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Using team science to address health disparities: MacArthur network as case example

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In this paper, the director and the administrator of the MacArthur Network on Socioeconomic Status and Health reflect on the evolution of the network. Against the backdrop of the science of “team science,” they describe the history and process of the network including the forging of a group agenda, the development of a creative, productive group working style, and the outcomes arising from these processes.

Keywords: team science; multidisciplinary; interdisciplinary; transdisciplinary

The papers in this volume attest to the complexity of answering the question “how does SES get under the skin,” and provide an overview of the significant progress that has been made in the last decade. They illustrate the necessity for causal thinking at several levels of analysis and across multiple disciplines, and the importance of conceptual, methodological, and analytic advances in addressing this question. They demonstrate the relevance of research findings to policy and the development of valid and effective interventions to reduce health disparities.

Many of the advances documented in this volume emerged from the work of the MacArthur Network on SES and Health in addition to the contributions of many individuals and groups who are also working on health disparities. The network provided a structure where scientists from a wide range of disciplines could address this issue by working together over an extended period of time. While today it’s not uncommon to have multidisciplinary teams of researchers addressing complex problems (indeed, this is the hallmark of the NIH roadmap initiatives), this type of collaboration was relatively rare when the network began over a decade ago. The number of projects undertaken through team science has been increasing but our understanding of how team science works is still in an early phase. Team science is potentially less efficient than the traditional single

investigator approach in part because it demands the transformation of a group of individuals in the service of reaching a shared vision. This raises the question of whether “the juice is worth the squeeze.” In this concluding paper, we attempt to capture the essence of our experiment in “team science,” and assess its value.

Types of team science

Researchers from multiple disciplines are increasingly working together to address complex, multifactorial problems. An analysis of nearly 20 million articles¹ documented not only substantial growth in publications from research teams but also the greater relative impact of works written by teams. Rosenfield differentiated three types and levels of collaboration: (1) *multidisciplinarity* occurs when researchers from a range of disciplines work on the same problem independently with an intention eventually to combine their findings; (2) *interdisciplinarity* occurs when researchers from different disciplines work together and contribute their perspective to work on a common program; and (3) *transdisciplinarity* is achieved when an interdisciplinary group also develops an overarching model that includes but transcends individual disciplines.² As we discovered when reflecting on our own

process, the boundaries between these categories are blurry, particularly that between interdisciplinarity and transdisciplinarity.³ While each type of disciplinary shift indicates progress toward greater integration, it's not always clear when a category shift has occurred.

The “science of team science” studies the processes and outcomes of this approach to research.⁴ The observations emerging from this work provide a context for understanding the Network history and accomplishments. Team science occurs in a variety of organizational structures.⁵ A given team may engage researchers within a single organization, across different organizations of the same type (e.g., across different academic institutions), or across organizations in different sectors (e.g., academic institutions and community or governmental groups). Individuals or groups can be in the same geographic area or spread across the globe. Additionally, the scope of analytical levels addressed by the team may vary; within the health arena research groups vary in how much of the range from “cells to society” is encompassed in their research vision. Groups also vary in size and in familiarity among members, with advantages and disadvantages associated with extremes on either side. On the one hand, smaller groups are likely to be more cohesive, more manageable, and therefore may be more efficient. However, larger groups provide greater access to different ideas and to physical and intellectual resources. And while cohesion may facilitate interaction and creativity, it may also dampen creative disagreement and diminish individual initiative.

Research on the science of team science has largely focused on large-scale efforts, with up to 200 investigators and annual funding of five million dollars or more. The MacArthur networks are considerably smaller both in terms of funding levels and size, with most consisting of 10–14 members. Yet some of the lessons that have been learned from the study of team science help us to understand the network process.

Beginning of the MacArthur Network on SES and Health

The SES network is one of 24 networks that have been established by the MacArthur Foundation, since 1982. The Foundation founders were prescient in their understanding of the importance of

breaking out of the silos of specific disciplinary approaches when addressing complex social problems as well as of the challenges to doing so. The networks were established to enable “sustained programmatic investigations that transcend boundaries among the biological, behavioral and social sciences. . .” (p. iii).⁶ Importantly, the Foundation provided flexible funding that allowed networks to develop their research agenda as a group. The funding extended over a number of years, which permitted initial time for exploration and discussion and reduced the danger of premature closure.

The original networks were organized around issues related to mental health across the lifespan; later networks have addressed a broader range of topics. Robert Kahn studied the early networks and observed a common progression in their development.⁷ The first stage involved a search for common concepts and themes across disciplinary divides, which evolved into development of a common language within the group. This common language and its underlying conceptual platform provided a foundation for initiating collaboration and undertaking joint projects. He identified several indicators denoting the success of the network process. These included the development of innovative research methods, creation of significant new data sets, novel findings, and identification of new concepts, hypotheses and directions for research.

The SES and Health Network had its roots in a prior MacArthur network formed to examine “Determinants and Consequences of Health-Promoting and Disease-Preventing Behavior” which was headed by Judith Rodin. Among its other activities the network explored the feasibility of developing a “biobehavioral battery” to assess psychological and social states that would best predict an individual’s overall health status and his/her risk of falling ill. At an initial meeting Len Syme, a noted epidemiologist, shared recently reported findings on 10-year mortality among participants in the Whitehall study of British civil servants. The research demonstrated the powerful effect of occupational grade on mortality rates of civil servants, and revealed a graded association of mortality and occupational grade. These epidemiological data were striking but were not known by meeting attendees from other disciplines. The findings contrasted with the primary focus in the U.S. literature on poverty, race, and health care access as the key explanatory factors for differential

health outcomes. None of these factors could account for the graded Whitehall findings, leaving unexplained the mechanisms that produced these striking results.

Forming a network: membership

The question of which mechanisms are responsible for the pronounced SES effects on health was sufficiently compelling that the MacArthur Foundation funded a new network to address it. As director, Nancy Adler was charged with assembling a multi-disciplinary group of researchers. Several members of the original health behavior network were intrigued by and actively engaged with this issue and they became the core of the new group. We organized a series of small meetings exploring links between social class and health to determine what was already known and what key questions remained to be answered. The meetings allowed us to interact with a wide range of researchers who were doing important work in relevant fields.

Many more people attended the initial meetings of the network than could be invited to join it, and several considerations guided selection of additional members. One was the range of disciplines represented. Within the limited number of network members, it was important to have different disciplines, skill sets, theoretical perspectives, and levels of analysis represented in the group. Starting with about a third of the members determined we looked for complementary areas of expertise. We resisted the impulse to add valued colleagues when they overlapped too much with areas already represented in the group. We needed new voices and searched especially for members who were at an earlier stage in their careers.

In selecting new members we also looked for evidence of interest in engaging in a network process. Traditional approaches to science reward individual effort. As a result, relatively few people have experience in working in a highly collaborative manner, and some are not particularly interested in doing so. Many meeting participants did brilliant research and enriched our understanding of the problem but did not engage in the process of merging their thinking with that of others. A predilection for such activity was needed if we were going to succeed in building an interdisciplinary or trans-disciplinary approach as the network evolved.

Forging a network: process

Organization and geography

As noted earlier, groups engaged in team science vary in the extent to which they work in proximity to one another and in the frequency of their face-to-face contact. As with all MacArthur networks, we were geographically dispersed, and the entire network physically met together four times a year. Sub-groups and topic specific “working groups” sometimes met separately on other occasions to develop project specific agendas and advisories for the network as a whole.

When teams of researchers are based within a single institution, their day-to-day interaction can help promote dialogue and maintain momentum. At the same time, teams assembled within institutions have to work against established structures. In most universities, power and resources flow through departments which are organized by discipline. Inter-disciplinary research may occur in cross-departmental institutes, but these can create divided loyalties and organizational issues may spill over into the scientific work. A network that exists outside of a specific organization frees its members to act more independently and perhaps think more freely. Taking faculty out of their home environment removes distractions during the meeting time (although Blackberries and cell phones can intrude), and this allowed us to forge new relationships and develop mutual understandings.

Network meetings typically lasted 2 days and were held in different parts of the country. The first day often included invited guests and focused on a specific topic that was of particular current interest to the group (e.g., early brain development, parasympathetic function). This session functioned as a two-way street since our guests learned from us as we did from them and several very productive collaborations developed from these encounters. The second day allowed network members to reflect on what our guests had taught us and its implications for our work. An important component of the second day was the development of group consensus around plans for research, potential collaborations, and future meetings. Developing consensus while together played an important role in sustaining the iterative process between meetings.

While meetings are important opportunities to forge a shared vision and agenda among members

who were spread out geographically, the actual process posed some challenges. Stokols *et al.* observed the problems of communicating across time zones.⁵ Our network certainly felt the impact of such time differences since our members came from multiple time zones, ranging from Michael Marmot in England to several members on the West Coast. The 8-hour span across these locales limited opportunities for teleconferences and narrowed the time period during in-person meetings when all participants were fully alert and at their peak. The existence of the network outside of the members' home institutions created challenges to maintaining activity on group projects between meetings. After meetings, network members returned to the demands of their home institutions and other professional commitments. The greater the extent that the Network's focus overlapped with a member's own area of interest and research (which was the case both for members who were recruited because of the overlap and for those who changed the focus of their own work because of their network experience), the easier it was for them to sustain movement on network projects when they returned home.

Group identity

As with a sports team, a science team needs to have players who have specialized skills and who fill specific positions. However although having talented individual players is necessary for success, it is not sufficient. The skilled individual players need to be united by a shared goal and shared vision for how to achieve the goal. Achieving a group vision may require relinquishing aspects of one's personal agenda. As fledgling athletes are told, there is no 'I' in 'team.' In academic life, however, 'I' plays a major role since promotions and awards, and other incentives, are based on individual achievement. Only in recent years have universities begun to implement policies that reward collaborative work, and their impact has yet to be evaluated.

In sports, the coach and the manager are responsible for establishing the game plan and its implementation. In our network, the agenda was set by the group but the director and administrator took on some of the functions of manager and coach. The network director provided intellectual leadership in developing the shared vision and research plans while the network administrator oversaw its implementation. The administrator played a key role in

tracking and integrating the various activities of the group. We were fortunate that both the founding administrator Grace Castellazzo, and her successor, Judith Stewart, had relevant professional experience and contributed to the science of the network, as well as handling its administrative aspects. Since network members, including the director, all had "day jobs" at universities the administrators were the only individuals whose primary professional work was the Network. The competing demands associated with the members' multiple professional positions conflicted to varying degrees with their engagement in network activities.

As noted above, some network members' own research prior to joining the network centered on socioeconomic status and other bases of health disparities. For them, the network extended and supported their work, and it was relatively easy for them to integrate network responsibilities with their ongoing professional activity. Others joined the network because of their interest in linking their work (e.g., on psychosocial determinants of health) to socioeconomic status. Network involvement may have had the largest impact on these researchers since they successfully incorporated a focus on SES effects into their personal research programs as a result of their participation. For these individuals, also, integrating network activities with their ongoing responsibilities was fairly straightforward. However, a subset of our members neither came with a prior engagement with health disparities, nor incorporated socioeconomic status into their personal research programs. For these individuals, although they developed an interest in health disparities, sustaining their participation between meetings was somewhat more difficult as the network's activities did not dovetail with their ongoing individual research.

Goals and "groupthink"

Guzman and Dickson describe how a shared goal increases interaction, effort, and collaboration of a group.⁸ We were fortunate in beginning with a specific question which served as a shared goal. Members of the network were committed to finding an answer to our guiding question of how SES gets into the body to affect health. The meetings provided opportunities to hear new data, get ideas from outside researchers, challenge our assumptions, and critique planned research. When considering research opportunities or plans for

meetings, or if venturing into interesting but tangential areas, we redirected ourselves by invoking our focal question. Early meetings were especially important for building bonds among our diverse group members whose disciplines spanned anthropology, economics, epidemiology, medicine, neuroscience, psychology, and sociology.

Stokols *et al.* note the importance of “the joint development of operating norms that encourage open communication, mutual respect, inclusiveness, and shared decision making” (SI04).⁵ The existence of such norms reduces conflict while still allowing open debate, and developing such norms involves social as well as intellectual engagement. Group dinners, time for socializing during breaks (never enough), and celebrating accolades and awards for members provided buttressing against divisions that could occur over scientific disagreements.

A small group can become insular and engage in “groupthink,” and we relied on several strategies to offset this tendency. First, although we always regretted when members chose to leave the network, such departures provided opportunities to bring in new members. Second, we added new additional members from time to time throughout the network’s existence. The addition of new members changed the group dynamic and brought new perspectives to our discussions. Third, the inclusion of guests at each meeting provided a constant infusion of new ideas and questions. At several points we invited guests to join us to critically review a particular network project or product. Both avenues of new ideas brought invaluable, fresh perspectives to our work, and we are appreciative of the willingness of colleagues to interact with us and share their thoughts. Finally, we supported a number of promising graduate students, postdoctoral fellows and junior faculty. Their work was shaped by the network and they, in turn, added new ideas to our work. Many of these associates of the network are coauthors on the papers in this volume (Edith Chen, Jane Clougherty, Peter Gianaros, Elissa Epel, Linda Gallo, Tara Gruenewald, Denise Janicki-Deverts, Arun Karlamangla, Pilyoung Kim, David Rehkopf, and Kerry Souza). They, along with the others (Sarah Burgard, Lia Fernald, Elizabeth Goodman, Brooks Gump, Gregory Miller, Joan Ostrove, Deborah Polk, and Katri Raikonen), are an important part of the network’s legacy.

The launch: extending our reach

Early in our life as a network we organized a large-scale conference on socioeconomic status and health. Held at NIH, it attracted around 300 attendees, including project officers and researchers from a wide range of NIH institutes, researchers who were interested in the question of how SES gets into the body, and policy analysts interested in reducing health disparities. The meeting launched the network and consolidated our understanding of the state of knowledge at the time about how socioeconomic status influences health. It also allowed us to engage with researchers who were looking at many aspects of social disadvantage in relation to a variety of health outcomes.

This conference provided a foundation not only for our network but for subsequent health disparities meetings at NIH. The presentations from the conference resulted in a special volume of the *Annals of the New York Academy of Sciences*⁹ which has been widely used as a reference book and as a text for university classes within a number of disciplines. The current volume stands as a bookend to that first network product, capturing what we have learned in our decade of work since the 1999 conference and the current state of knowledge about the pathways by which socioeconomic status affects health.

Aiming for transdisciplinarity

Models

Having assembled a multidisciplinary group who engaged in an interdisciplinary process, we worked to develop a transdisciplinary model to guide our work. We soon discovered the difficulties in doing so. As one member of the group noted, “models divide.” Several network members had developed their own conceptual models of how socioeconomic status influences health. While we used elements from these diverse models, it was difficult to capture all of the nuances and complexities identified by them in a single, generative model. We decided that a schematic model which depicted the major pathways by which socioeconomic status could affect health (see Fig. 3 in “Health disparities across the lifespan: meaning, methods, and mechanisms,” in this volume) would be the most productive in guiding our work. We knew it was vastly oversimplified and did not capture feedback loops, interactions

or moderating conditions, and also did not address the social, economic and political forces which create conditions of disadvantage and inequality. It did, however, allow us to decide where to focus our resources for the task of deconstructing the mechanisms linking SES and health. We focused primarily on an especially understudied pathway from SES to health, involving effects of environmental and psychosocial factors associated with social disadvantage on the mind/brain and the resulting neuroendocrine processes that affect disease risk. We also considered effects of environmental and psychosocial factors on health through their impact on health behaviors, focusing primarily on how SES and associated environments shape health behaviors rather than on the associations of these behaviors with health since the latter is well established. Although important, we did not focus on access to health care as a major pathway between socioeconomic status and health since there was already considerable work being done in that domain by other researchers.

Methods

The flexible funding provided by the MacArthur Foundation permits innovative cutting-edge work which would be unlikely to receive support from more traditional sources. It allows for risky pilot work which, if successful, can then compete for grants from NIH or other traditional funders. Importantly, it provided us with sufficient latitude to allow us to act quickly when opportunities arose. The Foundation gave us great leeway in developing new ways to test hypotheses about pathways linking socioeconomic status and health. We confronted a field where no existing data sets had adequate measurement in all of the domains needed to test our model. Data sets with good health outcomes rarely had in-depth information on socioeconomic status or on hypothesized mediators such as stress exposure, while data sets with good measures of socioeconomic status lacked biological assessment and health outcomes. The Foundation's provision of flexible research funds allowed us to take advantage of ongoing research efforts where we could expand the data collection to cover additional domains, including inclusion of new measures which we developed, to investigate the mechanisms we conjectured were important to the SES-health pattern. Foundation funding allowed us to hold network and special

topic meetings with enough regularity to forge a shared agenda, identify research opportunities, and maintain our activities.

One of our first major network tasks was identifying large scale studies to which we could add measures we deemed to be vital for unraveling the SES-health pathways. We used some of our funds to allow additional data collection in two large studies. One, the Whitehall study, under the directorship of network member Michael Marmot, came close to providing all the elements needed for our model; our funding allowed for expansion of the measures of socioeconomic status to include subjective SES for the full cohort and of biological measures in a subsample of Whitehall participants to provide a fuller set of indicators of allostatic load. The second study, CARDIA, is a longitudinal study of the development of cardiovascular disease in young adults. It began with approximately 5000 subjects at four sites where participants were stratified by sex, race/ethnicity (African-American and European-American) and education (12 years of education or less and more than 12 years of education). Network members Karen Matthews, David Williams and Ana Diez Roux were members of the CARDIA Emerging Science Committee and served as liaisons. Network funding supported the addition of a "psychosocial battery" to the Year 15 core exam for all participants and gathering of additional biological indicators for better assessment of allostatic load on a subset of 800 participants at two of the study sites.

We also supported development of a unique data set through network member Mark Cullen's involvement with the Alcoa Corporation. This company provides excellent health benefits for all employees and, as a result, their health claims data are quite comprehensive. Mark linked administrative data sets that had information on employment conditions, including work locale and pay grade, with health claims data that provided information on diagnosis and usage. This project produced a U.S. version of the Whitehall study where occupational status was precisely determined and health outcomes finely tracked. Network support allowed for initial analyses and facilitated a successful NIH application to support ongoing work.

Finally, we were able to fund pilot work and smaller "add-ons" to larger projects. In the same way that venture capital energized the biotech industry

through early funding of promising ideas, the ability to fund promising ideas that would not have sufficient preliminary data to attract NIH funding, was an extremely effective use of our funds. Evidence of the fruits of this investment is provided in this volume.

Measures

In the course of our work we created a number of significant new measures which were inherently entwined with our research questions. These include indicators for the measurement of allostatic load, of subjective social status, and of reserve capacity. The website maintained by the network was developed in part to make these measures available to the research community.¹⁰ In an early network project we compiled a series of “notebooks” of measures useful in researching pathways linking SES and health. These “notebooks”, posted on our Web site, addressed researchers’ needs for information on best measures for SES and mediating variables linking SES and health. The notebooks provide overviews of concepts and measurement instruments in four areas: the social environment, allostatic load, psychosocial elements and lifecourse development. They have proven to be very useful, attracting progressively greater numbers of users to the site each year with approximately 9,000 page hits per week last year, and escalating requests for permission to use network instruments (e.g., subjective social status or the network sociodemographic battery). The website also has served as an excellent vehicle for providing wide access to *Reaching for a Healthier Life: Facts on Socioeconomic Status and Health in the U.S.*,¹¹ a primer based on our understanding of the facts of U.S. health including policy guidelines to address them.

Transcending disciplines

As noted earlier, moving from multidisciplinary to interdisciplinary to transdisciplinary work involves increasingly greater integration although there are not clear lines demarcating the different levels. Our network researchers, from different disciplines and with unique theoretical frameworks and methodologies, clearly moved from multidisciplinary to interdisciplinarity in developing a common program. One might argue that the multilevel, longitudinal “network perspective” which evolved

represents a transdisciplinary approach to health disparities.

Changes in individuals and in the group process echo the transformation of individual network members into an integrated group. A light-hearted but telling joke among groups members was the giving of honorary titles during intense discussions, such as “this esteemed epidemiologist has become an honorary psychologist” or vice versa. These “honors” were generally bestowed when a member had suggested a previously criticized approach from the discipline bestowing the honor. Such playful title designations were particularly frequent during the years when we were developing a shared language and point of view. They signaled the increasing flexibility of our members to assume different perspectives, and their willingness to formulate points and queries from diverse perspectives. That SES effects on health are cumulative across the life course, that health affects SES as well as vice versa, that environments are themselves factors not just as they are expressed in individuals, now form core tenets in the thinking of all of our network members. This was not the case at the beginning of our work together.

When the group was initially challenged to consider the policy implications of our research, several members were vehemently opposed. Some felt that we had been assembled on our scientific merits and were not qualified to make policy recommendations. Even the most vociferous opponents were willing, however, for us to use some of our meeting time for policy discussions and for bringing in experts to help us to better understand the policy domain and what we could contribute to it. Through this process all network members reached the point where they became engaged in writing our document “*Reaching for a Healthier Life*” which has as one of its main tenets that “all social policy” (e.g., housing and education policy, labor regulations, and zoning) “is health policy.” To a person, they helped identify policies that would help reduce disparities.

Transdisciplinarity is perhaps most obvious in the result of our training activities. A new generation of health disparities and stress researchers trained with network members and participated in research supported by the network. They attended some of our meetings, and are coauthors on network publications. Several of them embody transdisciplinarity in the sense that their research questions and approaches are not capturable within any one

discipline. A multilevel, multidisciplinary approach is integral to the work of these scholars and researchers. Their overarching models include yet also transcend individual disciplines. They are identifying associations if not pathways between social and biological processes, whether it be showing telomere shortening associated with chronic life stress, brain morphologic changes associated with low social status, effects of low early-life SES on the epigenome of immune cells fostering the emergence of proinflammatory phenotypes, or offspring brain morphologic changes associated with maternal depression. Their research exemplifies complexities of the latest eras of disparities research discussed in “Health Disparities across the Lifespan: Meaning, methods and mechanisms” in this volume. We trust they will be leaders in the future evolution of this work.

Conclusion

Our experience in team science has been rich and rewarding. Abrams³ notes that “scientists who succeed in embracing a transdisciplinary approach experience it as a tipping point in their career, enhancing their professional growth and creativity” (p. 516). Individual network members agree they have been transformed. Over the last decade we forged a group identity which allowed us to contribute through communal action to the field of health disparities research, to mentor a new generation of researchers with the conceptual framework and methodological expertise to tackle the complexity of the pathways linking socioeconomic status and health, and to inform the increasingly vibrant policy dialogue about how to intervene to reduce disparities. As individuals we were changed by the experience and feel that our contributions as a group are far greater than the sum of our individual work. Needless to say we believe that the juice was worth the squeeze.

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Conflicts of interest

The authors declare no conflicts of interest.

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