Childhood obesity research at the NIH: Efforts, gaps, and opportunities

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ABSTRACT
Childhood obesity is a major public health challenge. This article describes an overview of the National Institutes of Health (NIH) behavioral and social sciences childhood obesity research efforts. The overview will highlight five areas of childhood obesity research supported by the NIH: (a) basic behavioral and social sciences; (b) early childhood; (c) policies, programs, and environmental strategies; (d) health disparities; and (e) transagency and public–private collaboration. The article also describes potential gaps and opportunities in the areas of childhood obesity and severe obesity, measurement, and sleep.

Keywords
Childhood obesity, Behavioral and social sciences, Health disparities, Infancy and early childhood, Sleep, Severe obesity

INTRODUCTION
Childhood obesity continues to be a major public health challenge with 18.5% of children aged 2–19 years having obesity [1]. Despite earlier reports that there may be stabilization of obesity among children [2], recent findings suggest that obesity is not decreasing and severe obesity is increasing among Hispanic children [3, 4]. Children who have obesity are more likely to have cardiovascular risk factors [5, 6], type 2 diabetes [7], and are at increased risk for morbidity and mortality as adults [8] including increased risk of developing several types of cancer [9].

To address the childhood obesity epidemic, the National Institutes of Health (NIH) supports a broad spectrum of biomedical and behavioral research that seeks to identify the causes and consequences of childhood obesity and to develop new and more effective approaches to its prevention and treatment [10]. The childhood obesity research that NIH supports includes studies in pregnancy, infancy, childhood, adolescence, and prevention and treatment approaches in families, schools, and other community settings, as well as in health care settings. The NIH also supports basic behavioral and social science research that is providing insights into factors related to the development, prevention, and treatment of childhood obesity, as well as environmental and policy-related research.

In the following section, we provide an overview of the NIH behavioral and social sciences childhood obesity research efforts. This overview is not meant to be a comprehensive summary of NIH’s childhood obesity activities, but instead is based on active and recently completed NIH-funded research activities including workshops and funding announcements as they relate to the behavioral and social sciences. This overview highlights five areas of childhood obesity research supported by the NIH: (a) basic behavioral and social sciences; (b) early childhood; (c) policies, programs, and environmental strategies; (d) health disparities; and (e) transagency and public–private collaboration. Based on research findings and workshop recommendations, discussions on potential gaps and future opportunities in childhood obesity research are provided.

Implications
Policy: Childhood obesity continues to be a major public health challenge, and research related to programs, policies, and/or environmental strategies could be further explored to assess factors related to the promotion of healthy weight among children.

Research: To address the childhood obesity epidemic, the NIH supports a broad spectrum of biomedical and behavioral research that seeks to identify the causes and consequences of childhood obesity to develop new and more effective approaches to its prevention and treatment, and synthesize and disseminate evidence within the NIH and with other stakeholder organizations.
NIH EFFORTS

Basic behavioral and social sciences research in childhood obesity

The NIH has long recognized the importance of basic behavioral and social science research related to pediatric obesity and has supported numerous efforts through various Institute and Center initiatives as well as through investigator-initiated research [11]. In particular, one major initiative, the Obesity-Related Behavioral Intervention Trials (ORBIT) consortium (www.nihorbit.org), was a trans-NIH program led by the National Heart, Lung, and Blood Institute (NHLBI) that facilitated the translation of basic behavioral and social science findings into pediatric and adult obesity-related interventions [12]. The findings from ORBIT and other investigator-initiated research have advanced our understanding of several drivers of food intake and eating behaviors such as taste preferences, self-regulation, impulsivity, sensitization to the relative reinforcing value of food, food reward and inhibition, emotional eating, habituation to food, and ability to delay gratification [13]. Another important trans-NIH initiative is the Science of Behavior Change (SOBC) that focuses on understanding mechanisms for novel targets of behavior change. Self-regulation, stress resilience and reactivity, and interpersonal and social processes have all been identified by SOBC as promising targets of behavior change and intervention development [14], and all of these targets can be considered relevant for obesity prevention and control.

Despite significant advances in our understanding of eating behaviors, the individual characteristics and processes that predict and explain physical activity behaviors are not well understood. In response, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) held a Workshop on Behavioral Phenotyping of Physical Activity and Sedentary Behavior in December 2015 to identify gaps and promising research opportunities in behavioral and psychological phenotyping related to variation in physical activity and sedentary behaviors as they relate to obesity [15]. This workshop resulted in the release of an NIDDK-led, trans-NIH program announcement (PAR-18-105) Ancillary Studies to Identify Behavioral and/or Psychological Phenotypes Contributing to Obesity.

Finally, research has demonstrated that characterizing and influencing individuals’ behaviors in relation to obesity prevention and treatment is increasingly complex and will require more personalized intervention approaches. Individuals’ behaviors do not operate in a vacuum nor are individuals necessarily characterized by one behavioral phenotype[16]. Future research in this area could work toward deciphering underlying behavioral mechanisms and developing theoretical frameworks that incorporate a more comprehensive and interdisciplinary approach, identifying patterns of behavioral and psychosocial phenotypes in the context of their various environmental influences.

Early childhood

Early childhood is a critical time period in the development of obesity, and the NIH supports several efforts focusing on the prenatal period through age 5. Recognizing the importance of the role of early childhood in the development of obesity, the NIH sponsored a 2013 workshop on the “Prevention of Obesity in Infancy and Early Childhood” [17], which resulted in a funding announcement, PA-18-032: Understanding Factors in Infancy and Early Childhood (Birth to 24 Months) that Influence Obesity Development (R01 Clinical Trial Optional).

In addition to studying obesity during infancy, the NIH also recognizes the importance of trans-generational impacts and has two large research initiatives that offer opportunities to better explore the trans-generational effects of obesity and its mechanisms: (a) Lifestyle Interventions for Expectant Moms (LIFE-Moms) and (b) Environmental influences on Child Health Outcomes (ECHO) program. Pregnancy is an opportunity to intervene and influence outcomes for the mother and offspring. In 2011, the NIH launched the LIFE-Moms consortium to determine whether behavioral and lifestyle interventions in overweight and obese pregnancy would have an effect on excessive gestational weight gain and impact maternal and child outcomes [18]. The findings from the LIFE-Moms consortium show that women randomized to the intervention group gained less weight compared with the standard care group [19]. The de-identified LIFE-Moms data will be available for investigators to access and analyze for future manuscripts. For more information, see https://repository.niddk.nih.gov/home/.

In 2016, the NIH launched ECHO to fund multiple, synergistic, longitudinal studies using 83 pediatric cohorts to investigate environmental exposures—including physical, chemical, biological, social, behavioral, natural, and built environments—on child health and development [20]. Obesity is a key pediatric outcome with data to be contributed by all cohorts, enabling investigators to explore how obesity emerges from a complex web of exposures in early childhood. Future research could continue to explore the mechanisms of how early-life exposures contribute to the development of obesity and what factors (e.g., home and pediatric settings) may be leveraged to encourage healthy weight development.

Policies, programs, and environmental strategies

Policies, programs, and environmental strategies have an important influence on childhood obesity, but how and to what extent they affect childhood obesity warrants further study. Many of the factors

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addressable by policy and environmental change, such as large infrastructure changes or implementation of taxes or subsidies, are not under the control of researchers and may not be studied using traditional randomized study designs, relying instead on a study design referred to as a natural experiment [21]. A 2010 Institute of Medicine report and 2011 NIH Strategic Plan for Obesity recommended increased emphasis on evaluation of policy and environmental changes to determine their impact on improved diet, physical activity, and weight outcomes [22, 23].

The NIH supports the evaluation of natural experiments through funding announcements PAR-17–178: Evaluating Natural Experiments in Healthcare to Improve Diabetes Prevention and Treatment (R18), PA-16–165: Obesity Policy Evaluation Research (R01), and PAR-18-834: Time-Sensitive Obesity Policy and Program Evaluation (R01). The grants funded through the aforementioned funding announcements cover a wide range of policy and environmental strategies including changes to the built environment through light rails, parks, and transportation improvements and the influence on physical activity and health; policies targeting sugar-sweetened beverages and the impact on diet and added sugars; and how later school start times are associated with weight and health outcomes among adolescents.

In addition to investigator-initiated research, the NIH has also launched large initiatives to assess how multi-level environmental factors affect childhood obesity. The NIH Healthy Communities Study was an observational study of 130 diverse communities that sought to determine the associations between characteristics of community programs and policies and body mass index (BMI), diet, and physical activity in children [24]. Data were collected on children (retrospectively up to 10 years using medical abstraction), their parents, the home environment, school lunch and physical activity environments, and community programs and policies (retrospectively up to 10 years). The results show that over time, more intense programs and policies are related to lower childhood BMI and that there are disparities in this association by sociodemographic family and community characteristics [25]. A de-identified public use dataset of the Healthy Communities Study is available for researchers to access at https://biolincc.nihbi.nih.gov/home/. Future research could investigate how contextual factors within communities (e.g., race/ethnicity of the community, crime, housing) interact with community programs and policies to promote healthy or obesogenic environments.

Health disparities

Obesity prevalence has risen to epidemic levels, particularly among various racial and ethnic minority groups, including Hispanics, African Americans, American Indians/Alaskan Natives, and low-income populations both in urban and rural communities and in all age groups across the lifespan [2]. To promote the health of future generations of adults, many NIH institutes have funded research addressing health disparities to gain a better understanding of the etiology of obesity as well as interventions that would lower the prevalence of obesity. The Childhood Obesity Prevention and Treatment Research (COPTR) consortium is an example of a large NIH initiative addressing health disparities and childhood obesity. COPTR tested multi-level multicomponent intervention approaches [26] to prevent excess weight gain in nonoverweight and overweight youth and to reduce weight in obese and severely obese youth [27]. Research funded under this consortium targeted preschoolers (2–5 years old) and preadolescents and adolescents (7–15 years old) with a total sample size of ~1,750 (N ~50% females and ~70% minorities) for 3 years of intervention [27]. Two obesity prevention trials tested approaches that target home, community, and primary care settings for preschool children living in low-income and ethnically diverse neighborhoods. Two obesity treatment trials examined therapies for overweight and obese children, 7–15 years old, in school and home settings in collaboration with local youth organizations. The findings from COPTR could contribute to future understanding of the multiple factors, including social determinants of health indicators, to prevent or treat obesity among a diverse population of low-income children [28, 29].

Recently, NIH staff led a systematic review of interventions addressing obesity disparities with the goal of providing guidance for future research, particularly in populations with a high prevalence of obesity and obesity-related cardiometabolic risk. The review noted a dearth of high-quality research that targets minority populations and a limited number of clinical trials in youth [30]. NIH staff also convened workshops such as the Multi-Level Intervention Research Methods: Recommendations for Targeting Hard-to-Reach, High-Risk or Vulnerable Populations and Communities. Recommendations from the workshop have been published elsewhere [31] and include recommendations under the following topics: study design and analytical approaches, intervention implementation, cultural adaptation of intervention, use of community health workers, and training of interventionists. Funding opportunity announcements that are relevant to health disparities research include PA-18–412: Addressing Health Disparities in NIDDK Diseases (R01 Clinical Trial Not Allowed); PA-18–152: Reducing Health Disparities Among Minority and Underserved Children (R01 Clinical Trial Optional); and PA-18–169: Reducing Health Disparities Among Minority and Underserved Children (R21 Clinical Trial Optional). Future
research needs to better understand the biological and behavioral mechanisms of childhood obesity as well as the contextual and environmental factors that may alleviate or exacerbate obesity disparities [32].

Transagency and public–private partnership
Launched in 2009, the National Collaborative on Childhood Obesity Research (NCCOR; www.nccor.org) brings together the nation’s four largest childhood obesity research funders—Centers for Disease Control and Prevention, NIH, United States Department of Agriculture, and Robert Wood Johnson Foundation—in a public–private collaboration to accelerate progress in reducing childhood obesity. Major NCCOR foci are identifying and evaluating practical and sustainable interventions; improving research resources (see Measurement section in this article for examples) to facilitate childhood obesity research and program evaluation; providing national leadership to accelerate implementation of evidence-informed practice and policy; and developing synergistic childhood obesity initiatives across multiple stakeholders [33].

NCCOR uses this collaborative approach to combine resources and expertise from stakeholder organizations to identify emerging areas of research need, formulate projects within the scope of the NCCOR mission, and identify external collaborators and funding sources by which to implement projects. Examples of NCCOR NIH led or co-led activities include (a) the Healthy Communities Study (https://www.nhlbi.nih.gov/science/healthy-communities-study-hcs/), (b) the Johns Hopkins Global Obesity Center (www.globalobesity.org), (c) the Envision Research Network (https://www.nccor.org/envision/publications.html), and (d) the Childhood Obesity Declines (https://www.nccor.org/projects/obesity-declines/) among others. Of note is that NCCOR recognizes that many and varied research design and evaluation approaches are needed to better understand the difficulties in reducing rates of childhood obesity, especially in the context of community-based initiatives. Thus, the initiatives cited here span research efforts, targeting individual behavior change to policy implementation, environmental to systemic social determinants of childhood obesity, and recognize the importance of community and academic partnerships. In addition to facilitating research resources and improving intervention and research methods, NCCOR is dedicated to the dissemination of promising evidence regarding intervention strategies and evidence-informed programs to policy makers and program implementers, particularly those embedded in the community and those addressing health inequities and underserved communities. Future research could continue to explore how partnerships with various entities such as housing, transportation, education, and social services can work together to more effectively deliver childhood obesity interventions.

GAPS AND OPPORTUNITIES
In addition to the abovementioned NIH efforts, severe obesity, measurement issues in childhood obesity research, and the mechanisms associated with sleep and obesity have emerged as gaps and opportunities for further childhood obesity research.

Severe obesity
Severe obesity in youth, defined as BMI ≥ 1.2 times the 95th percentile or an absolute BMI ≥ 35 kg/m², is a prevalent and serious disease with a limited number of effective and safe treatment options [34]. The prevalence of severe obesity among all children is 5.6% and is highest (7.7%) among adolescents aged 12–19 years [3]. To address the issue of severe obesity among adolescents, a workshop led by NIDDK, in cooperation with several NIH Institutes and Centers, entitled “Developing Precision Medicine Approaches to the Treatment of Severe Obesity in Adolescents” (https://www.niddk.nih.gov/news/meetings-workshops/2017/workshop-developing-precision-medicine-approaches-treatment-severe-obesity-adolescents) was convened in September 2017 to explore the current state of the science and identify (a) what is known regarding the epidemiology and biopsychosocial determinants of severe obesity in adolescents, (b) what is known regarding effectiveness of treatments for severe obesity in adolescents and predictors of response, and (c) gaps and opportunities for future research to develop more effective and targeted treatments for adolescents with severe obesity. Several gaps were identified and recommendations were made for opportunities to accelerate research to advance precision medicine approaches to treat severe obesity in adolescents and to enhance methodological rigor in pediatric obesity research. More research is needed to better understand the underlying etiology and pathophysiology of severe obesity in children and developing effective intervention approaches.

Measurement
Measurement is a fundamental component of all forms of research, including research on childhood obesity. The development and consistent use of high-quality, comparable measures and research methods is a priority. To address this need and encourage innovative research with novel assessment approaches, better statistical methods and modeling, and tools for culturally diverse populations and/or children at various ages, the NIH supports the Diet and Physical Activity Assessment Methodology (PA-16–167). However, the advancement and application of appropriate diet and physical activity measures remains challenging, as highlighted at two workshops at NIH, “Extending Dietary Patterns...
Research Methods” [35] and “Research Strategies for Nutritional and Physical Activity Epidemiology and Cancer Prevention” [36].

NIH resources are available to provide guidance on selecting measures and to provide tools for research. For example, NCI developed the Dietary Assessment Primer (https://dietassessmentprimer.cancer.gov/) to help determine the best way to assess diet, and specific dietary assessment tools, such as the Automated Self-Administered 24-Hour (ASA24; https://epi.grants.cancer.gov/asa24/) and Dietary Assessment Tool and the Diet History Questionnaire (https://epi.grants.cancer.gov/dhq2/). In addition, NCCOR’s Measures Registry and User Guides (https://www.nccor.org/nccor-tools/measures/) were developed for four relevant domains, including diet, physical activity, food environment, and physical activity environment, and were designed to provide an overview of measurement, describe general principles of measurement selection, present case studies, and direct researchers to additional resources across the lifespan.

Although these tools are useful, opportunities exist to further develop objective measurements of diet and physical activity through new technologies that integrate and exploit advances in wearable sensors and other novel image-based tools. More sophisticated exposure characterization for childhood obesity researchers could allow for measurement of individual diet and physical activity behaviors as well as a linkage in real time to other details that include geospatial location, time, and context, providing opportunities to examine new research questions and identify potential targets for intervention.

Sleep and obesity

Recent meta-analyses have found an association between shortened sleep duration and increased risk of obesity in children [37–39]. The relationship between sleep and obesity is stronger in younger children than in adolescents [37], and more research is needed to better understand why the relationship varies with age. Future research could also investigate the mechanisms of sleep/circadian rhythms and the development of obesity including how in utero factors may affect those mechanisms. Sleep is a modifiable behavior, and research is needed to better understand how improving sleep may affect weight gain, weight loss, and weight maintenance. For instance, a recent study found that it was possible to increase sleep in children, and the increased sleep condition versus decreased sleep condition was associated with lower self-reported caloric intake and weight, but the study was short in duration and had a small sample size [40]. More research is needed to better understand how intervention approaches including sleep can lead to the prevention and treatment of obesity. Furthermore, future research could address how health disparities may interact with sleep to affect obesity. NIH is currently supporting funding announcement PAR-17–234: Mechanisms and Consequences of Sleep Disparities in the U.S. (R01).

CONCLUSION

This article highlights NIH childhood obesity research efforts in the behavioral and social sciences. There are several activities that the NIH has undertaken to further the knowledge, prevention, and treatment of childhood obesity. In addition to the aforementioned NIH efforts, there are emerging gaps and opportunities related to severe obesity, measurement issues, and sleep and obesity. The childhood obesity epidemic continues to grow, and the NIH is committed to supporting research that will help alleviate the obesity epidemic. NIH will continue to support behavioral and social science approaches to better understand the drivers of childhood obesity and to develop effective interventions.

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