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Social determinants of health and obstetric outcomes: A report and recommendations of the workshop of the Society for Maternal-Fetal Medicine

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This article is a report of a 2-day workshop, entitled "Social determinants of health and obstetric outcomes," held during the Society for Maternal-Fetal Medicine 2022 Annual Pregnancy Meeting. Participants' fields of expertise included obstetrics, pediatrics, epidemiology, health services, health equity, community-based research, and systems biology. The Commonwealth Foundation and the Alliance of Innovation on Maternal Health cosponsored the workshop and the Society for Women's Health Research provided additional support. The workshop included presentations and small group discussions, and its goals were to accomplish the following:

1. Review the current evidence on the relationship between social determinants of health and obstetrical outcomes
2. Discuss approaches to and research opportunities for the epidemiologic analysis of social determinants of health in obstetrical settings
3. Discuss approaches to and research opportunities for measuring how social determinants get biologically embedded to influence health and disease risk
4. Discuss approaches to and research opportunities for interventions and strategies to mitigate the detrimental effects of social determinants of health and improve obstetrical outcomes

Key words: biological embedding, community organizations, epidemiologic analysis, health disparities, interventions, models, policy, racism, research, theoretical frameworks, weathering

Introduction

Addressing adverse social determinants of health (SDOH) that exist largely because of structural racism is foundational to improving obstetrical outcomes and eliminating health disparities. In this context, "obstetrical outcomes" refers to the outcomes that occur or are identified before or during an individual's pregnancy and those related to these periods that ramify through the individual's and their children's life course. In addition, although SDOH can exist as both positive and negative influences in a person's health trajectory, in this context, we will focus on how SDOH adversely affect human health and well-being (unless otherwise specified). "Structural racism" refers to the totality of ways in which societies foster racial discrimination, whether through housing, education, employment, healthcare, or criminal justice. Systemic racism is a fundamental cause of health disparities. The World Health Organization defines SDOH as "nonmedical factors that influence health outcomes"; such factors include "where people are born, grow, work, live, and age and the wider set of forces and systems shaping the conditions of daily life."[1] Despite initiatives that have sought to better understand and address the intersecting factors that result in inequities in obstetrical outcomes, the optimal methods by which SDOH are defined and quantified, the pathways by which SDOH affect intra- and intergenerational health, and the most effective means to combat the deleterious effects of adverse SDOH remain uncertain.

To address the relationship between SDOH and obstetrical outcomes, interdisciplinary leaders gathered for a 2-day workshop held during the Society for Maternal-Fetal Medicine (SMFM) 2022 Annual Pregnancy Meeting. Participants' fields of expertise included obstetrics, pediatrics, epidemiology, health services, health equity, community-

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based research, and systems biology. Entitled "Social determinants of health and obstetric outcomes," the workshop was cosponsored by the SMFM, the Commonwealth Foundation, and the Alliance of Innovation on Maternal Health and also received support from the Society for Women's Health Research. The structure of the workshop included presentations and small group discussions, and its goals were to accomplish the following:

1. Review the current evidence on the relationship between SDOH and obstetrical outcomes
2. Discuss approaches to and research opportunities for the epidemiologic analysis of SDOH in obstetrical settings
3. Discuss approaches to and research opportunities for measuring how social determinants get biologically embedded to influence health and disease risk
4. Discuss approaches to and research opportunities for interventions and strategies to mitigate the detrimental effects of SDOH and improve obstetrical outcomes

Of note, the workshop recognized that adverse SDOH and racism affect and are associated with adverse health outcomes among many different minoritized communities. Space limitations prevent a full survey of the totality of individuals' and communities' circumstances in this document, and the examples cited are meant to be exemplary and not comprehensive.

Background

Disparities in obstetric outcomes

More than 1200 women died in the United States from pregnancy-related complications in 2021.[2] Of these deaths, 3 in 5 are preventable. The high proportion of preventability underscores the need to identify and implement strategies to address the multiple contributing and modifiable factors. The contribution of adverse SDOH is starkly illustrated by the significant racial and ethnic disparities in pregnancy-related mortality. Black women have a pregnancy-related mortality ratio approximately 3 times as high as that of White women.[3-6] Between 2014 and 2017, Black women were 3 to 4 times more likely to die from pregnancy-related causes than White women, and American Indian and Alaska Native women were 2 times more likely to die from pregnancy-related causes than White women. Disparities in other important metrics are similarly notable:

- Between 2016 and 2017, non-Hispanic Black women were twice as likely to experience severe maternal morbidity than non-Hispanic White women.[7]
- The cesarean delivery rate for Black women between 2018 and 2020 was 35.8%, whereas the cesarean delivery rate in the overall population was 31.8%.[8]
- In 2019, Black, American Indian and Alaska Native infants were more than twice as likely to die within the first year of life than White infants.[9]

These disparities derive from multiple factors, including access to care, quality of care, prevalence of chronic diseases, and implicit and explicit biases on the part of healthcare systems and providers.[10–12]

Defining structural racism and how structural racism manifests

Race and ethnicity are social constructs without biological meaning. Alternatively, race and ethnicity are dynamic concepts that are shaped by geographic, cultural, and sociopolitical forces.[13] Structural racism directly affects health status and correspondingly is a fundamental cause of health disparities (e.g., through greater exposure to toxic chemicals in neighborhoods that had been redlined).[14] In addition, structural racism affects the provision and quality of healthcare because of differential treatment practices, lack of culturally responsive care, bias, a greater likelihood of health provider shortages, lower-resourced hospitals in neighborhoods with populations that are mostly Black, indigenous, and people of color (BIPOC), and undermining of public policies (e.g., Medicaid) that support populations with historical economic disadvantage.

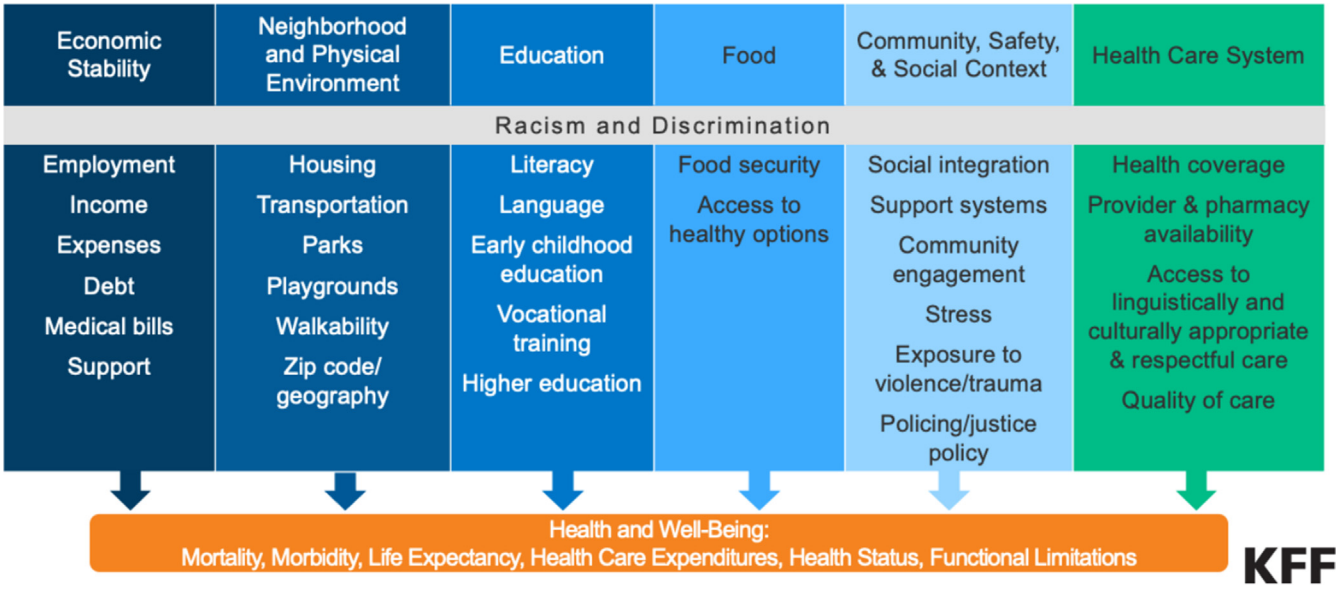
Racism and social determinants of health

SDOH—defined as the conditions in which people are born, grow, live, work, and age—are significant drivers of disease risk and susceptibility.[15] These determinants include education, income, access to transportation, access to safe and affordable housing, and access to nutritious foods (Figure 1). The differences in social position and power shape identities and access in society, and adverse SDOH disproportionately affect BIPOC individuals. For example, the poverty rate of 20.8% among Black individuals in 2018 was higher than that of any other racial and ethnic group.[17] In addition, Black individuals living in the United States experience hunger at 3 times the rate of White individuals and compose 40% of individuals who experience homelessness.[18]

Best practices in studying social determinants of health

To properly study the relationship between SDOH and health outcomes, researchers must ensure that their approaches and hypotheses have clear theoretical foundations and frameworks, such that they will measure the correct variables, use the appropriate methods, and amplify equitable approaches to positively affect the populations of interest. Several models that can help guide research were described during the workshop (Table). These models, as detailed below, were meant to be exemplary of commonly used constructs and not inclusive of all models that may be useful.

FIGURE 1
Social determinants of health



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Social ecological model

The social ecological model considers the complex interplay among multilevel contexts in which individuals and populations are embedded. These contexts include individual and population health, pathophysiological pathways, social conditions, living conditions, neighborhoods and communities, institutions, and social and economic policies. The social ecological model stresses that these multiple contexts are interrelated, highlighting the importance of addressing multiple dimensions simultaneously to improve health outcomes. For example, social conditions are factors that involve a person's relationships with other people; although social conditions exist at one level of the social ecological model, they cannot be considered in isolation from factors at other levels, such as individual resources to manage stressful life events. Stressful life events have been linked to heart disease, diabetes mellitus, cancers, stroke, depression, low birthweight, and perinatal mortality.[19–21] Conversely, greater social support[22–27] and coping[28] are associated with health and well-being.

Fundamental cause model

Advances in establishing a causal role between SDOH and health have focused on 2 major issues: the direction of causation and the mechanisms that explain observed associations.[29] The "fundamental cause" model posits that social conditions are root causes of health outcomes that operate upstream through multiple replaceable mechanisms to drive health inequities. Examples of upstream factors include exposure to social inequities, institutional inequities, and poor living conditions. Features of the fundamental cause model are that fundamental causes influence multiple diseases and operate through multiple interchangeable risk factors and that access to resources helps individuals avoid disease through various mechanisms, whereas lack of access to resources leads to a greater likelihood of disease.

Life course perspective

The life course perspective theory describes the accumulation of risk and protective factors across time and different "critical windows" that perpetuate health disparities.[30] In this framework, disparities in obstetrical outcomes are the consequences of differential developmental trajectories set forth by early life experiences and allostatic load (i.e., the cumulative burden of chronic stress and life events) over the life course. Accordingly, eliminating disparities requires interventions and policies that are more longitudinally and contextually integrated than those that currently prevail.[31] Lu et al[32] proposed a 12-point plan to reduce Black-White disparities in birth outcomes using a life course approach. The first 4 points (increase access to interconception care, preconception care, quality prenatal care, and healthcare throughout the life course) address the needs of individuals for quality healthcare across the life span. The next 4 points (strengthen paternal and partner involvement, systems integration, reproductive social capital, and community building) go beyond individual-level interventions to enhance systems that may influence the health of pregnant people, families, and communities. The last 4 points (close

TABLE
Theoretical models and frameworks for social determinants of health

Theory	Description	Key elements
Social ecological Model	Considers the complex interplay among multilevel contexts in which individuals (and populations) are embedded	• Individual health • Pathophysiological pathways • Genetic constitutional factors • Social relationships • Living conditions • Neighborhoods and communities • Institutions • Social and economic policies
Fundamental cause	Root causes of health outcomes operate upstream through multiple replaceable mechanisms to drive health inequities	• Social inequities • Institutional inequities • Living conditions
Life course perspective	Accumulation of risk and protective factors over time, across different "critical windows," and differentially by race and ethnicity perpetuates health disparities	• Risk factors • Protective factors • Socioeconomic status • Behavior • Prenatal care • Race and racism • Chronic stress • Allostatic load • Infection
Ecosocial	Conceptualizes health inequities in relation to power, levels, life course, historical generation, biology, and ecosystems	• Race and ethnicity • Social class • Gender identity • Sexual orientation
Reproductive justice	The human right to maintain personal bodily autonomy, have children, not have children, and parent children in safe and sustainable communities	This includes the right to: • Determine the optimal conditions under which to give birth • Have access to options to not have a child that are appropriate for the situation • Parent and raise children with dignity and access to necessary social support in a safe and sustainable community

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the education gap, reduce poverty, support working mothers, and undo racism) move further beyond the biomedical model to address the social and economic inequities that underlie health disparities.

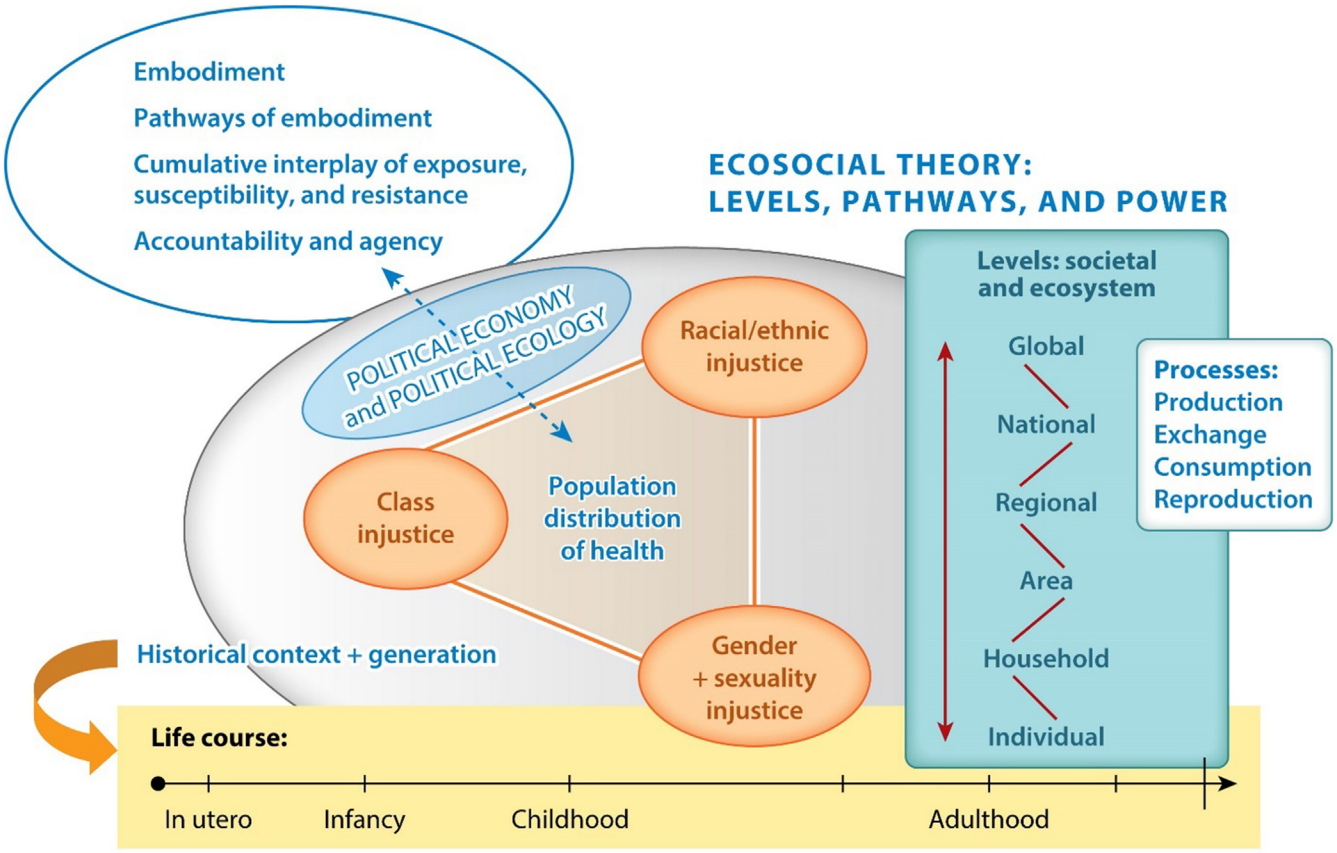
Ecosocial theory

The ecosocial theory integrates social and biological factors to understand health inequities about power, life course, historical trajectories, biology, and ecosystems (Figure 2). It describes processes through which injustice is lived through socially and legally ascribed identities over time at the intersections of race, ethnicity, class, gender identity, and sexual orientation. The ecosocial theory of disease distribution posits 4 core conjoined constructs: (1) embodiment (i.e., how we incorporate, biologically, our societal and ecologic context, the material and social world in which we live); (2) pathways of embodiment; (3) cumulative interplay of exposure, susceptibility, and resistance across the life course and levels; and (4) accountability and agency.[33] The construct of intersectionality, a term originating in the legal and social sciences, similarly conveys the socially structured entanglement of multiple types of injustice, although without focusing on the pathways and processes of literal biological embodiment.[33]

Reproductive justice

Reproductive justice refers to the human right to maintain personal bodily autonomy, have children or not have children, and parent children in safe and sustainable communities. Reproductive justice includes the right to determine the optimal conditions under which to give birth, the approach to use to delay or prevent having a child, and the ability to parent and raise children with dignity and access to necessary social support in a safe and sustainable community. This framework, created by Black women, was designed to shift power toward the expertise of Black

FIGURE 2
Ecosocial theory of disease distribution



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birthing communities while remaining inclusive for action needed to support all communities of color experiencing structural marginalization.[15,34]

Measurement

Theory-driven approaches to measurement are key to understanding structural racism, interpersonal racism, or other forms of discrimination and structural harm, such as colorism, intimate partner violence, and the housing or built environment. Of note, one illustrative and highly relevant example concerns the constructs of race and ethnicity. Identifying the race or ethnicity of a person or group of participants, along with other sociodemographic variables, may provide information about participants included in a study, give insight into the potential generalizability of the results of a study, and help to elucidate important disparities and inequities. If race and ethnicity categories are collected for a study, the reasons they were assessed should be described in the "Methods" section of the study, and these measures should be collected in alignment with current best practices.[35] Researchers should aim for inclusivity by providing comprehensive categories and subcategories where applicable and always attempt to collect a person's identity by self-report. Many people may identify with more than one race and ethnicity; therefore, categories should not be considered absolute or viewed in isolation.[36] In addition, it is essential to use caution in interpreting or generalizing findings from studies of risk that are based on populations of individuals representing specific or limited racial and ethnic categories,[36] given the different contexts in which individuals live.

Policy solutions

During the introductory session, several examples of legislation and policies directed at the many social determinants of obstetrical outcomes were provided. For example, the Black Maternal Health Momnibus Act of 2021 (and reintroduced in 2023) is a package of bills aimed at addressing the multilevel dimensions of the Black maternal health crisis in the United States.[37] The Black Maternal Health Momnibus Act will (1) make crucial investments in SDOH, such as housing, transportation, and nutrition, that influence

maternal health outcomes; (2) provide funding to community-based organizations that are working to improve maternal health outcomes and promote equity; (3) support the study of unique maternal health risks facing pregnant and postpartum veterans and support maternity care coordination programs within the Veterans Administration health system; (4) grow and diversify the perinatal workforce to ensure that every mother in the United States receives culturally congruent maternity care and support; (5) improve data collection processes and quality measures to better understand the causes of the maternal health crisis in the United States and inform solutions to address it; (6) support mothers with maternal mental health conditions and substance use disorders; (7) improve maternal healthcare and support for incarcerated mothers; (8) invest in digital tools (e.g., telehealth) to improve maternal health outcomes; (9) promote innovative payment models to incentivize high-quality maternity care and nonclinical perinatal support; 10) invest in federal programs to address the unique risks and effects of COVID-19 during and after pregnancy and advance respectful maternity care in future public health emergencies; (11) invest in community-based initiatives to reduce levels of and exposure to climate change-related risks for mothers and children; and (12) promote maternal vaccinations to protect maternal and child health.

The Social Determinants for Moms Act makes key investments and advances crucial research on social determinants to improve maternal health and end disparities in maternal health outcomes.[38] The Build Back Better Act is a bill that focuses on improving social infrastructure and contains economic and social provisions that support well-being of American families.[39] The Anti-Racism in Public Health Act calls on the federal government to develop an antiracism policy and address issues around the public health effect of racism through various federal agencies.[9] President Biden signed an Executive Order on Advancing Racial Equity and Support for Underserved Communities that calls for the federal government to pursue a comprehensive approach to advancing equity for all, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality.[40]

Following the introductory session that provided the above overview of the SDOH and obstetrical outcomes, participants separated into 3 breakout sessions, each of which addressed one of the central topics of the workshop. The discussions of each of these breakout sessions are summarized below.

Approaches to and research opportunities for the epidemiological analysis of social determinants of health in obstetric settings

Understanding the causes of health disparities is crucial to developing policies to eliminate them. However, identifying these causes is challenging for several reasons. Causal factors are frequently correlated, interact with each other, and may form interconnected causal chains that hinder the effort to distinguish a single causal effect from noncausal associations. In addition, causal mechanisms may operate at many levels, including behaviors, relationships, and social structures, each of which entails different conceptualization and measurement approaches. Furthermore, the processes leading to disparities may involve feedback loops and dependencies that result in dynamic relations and emergent properties that are not easily reducible to independent effects. Therefore, beginning to understand these complex causes is only possible if appropriate methodologies and complementary approaches are selected.[41]

In addition, it is important to incorporate and further develop models that reflect the multilevel nature of the causes of health disparities to provide richer and more accurate characterizations of plausible etiologic pathways. Researchers should consider expanding the use of complex systems analyses and simulation modeling to better characterize the intricate relationships between SDOH and health disparities and the interventions meant to mitigate detrimental consequences of SDOH. Lastly, qualitative and mixed methods analysis should be essential aspects of investigation so that participants' perspectives can illuminate plausible causal mechanisms and provide a better understanding of the effects of policies and interventions.[41]

Workshop participants agreed that primary prevention of adverse obstetrical outcomes and elimination of disparities will require a societal approach to improve education quality, income equity, and neighborhood characteristics.[42] To this point, studies in the literature evaluating SDOH and obstetrical outcomes have lacked breadth and, as noted above, have had significant limitations in the conceptualization and measurement of SDOH variables, particularly for constructs, such as race and ethnicity.[43] For example, studies may have used race and ethnicity in aggregate and siloed categories or as an "observed" rather than self-identified variable. The former may fail to account for differences or ambiguity within groups as they were defined, whereas the latter is inherently inaccurate if it is meant to capture a person's identity. For example, only a few studies in a systematic review on SDOH and pregnancy subdivided their racial and ethnic analyses by country of origin or maternal education—factors that may provide important insight into social position and, in turn, affect outcomes, such as severe maternal morbidity and mortality.[43] Moreover, race is not an isolated risk factor but rather a marker of risk for racism-related exposures.

An additional aspect of the sociohistorical context in which concepts of race and ethnicity exist is "colorism." Colorism, the practice of discrimination by which those with lighter skin are treated more favorably than those with darker skin, is a system of oppression that interlocks with racism and that affects obstetrical outcomes for people of color. For example, Slaughter-Acey et al[44] have

demonstrated that among Black women, skin tone was associated with daily experiences of racism and delayed entry into prenatal care.

The link between SDOH and outcomes resonates for clinicians given their experience that health outcomes are affected by patients' conditions outside the clinical walls, yet some clinicians have raised concerns about their involvement in SDOH-focused interventions.[45] First, they perceive that this is not their domain of expertise or current focus of accountability. Second, some clinicians may worry that healthcare systems already have enough to address and should not play a role in efforts to mitigate or improve SDOH. Third, some clinicians have expressed concern about the limited evidence of the effectiveness of SDOH-directed interventions[46] to improve health outcomes. These attitudes are important to address to facilitate the effective implementation of SDOH-directed interventions in the clinical setting and for healthcare to find its role in population health.[47]

That said, others believe there is enough science to support integrating SDOH measurement and intervention into clinical care and are pursuing evidence-informed interventions with community partners.[48,49] The Institute of Medicine (IOM), now the National Academy of Medicine (NAM), has recommended that social and behavioral health domains be captured in the electronic health record (EHR).[50] The incentive, training, and privacy barriers for incorporating SDOH into EHRs have been discussed by investigators, such as Gottlieb et al.[51] There is evidence that electronic SDOH screening produced higher rates of self-disclosure of some sensitive determinants (violence and substance abuse) than in-person screening.[52] More recently, the feasibility, reliability, and validity of the IOM/NAM recommended domains (except for income) were evaluated, and clinical trials to demonstrate improvement in obstetrical outcomes were recommended.[53] In addition, data frameworks have been proposed to integrate SDOH into primary care and capture SDOH domains in EHRs. Of note, one proposed framework includes embedding structural and individual SDOH data for use in primary care.[54] Screening tools that assess SDOH among specific populations have been developed, such as for an accountable health community initiative[55] and a pediatric emergency department with a predominantly low-income population.[52]

Models are emerging to guide the follow-up of patient-reported SDOH data. Of note, one example is a clinic-to-community treatment model for children living in food-insecure households.[56] State innovation models have explored connections among healthcare, social services, and some SDOH.[57] Accountable care organizations have responded to patients' nonmedical needs, such as transportation, housing, and food.[48] A randomized study, performed in 2 safety net hospitals, of a pediatric intervention of in-person navigation services that addressed families' social needs demonstrated a decrease in families' reports of unmet social needs and a reported improvement in children's overall health status.[58] The authors of this study recommend more evaluations to determine interventions that are most effective and should garner further investment. The Centers for Medicare & Medicaid Services (CMS) launched accountable health communities (ACHs)—the first innovation center model to evaluate the effects of matching the needs of a population (i.e., CMS beneficiaries) with community resources.[59,60] The 5-year ACH model tested 2 tracks: an assistance track, in which community service navigation assistance was provided; and an alignment track, which had as its goal partner alignment to ensure services are available and responsive. These evaluations will provide more evidence about effectiveness in achieving better outcomes, better experience, and lower costs through SDOH-focused interventions. Lastly, just as it is important to evaluate which programs and interventions are effective, it is also important to monitor for unintended consequences of programs and policies to ensure that outcomes and disparities do not worsen.

Research gaps, opportunities, and priorities

Participants in the workshop concluded that key scientific opportunities to improve obstetrical outcomes include improved data quality and measurement, a better understanding of the populations most affected by adverse SDOH, greater insight into several etiologies by which SDOH lead to adverse obstetrical outcomes, and more clinical research to identify preventive and interventional SDOH-focused strategies that enhance health and promote equity. All these efforts must be founded upon community engagement and participation in research.[61] Furthermore, these efforts require the innovative use of data to capture obstetrical events in population-level data systems that include information regarding SDOH on both structural (e.g., built environment) and individual (e.g., food and nutritional insecurity) levels. The inability to link maternal and infant health records and the inability to follow mothers across multiple pregnancies in the setting of insurance churn or changes in the healthcare setting were cited as challenges to fully understanding the linkage between SDOH and obstetrical outcomes through the life course. In addition, the efforts to improve health require the inclusion of individuals from groups historically underrepresented in biomedical research (e.g., those from minoritized communities, with lower economic status, from rural locations).[61] Furthermore, participants stressed the need to evaluate the intersection of SDOH and healthcare systems, including measuring healthcare provider access, SDOH knowledge and ability to handle SDOH needs, and the roles of cultural mistrust and implicit bias. Participants identified technology, such as telehealth and wearable devices, as research opportunities.

Key takeaways and recommendations

When assessing racial and ethnic categories in clinical research, it is crucial to approach the construction of these categories based on one's conceptual framework, analysis

plan, and intended sample. Self-report should be used whenever possible, and "check all that apply" should be offered to allow individuals who identify as multiracial to provide their identity.

In addition, people first and respectful language should be employed. An appropriate referent group specific to the research being conducted should be determined during the planning phase.

Measures of interpersonal discrimination at the individual and institutional levels are key to understanding the full burden of effect for birthing people. These may include overall experiences of unfair or differential treatment, context-specific experiences, implicit biases, and institutional practices. When considering research endeavors, it is important to examine how and in what contexts discrimination affects health and to develop plausible mechanisms to inform the construction of a research question.

Researchers should work to simplify maternal-child data collection procedures and efforts and use best practices that can be shared with the research community. This goal can be accomplished by integrating community-based participatory research practices and forming strong, trusting, and mutually beneficial relationships with community organizations.

Approaches to and research opportunities for measuring how social determinants get biologically embedded to influence health and disease risk

Biological embedding refers to the phenomenon by which exposure to adverse circumstances "gets under the skin" to generate stable alterations in biology that produce enduring, long-term effects.[62] SDOH in the context of obstetrics transduce via biological pathways to lead to population-level health disparities. Despite their unique histories, environments, and lifestyles, populations with historical disadvantages consistently show poorer obstetrical outcomes than those without disadvantages. The theory of historical trauma, which argues that a collective trauma experienced by one generation can negatively affect the well-being of future generations, is a potential framework for understanding the adverse health outcomes seen among populations with histories of subjugation.[63] It is evident from the earliest stages of life onward that stressors persist across the life span, are perpetuated across generations, and are strongly influenced by social and environmental factors, including chronic stress. A conceptual framework for action on SDOH includes enhancing socioeconomic status position and maternal circumstances, thereby mitigating stress and adverse psychosocial factors and improving physiological systems and child health outcomes.

A life course perspective recognizes the importance of time and timing in understanding causal links between exposures and outcomes within an individual life course, across generations, and in population-level disease trends. Adopting a life course perspective directs attention to how the SDOH operate at every level of development—early childhood, childhood, adolescence, and adulthood—to immediately influence health and to provide the basis for health or illness later in life. The life course perspective attempts to understand how temporal processes across the life course of one cohort are related to previous and subsequent cohorts and are manifested in disease trends observed over time at the population level.[64] Time lags between exposure, disease initiation, and clinical recognition (latency period) suggest that exposures early in life are involved in initiating disease processes before clinical manifestations; however, the recognition of early-life influences on chronic diseases does not imply deterministic processes that negate the use of later-life intervention.

Ben-Shlomo and Kuh[65] proposed a simple classification of potential life course models of health according to 2 main mechanisms. The "critical periods" model is when exposure during a specific period has lasting or lifelong effects on the structure or function of organs, tissues, and body systems. In addition, this is known as "biological programming," sometimes called a "latency" model. This concept is the basis of the hypotheses that posit the fetal origins of adult diseases, although it does not preclude the importance of later life effect modifiers.[66] The "accumulation of risk" model suggests that factors that raise disease risk or promote good health may accumulate gradually over the life course; however, there may be developmental periods when their effects have a greater effect on later health than factors operating at other times, and the fetal period has been identified as a particularly vulnerable period in this context.[67]

Circumstances in early life are seen as the initial stage in the pathway to adult health but with an indirect effect, influencing adult health through social trajectories, such as those that restrict educational opportunities, and, thus, influence socioeconomic circumstances and, in turn, physiological system and health and disease risk in later life. Risk factors tend to cluster in socially patterned ways; for example, those living in adverse childhood social circumstances are more likely to be of low birthweight and be exposed to poor diet, more childhood infections, and passive smoking. These exposures may raise the risk of adult respiratory disease, perhaps through chains of risk or pathways over time where one adverse (or protective) experience will tend to lead to another adverse (or protective) experience in a cumulative way. Ben-Shlomo and Kuh[65] argued that the life course approach is not limited to individuals within a single generation but should intertwine biological and social transmission of risk across generations. Such an approach must contextualize any exposure about geographical and secular circumstances that are unique to that cohort of individuals. Recently, the potential for a life course approach to aid understanding of variations in the health and disease of populations over time, across countries, and between social groups has been given more

attention. Smith and Morris[68] suggested that explanations for social inequalities in cause-specific adult mortality lie in socially patterned exposures at different stages of the life course.

The questions of which biological alterations occur in response to adverse SDOH and how these alterations can have long-lasting effects on later health and disease risk are ongoing areas of intense interest and active investigation. Elucidation of the "where" and "how" of biological embedding has broad significance for risk identification, prevention, early diagnosis, and treatment. Conceptual frameworks and empirical studies converge to strongly implicate chronic stress and stress-related biobehavioral processes as a major effector of the causal pathways linking upstream SDOH and health disparities.[69] In terms of fetal programming and the intergenerational transmission of SDOH, stress-related biological processes represent a major pathway through which many (perhaps most) adverse conditions exert their effects.

There is no direct vascular or neural connection between the maternal and fetal compartments; all exchange and communication are mediated by biological processes that interface with and through the placenta. Biomarkers of the endocrine (e.g., cortisol), immune and inflammatory (e.g., interleukin 6), and metabolic system (e.g., insulin) are responsive to perturbation or stress and also are known to play obligatory roles in the initiation, maintenance, and progression of normal gestation, fetal development, and birth, and they can mediate the effects of different intrauterine perturbations on fetal physiology.[67] At the molecular level, activation of these different stress systems in the maternal compartment can have downstream effects on fetal epigenetic characteristics (changes in the regulation of gene activity and expression that are not dependent on gene sequence), such as DNA methylation. A 2021 comprehensive review summarizes the epigenetic effects of social disadvantage.[70]

Furthermore, telomeres (noncoding tandem DNA repeats at the ends of eukaryote chromosomes that form a protective cap) were discussed as another potential molecular target in this context. There is evidence that telomere length is related to SDOH within and across generations.[71,72] Furthermore, alterations in mitochondrial biology in response to perturbations of the stress system represent a plausible mechanism underlying the phenomenon of developmental programming of health and disease risk.[73]

The processes implicated in biological embedding at the molecular levels, such as epigenetic changes, have been described almost exclusively in differentiated cells and tissues of individuals. However, differentiated cells may not constitute the most fundamental targets of biological embedding. The life span of most differentiated cells is significantly shorter than the temporal duration of social disadvantage's long-term effects. Although differentiated cells are continuously replenished, their replenishment does not occur from already differentiated cells but from only stem and progenitor cells. Based on these considerations, it is likely that the effects of social disadvantage on the developing fetus may extend to the level of stem cells, thus promulgating the effects of exposures through phenotypic manifestation in daughter cell populations.[74]

The effects of SDOH and systemic racism on physiology and health outcomes are thought to lead to earlier health deterioration among Black individuals than among White individuals. The cumulative burden of exposures is known as allostatic load, which represents a biological indicator of chronic, cumulative stress exposure[75] related to increased "weathering" or "wear and tear" caused by the high effort required to cope with acute and chronic stressors over the life course. Increased allostatic load is associated with an increased risk of chronic disease and comorbidities, including hypertension, abdominal obesity, and cardiovascular disease. This differential weathering is explained by race-related discrimination that affects Black individuals, in addition to gender discrimination, sexual harassment, and sexism, suggesting that the accumulation of stress over the life course may be intersectional. The concept of allostatic load has guided the exploration of how chronic stress before pregnancy may contribute to birth outcome disparities. For example, telomeres shorten with cell division until a certain point, after which the chromosomes are no longer stable and the cell either dies or enters senescence.[76,77] Because breaks in the DNA structure because of oxidative stress are not easily repaired in telomeres, oxidative stress is an essential mechanism by which telomeres are shortened.[78,79] As oxidative stress is an important mechanism linking aging, psychosocial stress, biological stress activation, inflammation, and disease development, telomeres may serve as a powerful marker of overall biological vs chronological age.[80–84]

Geronimus et al[85] proposed that the excess morbidity and mortality experienced by Black adults relative to White adults stems fundamentally from the persistent and multifactorial stressors—subjective and objective—experienced by Black adults. This stress leads to greater activation of the biological stress processes, which, in turn, leads to a greater allostatic load and greater levels of inflammation and oxidative stress. Early inflammatory processes and oxidative stress contribute to the Black-White disparities in the development and progression of the disease and subsequent mortality, with mononuclear cell telomere length marking this process. As measured by telomere length, Black women have a biological age 7.5 years older than White women of the same chronological age, with differences in perceived stress and poverty accounting for 27% of this difference.[85] A recent study measuring allostatic load biomarkers at a maximum of 4 months before pregnancy found that each unit of increase in allostatic load was associated with increased odds of preeclampsia (62%), preterm birth (44%), and low birthweight (39%).[86]

Key takeaways and recommendations

Stress biology is a unifying transducer of SDOH. Biological embedding, epigenetic characteristics, telomere biology, mitochondrial biology, and stem cells are all viable research

avenues to explore about SDOH. There is value to deepening biological understanding of SDOH, including increasing knowledge of biomarkers of effects at the individual and population levels. In addition, heightening our understanding of biological factors could lead to valuable feedback regarding healthcare and policy, such as proof of concept and messaging of relevance. Biological measures can provide crucial analytical tools to study the interactions between social experiences, such as racial discrimination, and health outcomes over the life course. Physiological dysregulation because of chronic stress has been proposed as a possible mechanism underlying disparities in birth outcomes. Assessing biomarkers of physiological dysregulation before conception or in early pregnancy may help to identify individuals at risk of adverse pregnancy outcomes.[86] Moreover, this research could facilitate postnatal interventions.

The choice of biomarker depends on the research question of interest and the effect of any given exposure, as biological pathways and outcomes are not independent but are conditional on other exposures and states (e.g., stress and nutrition and stress and infection). Investigators should use biomarkers that have provided the most consistent associations between SDOH and inflammatory states in nonpregnant and pregnant individuals, including children. The future of biological pathways research includes initiating biological data collection in trials, implementation studies, and epidemiologic investigations. This approach includes creating a standard template and systematized routine collection of biological samples (e.g., the Telomere Research Network[87]). It is important to incorporate the best practice epidemiology approaches and measures to biologic embedding work:

- Include relevant developmental periods (i.e., preconception, gestation, birth, lactation, and childhood).
- Collect measures (on SDOH and biological samples) on the biological father and/or co-parent in addition to the mother.
- Develop screening tools for early detection of vulnerability or previous adverse exposures to determine who is at heightened risk and, therefore, may benefit from behavioral or social interventions.
- Conduct and view biological work through the lens of equity.

Approaches to and research opportunities for interventions and strategies to mitigate the detrimental effects of social determinants of health and improve obstetric outcomes

Principles for intervention development

As a means of understanding the potential focus of interventions, the breakout group first delineated drivers of health disparities, including social and economic factors (e.g., inequities in employment, income, expenses, debt, medical bills, and support); neighborhood and physical environment factors (e.g., housing, transportation, safety, parks, playgrounds, and walkability); educational factors (e.g., literacy, language, early childhood education, vocational training, and higher education); food security and access to healthy nutritional options; community, safety, and social context factors (e.g., social integration, support systems, community engagement, stress, and exposure to violence and trauma); and healthcare system factors (e.g., health coverage, provider availability, provider linguistic and cultural competency, and quality of care). Pregnancy is a window of opportunity for access, acceptability and motivation, positive spread, and life course benefit. Cumulatively, this information allows the development of a framework for understanding how SDOH can influence and maintain health and health-related issues and for identifying promising points of intervention.

As noted earlier, the social ecological model considers the complex interplay between individual, relationship, community, and societal factors. It allows intervention developers to understand the multilevel influence of factors that put people at risk for health disparities and to generate interventions that address different levels. An example of an intervention at the institutional level is the Michigan Plan for Appropriate Tailored Healthcare (MiPATH) in pregnancy.[88–90] MiPATH is a tailored prenatal care model that provides patients with options for medical care, education, and support during pregnancy. Patient navigation, a patient-centered intervention that uses trained personnel to facilitate complete and timely access to health services, is an example of interpersonal intervention.[89,91,92] Elements of this intervention include identifying patient-level barriers to healthcare access, improving the timeliness of care, providing health education and resource referrals, offering social support, facilitating shared decision-making, and promoting health equity. Navigation has a simultaneous focus on patient-centeredness, systems-level expertise and tools, and awareness of community resources. Examples of interventions in the intrapersonal domain include those that address health literacy or provide mobile health (mHealth) tools. An example of an mHealth tool is SweetMama,[93,94] a novel mobile application to provide support and education to pregnant people with diabetes mellitus. Based on health behavior theories, SweetMama delivers a diabetes mellitus–focused educational curriculum containing tips, motivational messages, goal-setting messages, recipes, appointment reminders, and trusted resources.

Principles of intervention development should include solution-based design and design justice. Design justice rethinks design processes, centers people who are normally marginalized by design, and uses collaborative, creative practices to address the deepest challenges that communities face. This type of design emphasizes targeting the unique processes of obstetrical care and functioning despite the limitations of the health system. Tenets of this intervention in maternal care include establishing clear and

measurable SDOH goals, centering the maternal and family experience, and centering those who live on the margins. By focusing on interventions that will best serve the families who have been marginalized by current policy approaches, giving these families a meaningful voice in the design process, and evaluating the effectiveness of interventions according to outcomes they have identified as meaningful, this model marks a radical shift in the power dynamics of how policy is made and for whom it works.

Interventions should be implemented equitably. Current gaps in intervention development include that most interventions within obstetrics have been developed at the individual level and rarely are obstetrical health interventions developed with a multilevel focus on equity. In addition, SDOH are rarely considered in biomedical interventions; for example, clinical trials rarely collect data on SDOH that are relevant to sustainable dissemination and implementation of the intervention past the trial period. Other reported issues include that interventions are likely differentially effective for different indicators of health, the population of interest is rarely included in intervention development, there is inadequate intervention evaluation, and implementation science remains nascent in obstetrics.

Practical application with community organizations

The workshop overall and the group that focused on interventions discussed the key importance of community organizations and community-academic partnerships in the development and implementation of interventions meant to overcome adverse SDOH. Several examples of such organizations were presented. Of note, one example of a community organization working to sustainably improve obstetrical health outcomes and eliminate disparities is Mamatoto Village, a Black-led social change organization.[95] Mamatoto Village serves Black women through the creation of career pathways in maternal health and provides accessible perinatal support services designed to equip women with the necessary tools to make the most informed decisions in their maternity care, parenting, and lives. This organization provides collective care and runs on a community-centered model of care with a justice-centered lens. It provides social proximity, culture, a 3-generation approach (upstream solution, family wellness for the whole family), and training.

The California Preterm Birth Initiative conducts and funds transdisciplinary research across the reproductive life course to probe risk and resilience factors and identify promising interventions that can turn the curve on the preterm birth epidemic.[96] The California Preterm Birth Initiative addresses questions prioritized by women and vetted by community advisory boards, redefining the crisis of premature birth through justice and equity.

The Central Valley Health Policy Institute was established in 2002 at California State University, Fresno, to facilitate regional research to address emerging health policy issues that influence the health status of people living in Central California.[97] The EMBRACE Prenatal Care Program at the University of California, San Francisco, aims to provide women and providers with information about which type of enhanced prenatal care improves preterm birth rates, maternal mental health outcomes, and satisfaction with care so they may make informed decisions.[98] At inception, the study developed initiatives to address living conditions and other SDOH. It piloted a group prenatal care program to gain a nuanced understanding of the experience of care, including racism and other forms of discrimination, among Black and Latinx participants, and perceptions of respectful and disrespectful care.

Cradle Cincinnati is a network of partners working across sectors to measurably improve preconception health, pregnancy health, and infant health to reduce preterm birth and infant mortality in Hamilton County.[99] It uses a collective impact model and involves several health and civic partners, including community maternity hospitals, public health departments, churches, schools, social service agencies, and families. Their strategy includes supporting families through direct services, moving to an upstream approach through state-initiated policy, and amplifying community voices through a community-based model. Cradle Cincinnati's Queens Village program provides an example of authentically engaging the community via a data-driven strategy. The successes of Queens Village stem from listening and engaging with the community and building based on firsthand experiences for interventions and system-level change. Queens Village embraces theories, such as the Sojourner Syndrome and weathering (described earlier) that disproportionately affect Black women. The Sojourner Syndrome is an illustrative and symbolic representation that describes the multiple roles and social identities of Black women based on historical referents and adaptive behaviors that fostered survival and resilience under oppressive circumstances.[100] In addition, adaptive behaviors precipitate health risks because of chronic active coping.

In addition, Queens Village incorporates asset-based community development (ABCD) and community advisory boards. The ABCD is an approach to sustainable community-driven development. Beyond the mobilization of a particular community, it is concerned with how to link microassets to the macroenvironment. The ABCD's premise is that communities can drive the development process themselves by identifying and mobilizing existing needs, thereby responding to challenges and creating local social improvement and economic development. Community advisory boards are a collective group of community members and organization representatives that provide community information and assistance to the research project or initiative team. They focus on large-scale social change, systems change, and social cohesion through the strength of relationships and the sense of solidarity among community members, and they work on "future-casting" by focusing on predicting what may have a significant effect on their organization in the future.

Key takeaways and recommendations

It is important to understand that developing interventions with community engagement work is rarely quick, as it takes time to overcome historically rooted distrust, gain the multiple perspectives that are needed, and use the rigorous methods that are required. It is crucial to have clear goals, to communicate those goals early and often, and to align research and professional goals in health equity with the goals and priorities of the community. Guiding principles are addressing SDOH, having a clear scope of work, and aiming to achieve sustainable success.

Organizational challenges and opportunities include a need for interprofessional education, behavior change, and cultural humility skills. Approaches to convincing resistant organizations of the importance of SDOH and community-centered work may include investing in qualitative work, allowing for opportunities and forums where lived experiences can be shared, implementing principles of organizational change theory, and understanding extrinsic motivations. Research challenges and opportunities include encouraging investigators to be accountable for closing disparities, funding interventions aimed at SDOH, and addressing challenges of designing studies that have dual aims of improving health and closing equity gaps. Approach, messaging, and language aimed at underrepresented groups should be nonpejorative and nonblaming, and the inclusion of community members in the design of messaging and implementation of interventions is essential.

Future research needs and next steps

Actions for clinicians

Clinicians can volunteer for and support community organizations and raise personal awareness of SDOH in their practices. They should listen to the unique needs of patients and the community and develop a network for referrals and SDOH support. They can train other clinical team members to recognize and address SDOH in routine clinical practice. Clinicians should use a strengths-based perspective, inquiring about and incorporating a patient's supportive environmental factors, not just adverse SDOH. Furthermore, they should have an in-depth conversation with the patient to understand how the community systems are, or are not, working for them.

Actions for institutions

Institutions can ensure that quality improvement initiatives measure health equity by collecting the data that support SDOH interventions and tracking their progress. In addition, they can participate in State Perinatal Quality Collaboratives and other initiatives promoting birth equity. Institutions can apply diversity and inclusion principles to change institutional culture and promote, train, and retain diverse healthcare teams. Lastly, they can ensure that SDOH screening programs include resources and processes for linkage and partner with community leadership.

Actions for researchers

Researchers should move beyond identifying disparities by investing time and money in developing and testing potential solutions. They can test the effectiveness and implementation of interventions. In addition, they can use the shared power that is cultivated when working within communities to generate and implement solutions and use rigorous methods for intervention mapping and outcomes measurement. Lastly, they can address the sustainability of interventions by taking a systems change approach[101] while also advocating for funding for SDOH interventions.

Unifying principles of social determinants of health interventions

Discussants generated a list of unifying principles to guide SDOH interventions. The list is as follows:

- Listen to the community.
- Respond to patient needs—solve their problems, not yours.
- Be flexible and iterative in the development and implementation of interventions.
- Think outside the box, clinic, or hospital.
- Be trustworthy.
- Practice cultural humility.
- Connect to your "why."

Conclusion

Workshop participants proposed many recommendations and key points for addressing adverse SDOH and the effects of systemic racism in the context of obstetrical care and outcomes. In addition, they noted many research gaps that still exist in the evidence for best practices in determining how SDOH are best measured, how they exert their effects within and across generations, and how their effects on obstetrical health can be best modified. Issues proposed for further research and consideration include the following:

- Development of an evidence-based approach to define the most salient measures of structural racism and SDOH
- Focus not only on the adverse SDOH that may hinder the achievement of health equity but also on the salutary aspects (e.g., resilience or social support) that may enhance it
- Best practices to integrate community-based participatory methods into obstetrical research and program development
- Strategies to expand dissemination and implementation science in obstetrical research such that the gap between evidence and practice begins to narrow
- Best practices to allow for interventions to undergo iterative growth and change as population and community needs change while acknowledging the rigidity of factors, such as institutional culture and funding
- Initiation of biological data collection in trials, implementation work, and epidemiological studies

- Optimal strategies to incorporate SDOH into types of biomedical research, such as clinical trials or translational research, that have typically ignored social drivers of health
- Creation of a standard template and systematized routine collection of biological samples (This has been developed in the context of telomere research [e.g., Telomere Research Network, https://trn.tulane.edu].)
- Inclusion of relevant developmental periods (i.e., preconception, gestation, birth, lactation, and childhood) in research about SDOH
- Inclusion of measures (on SDOH and biological samples) of the father or co-parent
- Development of screening tools for early detection of vulnerability and previous and ongoing adverse exposures to diagnose early in life who is at heightened risk and therefore may benefit from behavioral or social interventions

It is hoped that this workshop will serve as a catalyst for the further development of evidence-based approaches to understanding the relationship between SDOH and obstetrical outcomes and to help guide the construction and implementation of interventions that can result in better outcomes and equity.

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