densely connected groups. Nodes that do connect these groups can then serve as important *brokers* of information or resources and can have a competitive advantage in the network. They can also increase efficiency, such as in a well-organized referral network, but they also might create bottlenecks or other inefficiency.

## Basic Egocentric Network Terms

- **Ego:** In egocentric work, the person who is being interviewed (usually) or observed (less often). The focal point of study.
- **Alter:** Individuals named by *ego* in a survey context.
- **Generator:** The survey question or term used to elicit ego's alters from an interview. "Whom do you talk to about important matters in your life?"
- **Content interpreter:** Characteristics of alters, such as gender, age, or beliefs.
- **Strength interpreter:** Quality and intensity of bonds between ego and alters.
- **Functional interpreter:** Types of exchanges, services, or supports provided between ego and alters.
- **Structural interpreter:** Relationships between alters, and ego's relationship with them. If ego names 10 people, a structural interpreter could ask if those individuals know one another and/or how close they are.
- **Density network:** If ego has been asked about the ways in which their alters are connected through the structural interpreter, this can create a small network that can be analyzed as sociometric.
- **Composition:** Those in the network of ego—family, friends, coworkers. Some individuals might have networks that are more dominated by kin, for instance.

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Prepared by Ann McCranie, May 2022, for an NIDDK workshop: *The Social Component of Diabetes Health Disparities: New Directions in Analyses and Interventions through Social Networks and Structures*

# Appendix B. Definitions of Terms Relevant to Disparties

**Culture:** According to the U.S. Department of Health and Human Services Office of Minority Health: ''Integrated patterns of human behavior that include the language, thoughts, communications, actions, customs, beliefs, values, and institutions of racial, ethnic, religious, or social groups.''[1]

**Health disparities:** The 2002 Institute of Medicine report on unequal treatment defined disparities in health care as "racial or ethnic differences in the quality of health care that are not due to access-related factors or clinical needs, preferences, and appropriateness of intervention."[2]

**Race and ethnicity:** The Office of Management and Budget stated in 1997 that "The categories represent a social-political construct designed for collecting data on the race and ethnicity of broad population groups in this country, and are not anthropologically or scientifically based."[3]

**Social determinants of health:** According to the World Health Organization: "The social determinants of health are the conditions in which people are born, grow, live, work and age. These circumstances are shaped by the distribution of money, power and resources at global, national and local levels."[4]

**Structural racism:** The way in which societies foster discrimination through mutually reinforcing inequitable systems.

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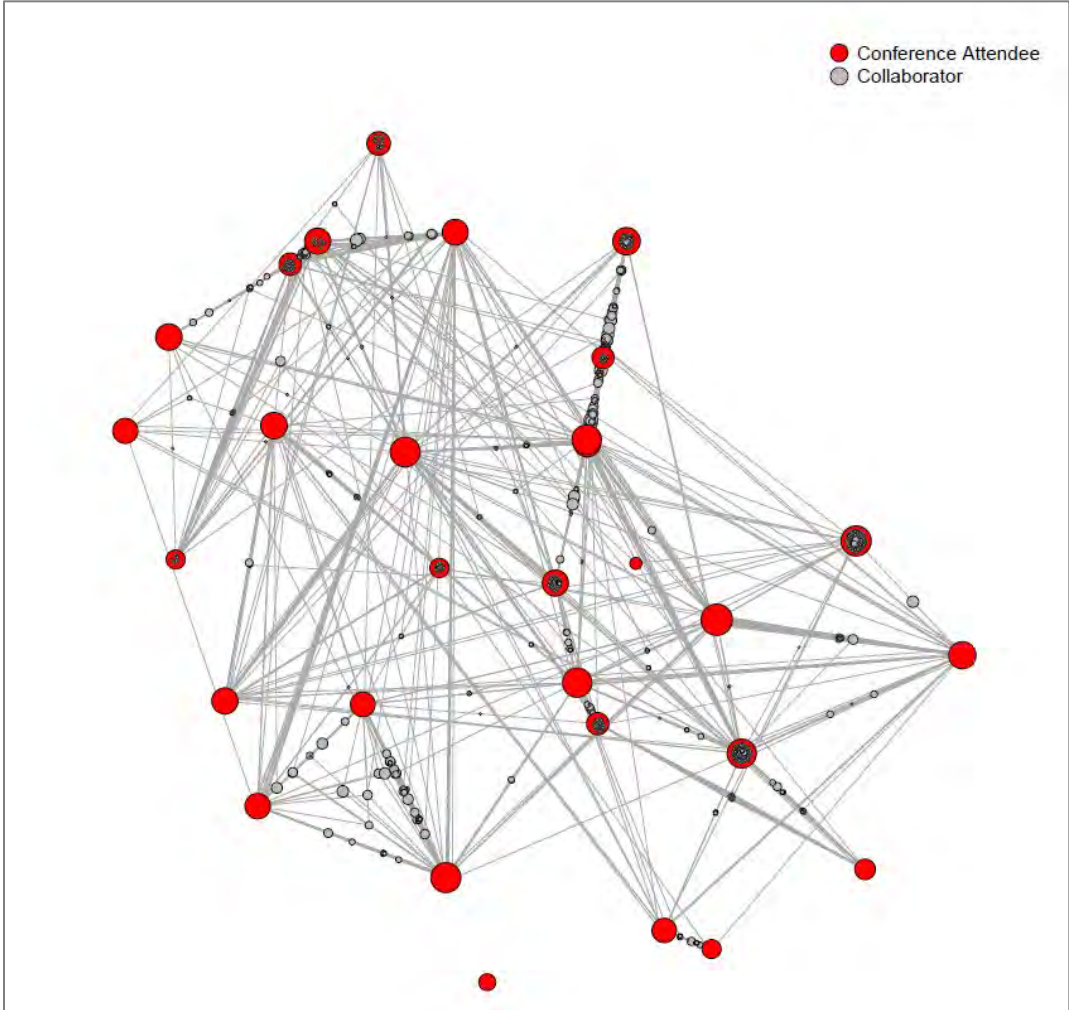# Appendix C. Prior Collaboration Networks of Workshop Participants



Figure 1. Conference attendees and their collaborations since 2014. This network was constructed using co-authorship and grant application data and included 30 conference participants for whom such data were available and their collaborators. The total number of edges is about 9,000.
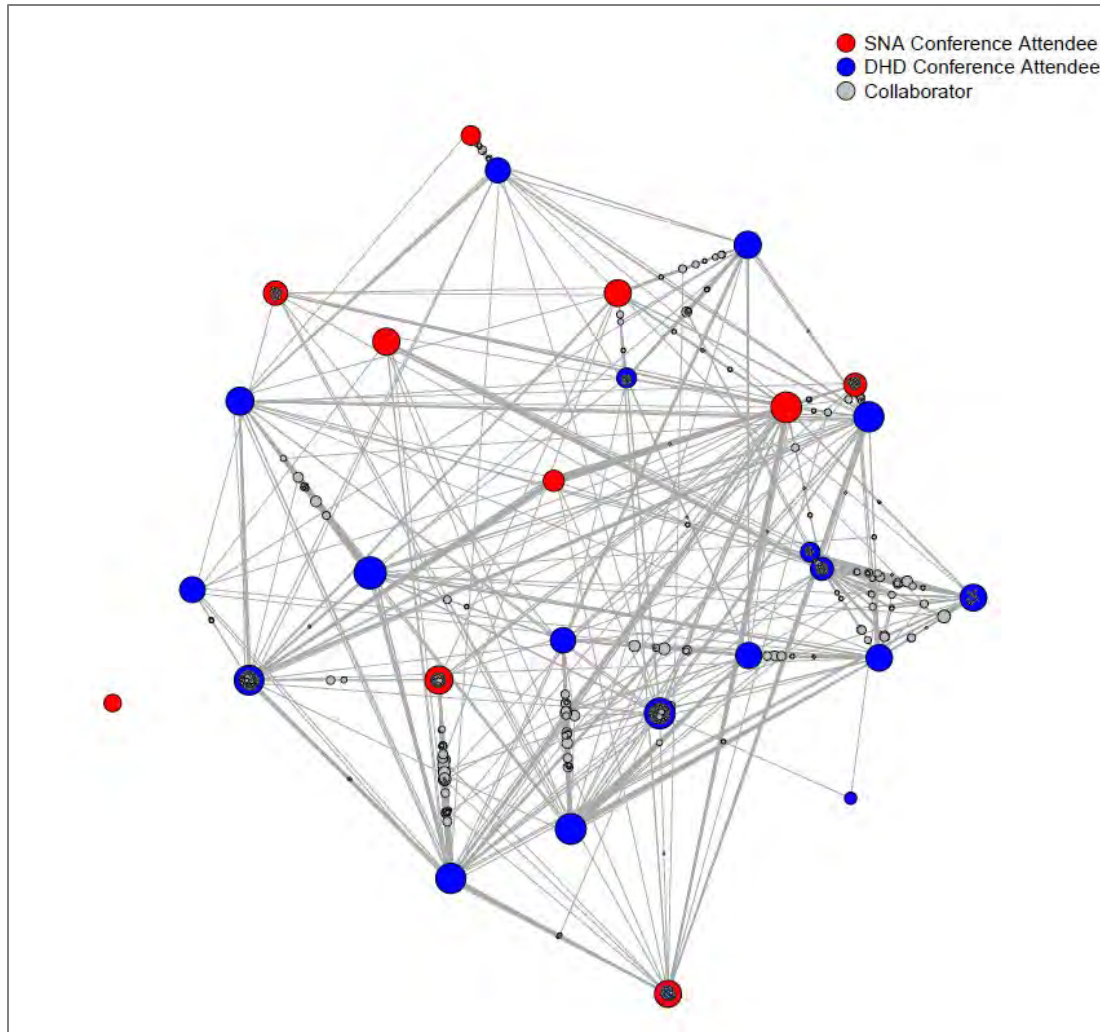
Figure 2. The collaboration network of conference attendees, colored by area of specialty (20 DHD, 10 SNA). The average numbers of edges is 327 for the DHD camp and 285 for the SNA camp.
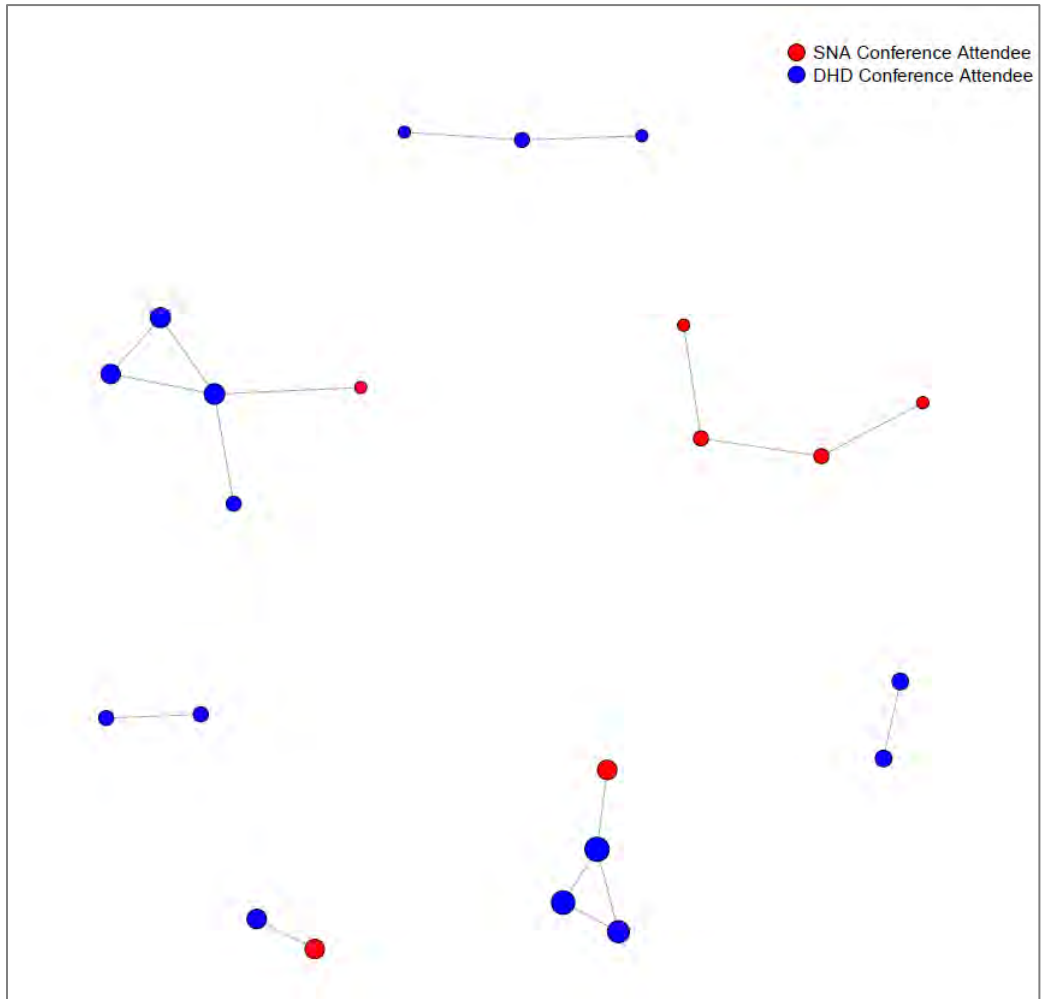
Figure 3. Conference attendees collaborating with each other, colored by area of specialty. This network graph shows that minimal cross-collaboration has occurred between the two groups of DHD and SNA. Compared to the DHD collaborations, multiple triangle connections on the SNA field are seen, indicating more complex relationships.
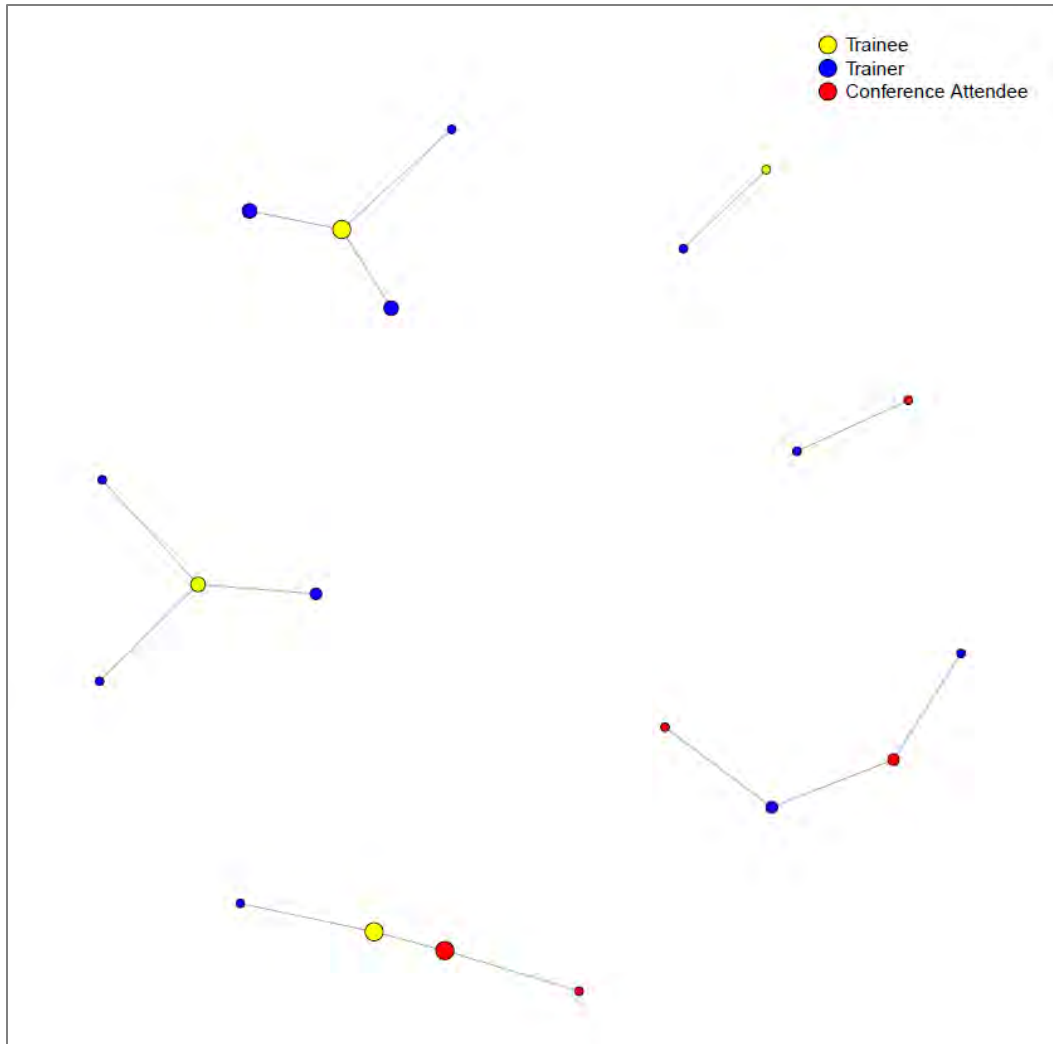
Figure 4. Collaborations between trainees, their mentors, and conference attendees. This network graph shows that the trainees already are collaborating with established principal investigators.

# Appendix D. Young Scholar Travel Awardees

To provide opportunities for the next generation of scientists to participate in this important discussion, a travel scholarship call was released for scientists ranging from senior graduate students to investigators less than 2 years into their first faculty appointment. In total, more than 50 applications were received, and 35 complete applications were reviewed. Travel scholarships were offered to the following awardees:

Kathryn Fantasia, M.D., Boston University
Allison Lewinski, Ph.D., M.P.H., R.N., Duke University
Weidi Qin, Ph.D., University of Michigan
Luis A. Rodriguez, Ph.D., M.P.H., R.D., Kaiser Permanente
Sherrie Wise Thomas, Dr.P.H., M.P.H., Wake Forest School of Medicine
Ryan Walsh, Ph.D. candidate, Washington University School of Medicine
Sijia Wei, Ph.D., Northwestern University

The awardees were paired with senior leaders in the field to co-moderate sessions and lead breakout group discussions.

# Appendix E. Workshop Agenda, Abstracts, and Participants

Attachment: Social Component of Diabetes Health Disparities_Final Binder.pdf

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