



SPECIAL ARTICLE

# A workshop report on the causes and consequences of sleep health disparities

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## Abstract

Sleep deficiencies, which include insufficient or long sleep duration, poor sleep quality, and irregular timing of sleep, are disproportionately distributed among populations that experience health disparities in the United States. Sleep deficiencies are associated with a wide range of suboptimal health outcomes, high-risk health behaviors, and poorer overall functioning and well-being. This report focuses on sleep health disparities (SHDs), which is a term defined as differences in one or more dimensions of sleep health on a consistent basis that adversely affect designated disadvantaged populations. SHDs appear to share many of the same determinants and causal pathways observed for health outcomes with well-known disparities. There also appears to be common behavioral and biological mechanisms that connect sleep with poorer health outcomes, suggesting a link between SHDs and other health disparities observed within these designated populations. In 2018, the National Institute on Minority Health and Health Disparities, the National Heart, Lung, and Blood Institute, and the Office of Behavioral and Social Sciences Research convened a workshop with experts in sleep, circadian rhythms, and health disparities to identify research gaps, challenges, and opportunities to better understand and advance research to address SHDs. The major strategy to address SHDs is to promote integration between health disparity causal pathways and sleep and circadian-related mechanisms in research approaches and study designs. Additional strategies include developing a comprehensive, integrative conceptual model, building transdisciplinary training and research infrastructure, and designing as well as testing multilevel, multifactorial interventions to address SHDs.

## Statement of Significance

Populations within the United States that have been designated as health disparity populations experience poorer sleep and more sleep deficiencies. Sleep health disparities (SHDs) may, at least in part, explain health disparities in other health outcomes for these populations. SHDs appear to share many of the same determinants and causal pathways observed for health outcomes with well-known disparities suggesting the importance of understanding SHDs and exploring if there is an association between SHDs and other health disparities. Research on SHDs may identify common causal health disparity pathways and/or sleep and circadian-related mechanisms that contribute to disparities in many well-known health disparities, providing better ways to improve minority health and reduce health disparities.

**Key words:** sleep; health disparities; epidemiology; social determinants; health disparity causal pathways; sleep and circadian-related mechanisms

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## What Are Health Disparities?

A health disparity is a health difference that adversely affects designated disadvantaged populations, including higher incidence and/or prevalence of disease, premature or excessive mortality, poorer health behaviors, and worse daily functioning (Table 1) [1]. Within the United States, racial and ethnic minority populations have experienced historic and consistent discrimination, social disadvantage, and health disparities [2]. Congress directed the National Institutes of Health to improve minority health and reduce health disparities through research and education and established criteria to designate populations as health disparity populations (HDPs) for these efforts [3]. Currently, Blacks/African Americans, Hispanics/Latinos, American Indians/Alaska Natives, Asians, Native Hawaiians, and Other Pacific Islanders, socioeconomically disadvantaged populations, underserved rural populations, and sexual and gender minority populations have been designated as US HDPs (Table 1).

## Sleep Health Disparities

Sleep health disparities (SHDs), defined as differences in one or more dimensions of sleep health (duration, efficiency, timing, regularity, alertness, and quality)—on a consistent basis—that adversely affect designated disadvantaged populations (Table 1),

Table 1. Definitions of Key Concepts

<p><i>Sleep Deficiencies:</i> Insufficient or long sleep duration, poor sleep quality, and irregular timing of sleep.</p> <p><i>Sleep Health:</i> Multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, that promotes physical and mental well-being. Dimensions are regularity, quality, alertness, timing, efficiency, and duration [27]. These dimensions should also be experienced on a consistent basis.</p> <p><i>Sleep Health Disparity:</i> A difference in one or more dimensions of sleep health (regularity, quality, alertness, timing, efficiency, and duration)—on a consistent basis—that adversely affects designated disadvantaged populations.</p> <p><i>Health Disparity:</i> A health difference that adversely affects defined disadvantaged populations, based on one or more health outcomes.</p> <ul style="list-style-type: none"> <li>• Higher incidence and/or prevalence of disease, including earlier onset or more aggressive progression</li> <li>• Premature or excessive mortality from specific conditions</li> <li>• Greater global impact of disease, such as disability-adjusted life years, as measured by population health metrics</li> <li>• Poorer health behaviors and clinical outcomes related to above, and</li> <li>• Worse outcomes on validated self-reported that reflect daily functioning or symptoms from specific conditions [1].</li> </ul> <p><i>US Health Disparity Populations:</i> Currently designated HDPs are Office of Management and Budget defined Racial/Ethnic Minority groups (Blacks/African Americans, Hispanics/Latinos, American Indians/Alaska Natives, Asian Americans, Native Hawaiians, and other Pacific Islander) and socioeconomically disadvantaged populations, underserved rural populations, and sexual and gender minorities (which include lesbian, gay, bisexual, transgender, and gender-nonbinary or gender-nonconforming individuals). Public Law 106-525, The Minority Health and Health Disparities Research and Education Act of 2000 (<a href="https://www.govinfo.gov/content/pkg/PLAW-106publ525/pdf/PLAW-106publ525.pdf">https://www.govinfo.gov/content/pkg/PLAW-106publ525/pdf/PLAW-106publ525.pdf</a>) established the process and criteria (differences in the overall rate of disease incidence, prevalence, morbidity, mortality, or survival rates in the population as compared to the health status of the general population) to designate HDPs.</p>
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are important to address. To date, minimal research has been conducted on the prevalence, incidence, morbidity, or mortality of sleep deficiencies for most of the designated HDPs; but when examined, sleep deficiencies are disproportionately distributed among HDPs [4, 5]. For example, racial and ethnic minority populations are generally more likely to experience sleep deficiencies and sleep disorders, greater sleep onset latency, excessive daytime sleepiness, less slow-wave (or deep) sleep, and obstructive sleep apnea (OSA) [6–12]. Sleep deficiencies can also vary based on a variety of socioeconomic status (SES) indicators, such as income, education, occupation, and wealth [10, 13–17].

## Health Disparity Causal Pathways

The sociocultural and physical/built environments of an individual have both direct and indirect influences on their development and health over their life course [18]. The NIMHD Minority Health and Health Disparities Research Framework (<https://nimhd.nih.gov/about/overview/research-framework/>) recognizes the importance of sociocultural and physical/built environments on minority health and health disparities. The levels of influence are societal, community, interpersonal, and individual [3]. Each level has health determinants from the biological, behavioral, physical/built environment, sociocultural environment, and health care system domains that influence health. Health disparities can arise as a consequence of an individual's social identities and statuses, which can result in exposure to multiple determinants at multiple levels that manifest as poorer health outcomes [19].

Social identities and statuses such as race, age, sex, sexual orientation, nationality, and SES can intersect and exacerbate effects beyond any individual identity or status and also influence an individual's experience and exposures within the sociocultural and physical/built environments [20]. Furthermore, experience based on social status will vary greatly due to the historical and contemporary context of a specific geopolitical location [21, 22]. Disparities in health outcomes across populations and geography can be attributed, in part, to discriminatory policies and practices involving racial segregation, disproportionate material deprivation, limited access to health care, or greater exposure to detrimental features of the physical/built environment such as light, noise, and air pollution, all of which are known to also affect sleep [23–25]. The distribution of sleep deficiencies overlaps with the same geographic regions and the same populations as those most impacted by health disparities [26]. The dimensions of sleep health are responsive to differences in sociocultural and physical/built environmental opportunities, demands, and resources; thus, incorporating health disparity causal pathways into SHD research is critical. Health disparity causal pathways are complex; but at their core, these pathways recognize health outcomes are influenced by social identities and statuses and exposures within the sociocultural and physical/built environment.

## Sleep and Circadian-Related Mechanisms

Sleep and circadian rhythms are fundamental requirements for maintaining biological homeostasis. These integrated physiological and behavioral processes affect one another and are essential to biological organization ranging from gene expression to

behavior. Sleep deficiencies impact sleep and circadian-related mechanisms, such as learning and memory consolidation, emotional regulation, energy conservation, metabolism, immune function, and cardiovascular regulation, and can mediate or modify different health outcomes. Downstream consequences of disrupting these mechanisms, including hyperreactivity of stress and fight/flight responses, alterations in the immune response, dysregulation of energy homeostasis, and impaired neurobehavioral development and function are also implicated in health disparities; thus, it is essential to incorporate sleep and circadian-related mechanisms into SHD research [27, 28].

## Strategies to Address SHDs

The National Institute on Minority Health and Health Disparities (NIMHD), National Heart, Lung, and Blood Institute (NHLBI), and

the Office of Behavioral and Social Sciences Research (OBSSR) organized a workshop to address SHDs. Experts on health disparity causal pathways and sleep and circadian-related mechanisms were brought together to identify scientific gaps, opportunities, and strategies to understand and address (1) the underlying health disparity causal pathways contributing to SHDs and (2) how SHDs may have consequences that result in disparities in other health outcomes for HDPs. Below are strategies to improve the understanding of health disparity causal pathways (causes) and health outcomes (consequences) of SHDs for these designated HDPs.

Strategies to address SHDs emerged in the following four areas which are described in detail below and summarized in [Table 2](#): (1) Develop and Promote Integrative Research on SHDs, (2) Investigate the Causes and Health Consequences of SHDs, (3) Develop Interventions to Address SHDs, and (4) Build Research Infrastructure and Training Opportunities.

**Table 2.** Sleep Disparities Research Strategies

<b>I. Develop and Promote Integrative Research on SHDs</b>	
1. Develop and promote an integrative conceptual framework	a) Develop and promote a comprehensive testable conceptual framework for studying SHDs b) Operationalize a definition of sleep health that is reliable across populations
2. Promote integrative research approaches	a) Integrate health disparities and sleep research approaches b) Promote the research continuum from etiology to intervention to dissemination and implementation science
<b>II. Investigate the Causes and Consequences of SHDs</b>	
3. Examine the role of sociocultural and physical/built environmental determinants in SHD and as contributors to sleep health	a) Investigate racism and other forms of discrimination as a major contributor to cumulative chronic stress and driver for SHD b) Leverage multilevel and multifactorial study designs to examine causal pathways for SHDs c) Investigate potential protective/resiliency factors for healthy sleep
4. Investigate the health and social consequences of SHD	a) Investigate sleep as a potential contributor to disparities in health outcomes b) Investigate the influence of sleep on a broader range of health outcomes in a defined population study c) Investigate the influence of SHDs on daily function, quality of life, and social consequences d) Investigate the interconnected and bidirectional nature of sleep with multimorbidity of chronic conditions
<b>III. Develop Interventions to Address SHDs</b>	
5. Develop interventions to promote sleep health	a) Design interventions aimed to improve sleep health awareness in health disparity populations b) Develop population-level interventions focused on policies and practices to promote healthy sleep
6. Develop multilevel, culturally tailored interventions to address SHDs	a) Promote multilevel interventions that incorporate social and environmental determinants of health to address SHDs b) Adapt and develop evidence-based, culturally appropriate interventions across the life course for specific health disparity populations c) Develop approaches to promote early detection of poor sleep and sleep disorders among health disparity populations in various settings
7. Investigate sleep interventions as mediators or modifiers for health outcomes with observed disparities	Determine whether sleep mediates or modifies interventions addressing health outcomes with observed disparities
<b>IV. Build the Research Infrastructure and Training Opportunities for SHDs</b>	
8. Optimize the use of existing data and promote the advancement of methodologies and research infrastructure	a) Leverage existing data sets from health disparities or sleep fields and advocate for the inclusion of sleep and health disparities measures b) Prioritize increased representation from racial/ethnic minority and other health disparity populations in sleep studies c) Develop and expand methodologies to assess population-level differences in sleep studies
9. Promote integrative training opportunities	Incentivize a training pipeline that develops a diverse workforce capable of conducting transdisciplinary research on SHDs

## Develop and promote integrative research on SHDs

The incidence and prevalence of sleep deficiencies at a population level are influenced by many of the same determinants for other health outcomes with known health disparities. Thus, a nuanced integration between health disparity causal pathways and sleep and circadian-related mechanisms tailored for the specific population(s) and sensitive to the sociocultural context(s) is needed to understand and address SHDs.

### *Develop and promote an integrative conceptual framework*

**Develop and promote a comprehensive conceptual framework for studying SHDs.** Several conceptual frameworks that are important for integrative research between health disparity causal pathways and sleep and circadian-related mechanisms include *socioecological, life course, and circadian rhythm perspectives*. The conceptual framework should be able to be tailored for specific populations and the sociocultural context. The *socioecological framework* emphasizes the importance of integrating societal and community determinants (health disparity causal pathways) with interpersonal and individual determinants (sleep and circadian-related mechanisms) to understand and address SHDs [3, 18]. Social identities, social statuses, and the local geopolitical setting influence exposure to and experiences within sociocultural and physical/built environments. Furthermore, experiences may vary across individuals from different populations, locations, and cultures [29–31], which underscore the importance of studying population differences in SHDs within the sociocultural context.

*Life course perspectives* recognize the importance of critical and sensitive periods of development at specific life stages (e.g. gestation, childhood, adolescence, young adulthood, midlife, and old age) [32, 33]. Important life course concepts include the timing of adverse exposures, linked exposures, and cumulative exposure that result in shifts in health trajectories. This perspective posits transgenerational transmission of health disparities occurs through both sociocultural and biological mechanisms and highlights the importance of longitudinal and multigenerational research designs to study SHDs [32, 33].

Sleep is highly intertwined with *circadian rhythms*. Humans evolved to obtain adequate exposure to sunlight during the day and moonlight or darkness at night [34]. Disruption of natural light/dark cycles, such as artificial light at night can disrupt sleep and may lead to circadian misalignment which has been associated with increased risk of obesity and cardiovascular disease (CVD) [35–37]. Thus, important concepts to study SHDs include the 24-h day, light/dark cycles, and influences from the physical environment such as season and geography. Important approaches will include time-based methods such as ecological momentary assessments to capture daily experiences in an individual's natural environment and accounting for season and geography.

**Operationalize a definition of sleep health that is reliable across populations.** Sleep health, with both voluntary and involuntary characteristics, can be considered a multidimensional pattern of sleep and wake, adapted to individual, social, and environmental demands, that promotes physical and mental well-being [27]. An emphasis on sleep health is not intended to discount the importance of addressing sleep disorders or sleep deficiencies, but

rather to stimulate research on the role of sleep as a risk and/or protective factor. As cardiovascular health can often be improved even in the absence of disease to promote health and reduce the risk of future disease, operationalizing sleep health can expand the understanding of the role of sleep in promoting health.

To operationalize sleep health will require the development of definition(s) and measures that are valid and reliable across populations. Because some aspects of sleep health are potentially modifiable, investigating the role of sleep as either a protective or risk factor for populations most negatively affected by poor health may provide ways to improve overall health and address health disparities.

### *Promote integrative research approaches*

**Integrate health disparities and sleep research approaches.** Effectively integrating health disparity causal pathways and sleep and circadian-related mechanisms is needed to advance SHDs research. To date, most sleep research has focused on biological pathways and mechanisms while largely ignoring the influence of the sociocultural and physical environments of research participants. Similarly, health disparities research has focused primarily on the influence of social determinants on health outcomes without considering the biological mechanisms and pathways involved.

The promotion of integrative transdisciplinary approaches is needed to better integrate the fields. Studies should explicitly delineate the relevant theories for health disparity causal pathways (such as critical race theory, minority stress, cumulative disadvantage [23, 38–40]) as well as delineate the specific sleep and circadian-related mechanisms that are being incorporated into the research study design. In addition to culturally informed design and delivery models, research studies should include expertise from multiple disciplines, utilizing biopsychosocial approaches that examine health outcomes as a result of biological, psychological, and social determinants rather than purely biological factors. These multilevel approaches that consider the influence of various determinants from multiple levels (e.g. individual, family/household, community, and/or societal) will also be important for both etiological and intervention studies in SHDs research [41, 42]. A key initial step is including measures of sleep as well as sociocultural and physical/built environment determinants in the same study. Another opportunity is to add measures of either sleep or sociocultural and physical/built environment determinants to well-characterized cohort studies or use geocoded data to link studies with biological measures with sociocultural or physical/built environmental administrative data sets.

**Promote the research continuum from etiology to intervention to dissemination and implementation science.** The research continuum from etiology to the design and testing of interventions should initially consider how to deliver and sustain interventions for the lived experience of HDPs. Community-based participatory research principles, in descriptive, observational, etiological, and/or intervention research, can enhance the relevance, quality, effectiveness, and sustainability of the findings for specific populations [43, 44].

Typically, interventions for the general population or the idealized patient are not easily or effectively transferred to low-resource settings or varied sociocultural contexts [45, 46].



Incorporating sound dissemination strategies and implementation science within the early stages of the integration of sleep and health disparities research fields will mitigate future barriers that prevent efficient and effective adoption of proven outcomes.

### Investigate the causes and consequences of SHDs

**Examine the role of sociocultural and physical/built environmental determinants of SHDs and as contributors to sleep health**

**Investigate racism and other forms of discrimination as a major contributor to cumulative chronic stress and a driver for SHDs.** Racism and other forms of discrimination are fundamental determinants of health disparities that can contribute to exposures in the physical/built and sociocultural environments. Discrimination can be defined as a system of structuring opportunity and assigning value based on the social interpretation of phenotype or external appearance [47]. This system of inequitable distribution of power and resources leads to disadvantaged and advantaged individuals and communities, likely contributing to the manifestation of health disparities. For instance, discriminatory policies and practices contribute to racial disparities in residential segregation, housing and food insecurity, poverty or financial instability, lower levels of educational attainment, occupational stressors, and inadequate access to and utilization of quality health care [48–52].

Racism and other forms of discrimination operate on multiple levels and across the life course; therefore, investigating the timing and exposure to structural, interpersonal, and internalized discrimination and effects on physiological and biological mechanisms is crucial to understanding SHDs [47, 53–55]. For example, discrimination has been associated with poor sleep quality, short sleep, trouble falling asleep, and poor sleep continuity [56–61]. More research is needed on the potential mechanisms by which discrimination affects sleep in populations experiencing health disparities, such as allostatic load induced by stress related to racism-related vigilance, depression and anxiety, and risky-coping behavior [62–64]. Additionally, it is important to consider intersectionality, the intersecting and exacerbating effects of multiple social statuses, when examining the role of racism and other forms of discrimination in SHDs [65, 66].

**Leverage multilevel and multifactorial study designs to examine causal pathways for SHDs.** Health outcomes are typically examined one health determinant at a time; however, health disparities arise due to interactive factors from multiple domains of influence. A paradigm shift is needed to advance SHDs research, from examining single vulnerabilities and single determinants to an appreciation of intersectionality of multiple dimensions of social inequality and the convergence of determinants arising from multiple levels and systems, including health care, economics/labor, education, social services, and criminal justice [65–67].

Since causes of health disparities are complex and multifactorial, study designs for SHDs research need to consider the influence of sociocultural and physical/built environmental factors. Features of the physical and built environment such

as light, noise, poor air quality, walkability and housing conditions, access to natural amenities (e.g. green space) have been shown to affect sleep and are likely to contribute to SHDs [68]. In addition to the physical environment, the sociocultural environment like family dynamics, safety, and social cohesion has been shown to influence sleep and sleep disorders among adults and children [69].

**Investigate potential protective/resiliency factors for healthy sleep.** Positive adaptation to negative exposures is a clear demonstration of resilience [70]. “Health resilience is the capacity to maintain good health in the face of significant adversity” [71]. Protective factors that promote health and protect against the harmful effects of adversity can operate at individual and contextual levels. More research is needed to identify how potential protective factors and resiliency influence and mitigate risk for SHDs. For example, physical activity was shown to be protective in adolescents where short or poor-quality sleep lessened the amount of internalizing and externalizing problems associated with poor sleep [72]. Sleep was shown to moderate discrimination’s effect on anxiety or mitigate the effects of family stress such as marital conflict, harsh parenting, and parental psychological control on adolescent cognitive functioning [73, 74]. Because an individual’s sleep adapts to their individual, social, and environmental demands, protective factors may mediate or modify exposures to adverse physical and social conditions; thus, these factors could be leveraged for effective interventions to address sleep deficiencies, improve sleep health, and reduce disparities.

### Investigate the health and social consequences of SHDs

Limited data are available on the consequences of sleep on health among designated HDPs. More research is needed to answer the question of whether sleep deficiencies influence health outcomes for which there are known health disparities in designated HDPs.

**Investigate sleep as a potential contributor to disparities in health outcomes.** The influence of sleep on various health outcomes has been reported in non-Hispanic Whites. Racial and ethnic minority and low SES populations are more likely to be shift workers and are at increased risk for circadian disruption or circadian misalignment, which can alter sleep and health trajectories [75]. As this example illustrates, it is plausible that sleep deficiencies could play a role in driving various health disparities. Thus, an important research strategy is to examine whether SHDs are a potential contributor to known health disparities in designated HDPs.

**Investigate the influence of SHDs on a broader range of health outcomes in a defined population study.** Rather than investigating one health outcome at a time in each study, research designs should assess multiple health outcomes within the same study. For example, researchers studying cardiovascular health and related biological indicators such as smoking status, physical activity, diet/nutrition, weight/body mass index, blood pressure, cholesterol, and/or blood glucose could also gauge whether there is an interaction with mental health outcomes [76]. Investigating the influence of sleep on a broader range of health outcomes in a defined population study would determine

whether there are common causal health disparity pathways and/or sleep and circadian-related mechanisms that contribute to disparities.

**Investigate the influence of SHDs on daily function, quality of life, and social consequences.** The effect of sleep deficiencies on daily function and quality of life is equally as important as their effects on health outcomes or morbidity and mortality. Furthermore, health disparities for these real-world and social outcomes have been found within designated HDPs [77, 78]. The opportunity and ability to succeed in educational and occupational settings along with family and other social or interpersonal relationships also translate into real-world importance and could be affected by poor sleep. For example, sleep deficiencies are related to increases in the risk of serious accidents and injury at work and while driving; poorer cognition, social interactions, and emotional functioning; as well as higher risk-taking behaviors. Assessments of SHDs should encompass measurements of physical, mental, and social functioning and well-being.

**Investigate the interconnected and bidirectional nature of sleep with multimorbidity of chronic conditions.** It is important to recognize the interactive, bidirectional nature of sleep. Sleep influences a wide range of diseases and conditions. These same diseases and conditions can affect sleep. Furthermore, multimorbidity, commonly defined as two or more coexisting chronic diseases, is prevalent in the United States and disproportionately affects HDPs [79–81]. Thus, research designs need to take into account the interactive, bidirectional nature of both sleep and multimorbidity. How SHDs lead to higher rates of various comorbidities and how multimorbid conditions may influence sleep patterns, as well as potential interactions between sleep and multimorbidity, are important questions. Designing research studies with multimorbidity may enable teasing apart and identifying complex health disparity causal pathways and common sleep and circadian-related mechanisms.

### Develop interventions to address SHDs

Interventions should be relevant and culturally acceptable for diverse populations as well as scalable and sustainable. The effectiveness of the interventions, with regard to differing cultural sleep behaviors and beliefs and/or for settings such as low-resourced urban neighborhoods and community, rural and/or health care settings for medically underserved, should also be assessed.

#### *Develop interventions to promote sleep health*

Despite Healthy People 2020 identifying chronic sleep loss as having a negative public health impact [82] and recent improvements in awareness through national campaigns, such as “National Healthy Sleep Awareness Project” led by the Centers for Disease Control, the American Academy of Sleep Medicine, and the Sleep Research Society [83], greater awareness of the importance for healthy sleep and the public health impact of chronic sleep deprivation and sleep disorders is needed among the lay community and health care professionals [84].

**Develop interventions aimed to improve sleep health awareness in HDPs.** There is a lack of awareness of the importance of

sleep for health, especially among populations experiencing health disparities. It has been shown that African American participants are less likely than their White counterparts to report motivation to make time for sleep and less likely to have access to information about sleepiness and the relationship between sleep and health [4]. Promoting sleep health should incorporate the related health beliefs, practices, linguistics, and other socio-cultural context of different populations. Including culturally tailored components can enhance the relevance and effectiveness of interventions among populations particularly vulnerable to sleep deficiencies in hopes of promoting sleep health.

**Develop population-level interventions focused on policies and practices to promote healthy sleep.** The promotion of healthy sleep policies and practices should be based on sociocultural context and developed for multiple settings (i.e. home, work or school, and recreational activities) and sectors (e.g. health care and occupational industries). The barriers to attaining sleep health and circadian rhythms that differ across populations along with cultural health beliefs, practices, behaviors, and unique needs such as linguistics should be incorporated into interventional designs. Examples of sleep- and circadian-related policy and practice interventions include workplace policies that provide flexible work schedules and school start times that allow for adequate sleep hours for adolescents [85]. Additionally, policy and practice interventions to promote sleep health will require recognition of the public health and economic importance of sleep by key decision-makers and stakeholders. Cost-benefit analyses focused on interventions to promote sleep health will also be important for design, scalability, and effective implementation.

#### *Develop multilevel, culturally tailored interventions to address SHDs*

Interventions that directly address SHDs are limited, but there are some examples from designated populations experiencing health disparities in OSA [86, 87]. Among African American adults, OSA is associated with poorer CVD outcomes and lower treatment adherence. A tailored intervention to address barriers for effective care including lack of OSA awareness, inadequate health care access, language barriers, and mistrust of health care systems was found to be three times more successful in promoting sleep consultation and evaluation but showed no difference in adherence to treatment [86]. Subsequently, several interventions were designed to address the low-adherence OSA evaluation and treatment through peer-based sleep health education and social support [87] and a web-based sleep educational intervention to increase OSA knowledge and health literacy among African Americans [88]. More efforts are needed to develop tailored interventions to address SHDs and its health consequences in populations experiencing health disparities.

**Promote multilevel interventions that incorporate social and environmental determinants of health to address SHDs.** Sleep intervention research, as well as interventions on disparities in other health outcomes, is primarily conducted at the level of the individual. However, because sleep health and SHDs are influenced by sociocultural and physical/built environmental determinants, multilevel approaches that address sociocultural and physical/built determinants of health are needed. For example, to address obesity disparities, interventions that

improve nutrition and physical activity at the individual level are unlikely to succeed when the food and sociocultural environments (e.g. unsafe and limited recreational space, ready access to low-cost, calorie-dense food options) and high rates of poverty present severe barriers to maintaining healthy diets and active lifestyles.

Place-based interventions, such as a housing intervention, could uniquely address multiple sociocultural and physical/built environmental determinants of SHDs, including individual lifestyle and SES tailored for the specific sociocultural context. Treatment and prevention interventions require multi-level solutions and engagement of multi-sectoral stakeholders (e.g. education, housing, labor/economics, justice, health care) [89–91]. Understanding the various contexts that influence individual-, interpersonal-, and community-level risk for SHDs is central to identifying intervention targets. Efforts to reduce health disparities and promote health must, therefore, address the dynamic interplay of multiple levels of influence to be effective [89].

**Adapt and develop evidence-based, culturally appropriate interventions across the life course for HDPs.** The adaptation and development of evidence-based, culturally appropriate sleep interventions that are appropriate for these designated HDPs are sparse. Many evidence-based interventions have exhibited limited adoption, reach, and sustainability when implemented in diverse community settings, especially in low-resource settings that serve populations experiencing health disparities. HDPs have been underrepresented in research testing the efficacy of interventions to improve health [45]. Interventions for HDPs that often require extensive adaptations to intervention content and delivery may need to use a variety of approaches to identify appropriate strategies to improve the acceptability, practicality, feasibility, and integrability of an evidence-based intervention [45].

Furthermore, interventions need to be designed from a life course perspective to take into account that health outcomes develop over time and specific developmental periods when conditions are most responsive. Furthermore, the interventions themselves may have latent, pathway, or cumulative effects depending on when and how frequently they are administered [32]. To address this gap, first, the effectiveness and implementation of well-established evidence-based sleep interventions should be examined among designated HDPs for a wider range of sociocultural settings and life stages. Second, interventions should be adapted to better address the sleep needs of these populations and settings.

**Develop approaches to promote early detection of poor sleep and sleep disorders among HDPs in various settings.** The accumulating empirical evidence of the existence of SHDs points to the need for evidence-based population-specific sleep interventions to address SHDs across the continuum of care. For example, racial and ethnic minorities experience disparities in health care quality for sleep disorders, even when insurance status, income, age, and severity of conditions are comparable [29]. Despite an increased likelihood of short sleep duration and identified poor health outcomes, minorities tend to report fewer sleep disturbances [29, 92] and are often un- or underdiagnosed [93]. Furthermore, there is limited awareness, knowledge,

and screening opportunities for sleep disorders like OSA [94]. Although some patient-level characteristics are known, much is unknown about provider- and health care system-level factors. Interventions should consider how social and cultural factors influence patient expectations, health-seeking behaviors, and underlying differential treatment responses.

Most population-specific interventions have been conducted in a clinical setting, however, the benefits of school-based screening and prevention programs have been demonstrated for a variety of health conditions. Although largely uninvestigated, studies exploring the effectiveness of school-based sleep interventions are promising [95]. Effective interventions in stimulating healthy sleep duration and adherence to regular bedtimes are mostly multibehavioral interventions that include creating daily healthy routines and intervening at multiple settings such as home, community, and school. Strategies to develop interventions for various settings should begin with engaging community members and stakeholders to incorporate key cultural beliefs, practices, constraints, and concerns.

**Investigate sleep interventions as mediators or modifiers for health outcomes with observed disparities**

**Determine whether sleep mediates or modifies interventions addressing health outcomes with observed disparities.** Sleep interventions could modify or potentiate other health outcomes. Furthermore, interventions that target nonsleep health outcomes with known health disparities could also improve or worsen sleep, which in turn could also contribute to the overall effectiveness of the intervention for the nonsleep health outcome. Understanding the contribution of adequate sleep or sleep deficiency to the disparities observed with health and/or social outcomes may enhance the efficacy and effectiveness of these interventions. For example, incorporating a sleep component into a health disparity intervention that uses behavioral modifications to reduce high-risk health behaviors may improve overall physical and mental health.

**Build the research infrastructure and training opportunities for SHDs**

**Optimize the use of existing data and promote the advancement of methodologies and research infrastructure**

Advancement in integrative methodological approaches and research infrastructure is key for moving SHDs research forward. Leveraging and maximizing the use of existing data sets, increasing representation of designated HDPs, explicitly assessing population-level differences, and further developing valid and reliable tools (e.g. biomarkers/assays) for assessing sleep and circadian phases, both independently and in combination, are all approaches that can be used to address SHDs.

**Leverage existing data sets from health disparities or sleep fields and advocate for the inclusion of sleep and health disparities measures.** A few large-scale epidemiological studies have been designed to assess the associations between sleep and health outcomes for HDPs (e.g. sleep ancillary study of Multi-Ethnic Study of Atherosclerosis). However, there are key epidemiology studies, both cross-sectional and longitudinal cohorts that have diverse representation and have contributed to the



understanding of either sleep or health outcomes. This strategy advocates for the inclusion of both sleep and health disparities measures to key epidemiological studies to increase the capacity of studies to be leveraged to better understand SHDs. In addition to self-reported sleep measures for entire study samples, objective sleep measures for representative subsets should be prioritized. Additionally, social determinants (e.g. residential, occupation, education), measures important in health disparities (e.g. discrimination such as racism, geocoding to link sociocultural and physical/built environmental data), and representation for designated HDPs across several locations and sites should also be added.

**Prioritize increased representation from racial/ethnic minorities and other HDPs in sleep studies.** Researchers should ensure representation of underrepresented designated HDPs in studies with sleep measures by being cognizant of recruitment concerns and selection bias when designing studies to better understand SHDs. Furthermore, attention to how contextual factors may influence the study population, such as geographic region, seasons/time of year, recruitment using mono- versus multi-lingual and site type such as clinical versus community, is important to ensure an adequate study population for SHDs research questions.

**Develop and expand methodologies to assess population-level differences in sleep studies.** The development of new and the enhancement of existing sleep and circadian phase assessments/tools, such as standardized questions, self-reported/objective measures, and biomarkers that are valid and reliable across populations are needed. Methodologies are needed that are adaptable for broad assessment modality (in-person, telephone, computer-assisted interviewing, etc.) and translatable across populations and sociocultural contexts. For example, sleep duration measures work well across cultures and languages, however, measures of insomnia may perform differently across populations since the assessment requires perception, which can differ across cultures.

### Promote integrative training opportunities

#### **Develop a diverse workforce capable of conducting transdisciplinary research on SHDs**

Integrative research training across the sleep and health disparities fields is vital to the advancement of SHDs research. First, the research workforce should be racially and ethnically diverse across sleep and health disparities in scientific fields. Second, infrastructure and support for transdisciplinary research should be developed and promoted for upcoming researchers.

Research investigator training in SHDs research should occur in multiple areas, including clinical, public health, dissemination, and implementation science training. Efforts such as training workshops, educational courses, and mentoring from experts in both sleep and health disparities can be used for future workforce development and may prevent unnecessary attrition of diverse researchers across the various career stages. Training in community-based participatory and community-engaged research is critical, as involving the community in all stages of project development, and is critical to the success of the project or program.

## Summary

This workshop report highlights research gaps, challenges, and opportunities in sleep and health disparities research that are important to advance the emerging field of SHDs among designated US HDPs. Since the causes of health disparities are complex and multifactorial, future sleep disparities research should focus on health disparity causal pathways and sleep and circadian-related mechanisms to understand SHDs. Proposed strategies from the workshop include (1) focusing on sociocultural and physical/built environmental determinants of sleep health to understand the underlying contextual factors to target disparities in sleep, (2) better integration of sleep and health disparities research fields, and (3) designing multilevel interventions through transdisciplinary teams to ultimately address SHDs. Research focusing on causal pathways and consequences of SHDs is warranted with the ultimate goal of accomplishing sleep health equity, “equal opportunities that are given to each individual and/or communities based on their need, no matter their age, sex, race/ethnicity, geographic location, and socioeconomic status, to obtain recommended, satisfactory, efficient amount of sleep with appropriate timing that promotes physical and mental well-being” [82].

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