U.S. Childhood Obesity and Climate Change: Moving Toward Shared Environmental Health Solutions

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ABSTRACT

This article focuses on the epidemic of childhood obesity, a significant cause of pediatric morbidity in the United States. It begins with a review of the evidence regarding environmental influences on obesity. Then it draws from that evidence to cite examples of climate change prevention and preparedness efforts that could also benefit the obesity problem. Climate change is a global environmental issue predicted to negatively impact children’s health. In the United States, many regions are expected to experience worse air quality, increased vector-borne disease, and changes in food availability. Children’s size, developmental stage, and long life expectancy make them unique when considering health effects from the environment. Furthermore, in the latter part of this century, the children of today will become seniors, a group also vulnerable to predicted health impacts from climate change. These vulnerabilities will contribute to existing health disparities that are due, in part, to unequal risk factors in communities of color and low income. Improved air quality, healthier diets, and increased physical activity are all potential results of climate change interventions. Unintended potential negative consequences are also discussed and careful pre-intervention assessment is emphasized. Interdisciplinary collaborations for research and solutions are needed for large scale environmental issues such as climate change and their impact on multi-factorial health problems including childhood obesity. Carefully selected climate change-related efforts can simultaneously address current children’s health problems, future population health concerns, and ultimately result in more equitable health for all.

NEW PEDIATRIC MORBIDITIES

While childhood infectious diseases continue to significantly burden parts of the world, they are rapidly becoming eclipsed by the emergence of previously rare and altogether new problems referred to as the new pediatric morbidities. These are typically chronic conditions that persist into adulthood and include obesity, asthma, neurodevelopmental disorders like attention-deficit and hyperactivity disorder (ADHD), childhood cancers, birth defects, and preterm birth. The portrait of childhood conditions in the United States is very different from global pediatric disease but increasingly these new morbidities are beginning to appear around the world due in part to changing global trends in diet, activity levels, and air quality.2,3 Within the United States, significant disparities exist in children’s health that are related to numerous factors including different environmental exposures. Research shows that environmental factors such as the built, or human-made, environment contributes to the rising prevalence of these health problems.

Whether considering the built environment or environmental toxins, children’s size, developmental stage, and long life expectancy make them uniquely vulnerable. Through different mechanisms in different parts of the world, climate change is creating new environmental risks while exaggerating old ones to which children have increased vulnerability such as increased heat, changes in outdoor air quality, rising sea level, and contaminated water. Older individuals are also more vulnerable to these changes. The children today will be seniors in the latter...
part of this century. The effects of climate change on both current and future environmental risks thus will impact today’s children throughout their life span.\textsuperscript{6,7} Furthermore, climate change is exacerbating already glaring international disparities in children’s health and is thus an environmental justice issue. Environmental justice issues are defined here as unequal community exposures (chemical or otherwise) resulting from the actions and decisions of persons, institutions, or nations external to those exposed communities.

Obesity and, increasingly, climate change have been at the forefront of health concerns, with widespread coverage in scientific journals, national and international conferences, and the media. Yet opportunities for exploring interdisciplinary approaches to addressing these health issues have been far fewer. The purpose of this article is to identify potential co-benefits from climate change interventions on one major U.S. pediatric morbidity, obesity. First, evidence regarding environmental risk factors for pediatric obesity is examined. Then, some select climate change prevention and preparedness interventions and their demonstrated or potential co-benefits for obesity are described. Of note, some diseases such as asthma have a more extensive body of research on environmental risk factors and quantified studies of co-benefits from climate change interventions.\textsuperscript{5,8–14} The purpose of this article is to explore the potential crossover between climate change interventions and pediatric obesity, an interface which has received considerably less attention. The importance of this approach lies in its potential ability to break ongoing cycles that perpetuate poor health outcomes and on-going injustice.

**OBESITY**

Affecting over 15% of children nationally,\textsuperscript{15–18} childhood obesity is defined as having greater than 95th percentile for body mass index (BMI, weight in kilograms divided by height in meters squared) for a child’s age. While the national average is high, there are communities within the United States, such as East Harlem, New York, where more than 25% of young children are obese. Thus the burden of this illness is not equally distributed. Additionally, in communities of color and low income, such as East Harlem, there is also evidence of unequal chemical and built environment exposures which are discussed in more detail later. Lastly, there is emerging evidence regarding the relationships between these unequal exposures and the prevalence of obesity which contribute to this as an environmental justice issue.\textsuperscript{19}

In terms of the consequences of obesity, obese children are more likely to have insulin resistance, diabetes, hypertension, cancer, gallbladder disease, liver disease, atherosclerosis, and depression. In addition, adults who were obese as children have increased mortality regardless of their adult weight.\textsuperscript{20} Lack of physical activity and high calorie diets are known risk factors for obesity among children in the U.S. Many individual factors also influence this relationship and are more studied among adults. Examples include co-morbid conditions and individual perception of safety.\textsuperscript{21} The following section reviews the evidence on environmental factors and interventions that influence physical activity levels and food habits.

**BUILT ENVIRONMENT AND OBESITY**

The few existing child-focused studies have shown a positive correlation between physical activity level and time spent outdoors, residential proximity to recreational facilities and parks, availability of adult supervision, improved school facilities such as basketball courts, and housing density.\textsuperscript{22–24} Other studies have shown that increased presence of green spaces as measured by satellite-derived greenness measures and geographical information system (GIS)-based neighborhood vegetation measures are inversely associated with children’s BMI.\textsuperscript{25,26} These factors are considered part of the built environment. One study found that, instead of the physical environment, a positive social environment—higher collective efficacy, more collective socialization of children, more social ties among neighbors, and greater perceived neighborhood safety—was positively associated with more activity.\textsuperscript{27}

For adult studies of obesity, the body of evidence is larger. Multiple studies have documented an association between characteristics of adults’ neighborhoods, physical activity levels and BMI.\textsuperscript{28} Presence of specific neighborhood amenities such as walking trails, sidewalks, and bicycle paths are associated with more adults meeting basic recommendations for physical activity.\textsuperscript{29,30} Street connectivity and mixed residential densities are also associated with increased physical activity.\textsuperscript{31} Studies have further demonstrated a positive association between obesity and increased vehicle miles traveled as a result of urban sprawl (defined as low density developments surrounding urban areas).\textsuperscript{32,33} In an Oregon study, increased neighborhood fast-food outlets and individual unhealthy eating behaviors were related to weight gain, while better neighborhood walkability and increased levels of physical activity were likely to be associated with maintaining a healthy weight over time. In this study, walkability was determined by a composite score that included land-use mix, street connectivity, public transit stations, and green and open spaces.\textsuperscript{34} As we will discuss in more detail later, many of these built environment factors are areas of potential intervention that can impact obesity problems as well as both the causes of and necessary adaptations to climate change.

**Environmental interventions and obesity**

Despite a growing body of evidence supporting an association between environmental factors, physical activity level, dietary quality, and obesity, research gaps remain regarding obesity interventions specifically addressing these factors. For example, few studies demonstrate the effectiveness of community level interventions to increase access to physical activity resources and the subsequent impact on childhood BMI or obesity-related health outcomes.\textsuperscript{35} One review focusing on interventions...
to prevent or manage type 2 diabetes in children concluded that 60–90 minutes of daily physical activity and less than 60 minutes of daily screen time (including video games) were necessary but called for larger-scale studies to determine the most effective methods of achieving these goals.\textsuperscript{36} Cochrane reviews on treatment and prevention of obesity in children state that longer-term studies are needed to demonstrate effectiveness and not enough evidence has been gathered to show that one particular program is successful at obesity prevention. Though, most programs reviewed showed moderate increases in physical activity or improved dietary choices.\textsuperscript{37,38}

The effectiveness of interventions that target entire communities such as increased availability of fruits and vegetables has been little studied with respect to impacts on children’s dietary habits and subsequent risk for obesity. One study demonstrated that lower fruit and vegetable prices were associated with decreased BMI gain in elementary school age children.\textsuperscript{39} Additionally, relatively simple environmental interventions have positively altered children’s eating patterns. For example, after the introduction of a salad bar in an elementary school, increased fruit and vegetable consumption correlated with decreases in overall fat and calorie intake.\textsuperscript{40} There are additional benefits of children having more exposure to fresh food. The presence of school gardens are thought to enhance academic instruction.\textsuperscript{41} And, while there is a need for more research, there is strong theoretical support of school gardens’ positive impact on student well-being.\textsuperscript{42}

As mentioned previously, some obesity interventions target the availability of healthy food choices on a community level. Linking food availability to health outcomes is a multi-step process. Some of the more intermediate links have been better examined than health outcomes. For example, increased fruit and vegetable consumption has been associated with the presence of at least one supermarket within the neighborhood.\textsuperscript{43} A further study went on to demonstrate that presence of neighborhood supermarkets is associated with less obesity in adults.\textsuperscript{44} Also importantly, some factors that put certain children at unequal risk have been shown to exist such as inequities in food store availability by race/ethnicity in some communities within New York City.\textsuperscript{45} As with physical activity interventions for obesity, the evidence of the effectiveness of dietary interventions for weight loss, especially in adolescents, is lacking.\textsuperscript{46,47} If anything, the limited evidence of effective interventions should underscore the need for multi-disciplinary and integrated solutions to tackle these multi-factorial problems. With this in mind, this article will now examine solutions that can feasibly address more than one problem at a time.

\textbf{CLIMATE-SPECIFIC SOLUTIONS}

We focus now on examples of climate change interventions that have demonstrated or potential co-benefits for childhood obesity. Climate change solutions or interventions are broadly defined here to include prevention efforts that target greenhouse gas emissions or preparedness efforts that help individuals and communities adapt to protect human health as climate changes.

\textbf{Urban planning}

Many climate change initiatives included in urban planning efforts have potential to increase physical activity levels in children. One substantial urban initiative launched in 2007 in New York City is called PlaNYC and includes climate change prevention and preparedness efforts as well as many other urban planning goals. This plan includes an open space initiative with the goal of having every city resident within a ten-minute walk of a park. Improved lighting on public spaces such as school yards will extend usable hours as well as increase public safety. Another PlaNYC program, called MillionTreesNYC, aims to plant one million trees in the city limits within a decade. Chicago and Philadelphia have similar programs called, respectively, the Chicago Climate Action Plan and GreenPlan Philadelphia. A large part of these programs are street tree initiatives which will increase neighborhood greenness, a factor associated with increased physical activity for children. These tree initiatives and other adaptation measures will reduce the urban heat island effect—a result of more dark, heat-absorbing surfaces in cities relative to suburban or rural areas—and thus reduce the impact of recurrent and increasing heat waves (e.g., tax incentives for lighter colored roofs and promenades with reduced vehicular traffic).\textsuperscript{48–51}

A number of urban planning initiatives including PlaNYC, Greenprint Denver of Denver, Colorado, and GreenLA of Los Angeles, California are framed around an expectation of an increasing urban population with goals of maintaining high-quality living and mixed use zoning within areas of increased housing density, other factors associated with more physical activity. Numerous cities, including Washington DC, have started bike share programs to encourage non-motorized transportation. A point of criticism about some of these programs is that some initiatives could have disproportionate negative effects on certain communities if not implemented carefully. One example is the effort to increase public transportation use. Projects must be carefully examined so as not to increase traffic in peripheral, low-income neighborhoods where there are large numbers of asthmatic children who have increased susceptibility to the effects of air pollution. That said, some of these incentives such as increased use of public transport and more green space, if carefully implemented, could have positive health effects for those same children.\textsuperscript{48,52–58}

\textbf{Food production}

Food and agriculture are responsible for a substantial portion (over 15% or more depending how much food transportation is included in the calculation) of global and U.S. greenhouse gas emissions. A disproportionate amount of those gases come from livestock production. Increased livestock production leads to increased demand for animal feed which can drive up the cost of food grains for people. Plant-based diets use much less energy than
meat based diets—particularly those diets including meat from ruminants like cows and sheep that produce methane, a potent greenhouse gas. The heavily meat based diet in the United States differs from the majority of the world who eat primarily plant-based diets out of economic necessity. These differential global diets are a cornerstone of climate justice advocacy. Climate justice efforts emphasize that the contributions to climate change, such as the larger per capita greenhouse gas emissions from countries that consume large quantities of meat, are much higher than in countries where the impacts of climate change are expected to be the most significant.

Because plant-based diets contribute significantly less greenhouse gases into the atmosphere than meat-based diets, some climate change interventions advocate for plant-based diets as a means of climate change mitigation. One initiative, called Meatless Monday, began and is still billed in the United States as a health campaign but increasingly its merits as a climate change intervention are being touted. This campaign seeks to encourage carnivorous individuals to decrease their meat intake by skipping meat-containing meals one day per week. Additionally, many communities in the United States have become part of an unofficial local foods movement including farm to school programs, farmers’ markets, and community supported agriculture (called CSAs). As inadequate fruit and vegetable intake contributes to the childhood obesity epidemic, the promotion of plant-based diets thus has a dual role in addressing both obesity and climate change.

The previous examples focus on changing consumer demand. Climate change initiatives can also affect dietary habits in the form of incentives and policies for farmers. In 1999, member countries of the Organization for Economic Co-Operation and Development provided substantial subsidies—close to $300 billion—to support agricultural production. The orientation of these funds can substantially alter farming practices. The United States’ Conservation Reserve Program pays for land to be taken out of production for certain periods of time, a practice that is known to rejuvenate soil and decrease need for fertilizers. In addition to providing positive financial incentives, the government may also penalize climate-harmful practices. Penalties include taxes on fertilizers or pesticides which use fossil fuels in production and removal of subsidies that do not promote ecological health. The Kyoto Protocol, a measure to set international limits on greenhouse gas emissions, is one example of both the complexity and importance of international policies due to the global nature of pollution and climate change. As long as the U.S. continues to rely on fossil fuels for fueling farm production and producing pesticides, significant benefits may be seen by reducing the energy demand of food production. Some effects could be lower coal plant emissions and less diesel vehicle emissions. No studies were found that specifically quantify pediatric health benefits from interventions targeting these factors but the supporting theory is strong. Figure 1 summarizes the multiple levels on which these interventions work.

**PRECAUTIONARY APPROACHES**

Regardless of the potential effects of any climate change or pediatric obesity intervention, thorough assessments are warranted prior to implementation of large-scale projects to try to determine who will benefit or be harmed and when and where that benefit or harm will

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**FIG. 1.** Examples of community level climate change interventions with variable potential impacts on childhood obesity at the level of the child, family, and school/community. Adapted from Ecological Systems Theory model.
occurred. Increasing physical activity is one significant arm of the environmental interventions regarding obesity and increased human-powered transportation is a central theme of many climate change interventions. Within both types of intervention, safety during that physical activity is of significant concern. Unintentional injury, though not considered a new pediatric morbidity, is the leading cause of death for children. While the majority of the unintentional injuries are due to motor vehicle crashes, a study in Baltimore, Maryland documented increased pedestrian-vehicular crashes near schools that had more features that increased pedestrian demand. Projects such as Safe Routes to School are planning efforts to try to reduce additional accidental injuries while helping to increase physical activity. As increased walking and bicycle riding are encouraged it is essential that safety precautions (such as helmets, sidewalks with adult supervision, and play spaces that are isolated from vehicular traffic) be used to prevent an increase in morbidity or mortality associated with these activities. Any climate change intervention should be explored for its potential to reduce injury risk factors or at a minimum safeguard against their increase.

While any intervention should try to minimize negative health consequences, at times, climate change interventions could have simultaneous positive and negative effects on pediatric morbidities. Take for example urban greening efforts which encourage outdoor time and indirectly increase physical activity. While vegetation can improve air quality, the intervention could result in greater exposure to existing outdoor air pollution and worsening of symptoms for asthmatics. In these situations, additional efforts are needed such as education about how to monitor air quality. Information is publicly available on the AirNow web site which alerts asthmatics to avoid outdoor activity when levels of some air pollutants pose an increased risk. The counter-argument to avoiding outdoor air pollution is that indoor air pollution has numerous known potentially modifiable risk factors such as cigarette smoke, mold, cleaning product vapors, and pesticides so education needs to address both indoor and outdoor risks in order not to present too biased a picture. This scenario is not the only way asthma and obesity are potentially related. Numerous studies have identified an association of asthma with obesity. The causal direction of this relationship has not been well established but weight loss has been shown to decrease the severity of asthma. This relationship represents an additional area of potential benefit and caution.

The challenges of climate change intervention assessments are daunting for even seasoned health and other risk assessment professionals. Even more difficult is communicating this information to individuals without specialized training in the relevant fields. This additional challenge is being addressed by the growing fields of risk communication and environmental health literacy. For pediatric health issues, a national network called the Pediatric Environmental Health Specialty Units, staffed by trained physicians, fields questions regarding the particular complexities of pediatric environmental health. The National Children’s Study which began enrollment in 2009 in the U.S. will build the knowledge base on which pediatric environmental health professionals and others rely to inform pre-intervention assessments, improve risk communication strategies, and enhance environmental health literacy.

CONCLUSION

This article highlights the unintended consequences of climate change interventions that could have positive health effects on childhood obesity while at the same time including precautionary advice about potential unintended negative effects of certain interventions. Both types, positive and negative, are important to include in the program planning or resource allocation effort and would provide a helpful contribution to any cost-benefit analysis or intervention comparison. Clearly, the piece-meal approach of this article and reliance on theoretical effects demonstrates that further studies are needed to assess which programs have greatest health benefits. Many climate change interventions are costly and justification depends often on a multidisciplinary assessment. Sometimes accounting for health benefits alone is not enough to demonstrate cost-effectiveness. In one study, the cost of installing a light rail in a North Carolina city was calculated to be larger than the public health benefits over a nine-year period leading the authors to conclude that additional—perhaps ecological, commercial, and social capital—benefits need to be figured into the analysis as well to be convincing economically and thus requires engaging other stakeholders.

Climate change represents an unprecedented challenge in terms of space, time, and environmental justice. Thus, unprecedented collaborations that also go beyond normal discipline boundaries are needed. Requirements in grant funding, mandates from government agencies, and outreach by health departments can bring academic, community-based, and government groups together from numerous fields to interact and inform each other. Ultimately, the better informed community members—especially environmental justice communities—health professionals, and civic leaders are the better they will be able to advocate for their personal and collective short- and long-term well-being.

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