The Built Environment and Actual Causes of Death: Promoting an Ecological Approach to Planning and Public Health

Nisha D. Botchwey¹, Rachel Falkenstein², Josh Levin¹, Thomas Fisher³, and Matthew Trowbridge⁴

Abstract
This article reviews empirical scholarship on preventable actual causes of death—namely, physical activity, food, and traffic-induced injury—related built environment interventions that lead to health improvements. A systems perspective built on the ecological health model is offered that addresses social determinants of health- and place-based contexts. In doing so, this article offers examples of upstream approaches to address the actual causes of death and ends with guidance on planning practice, research, and teaching organized around the research divisions of the Association of Collegiate Schools of Planning.

Keywords
health, community development, food system, transportation, urban form, quality of life

Introduction
In 1993, the then director of the Centers for Disease Control and Prevention (CDC), William Foege, and Michael McGinnis published a groundbreaking work on “Actual Causes of Death in the United States,” linking risk behaviors such as tobacco use, poor diet, and physical inactivity with the United States’ CDC 1990 mortality data. Nearly ten years later, in 2004, Mokdad, colleagues, and the then CDC Director Julie Gerberding continued this reporting for 2000 mortality data. These pairings allowed for the unprecedented quantification of risk behaviors as actual causes of death (Danaei et al. 2009). For example, although it was generally known by the year 2000 that poor diet and physical inactivity are linked to obesity and obesity-related deaths, it was not until Mokdad et al. highlighted these risk behaviors and their associated health outcomes that the public health field seriously considered the urgency of adopting a broader and more ecologically targeted preventive orientation (Danaei et al. 2009; Galeo et al. 2011; Pugh and Zarus 2012). This article proposes that planning can provide appropriate and important direct interventions for three actual causes of death: physical inactivity, poor nutrition, and traffic-induced injury.

Statistics based on the actual causes of death perspective (see Table 1) suggest a need for increased investment in prevention and a focus on population-level health behavior change, both of which can be supported through environmental design and land use strategies. For example, in the year 2000, while tobacco was the number one actual cause of death, poor diet and physical inactivity followed as a close second. These are aggravated by sedentary lifestyles and high-fat/low-fiber diets, behavioral risk factors both closely associated with many of the leading causes of death such as heart disease, cancer, and diabetes. Just as striking is the sharp increase in the prevalence of childhood obesity in the United States. Obesity in adolescents (aged twelve—nineteen) has more than quadrupled since 1970, reaching a rate of 21 percent in 2012 (Ogden et al. 2014; National Center for Health Statistics 2012). Today, nearly one in three children in the United States is obese or overweight, one in three American adults is obese, and over two-thirds of adults are overweight (Flegal et al. 2010).

Public health, as opposed to clinical medicine, has a unique link to the community planning fields in that it has traditionally focused on the health of populations rather than of individuals (Farr and Virchow 2009). This emphasis on phenomena occurring at the broader community level unites public health with the variety of design fields involved in urban and regional planning.

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Table 1. Actual Causes of Death in the United States, 2000.

<table>
<thead>
<tr>
<th>Actual Cause</th>
<th>Number (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco</td>
<td>435,000 (18.1)</td>
</tr>
<tr>
<td>Poor diet and physical inactivity</td>
<td>365,000 (15.2)</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>85,000 (3.5)</td>
</tr>
<tr>
<td>Microbial agents</td>
<td>75,000 (3.1)</td>
</tr>
<tr>
<td>Toxic agents</td>
<td>55,000 (2.3)</td>
</tr>
<tr>
<td>Motor vehicle</td>
<td>43,000 (1.8)</td>
</tr>
<tr>
<td>Firearms</td>
<td>29,000 (1.2)</td>
</tr>
<tr>
<td>Sexual behavior</td>
<td>20,000 (0.8)</td>
</tr>
<tr>
<td>Illicit drug use</td>
<td>17,000 (0.7)</td>
</tr>
<tr>
<td>Total</td>
<td>1,159,000 (49.2)</td>
</tr>
</tbody>
</table>

Source: Adapted from Mokdad et al. (2004, 2005).

Mokdad et al. (2004) found that of the 2.4 million deaths in the United States in 2000, approximately half of them (49.2 percent) are attributable to nine actual causes or preventable behaviors and exposures. Planners and other designers of the built environment can directly address nearly a fifth of these deaths through built environment interventions that target poor diet and physical inactivity and motor vehicles.

The growing focus on improving quality of life is directly measured by actual causes of death. This stems from adoption of an *ecosocial or social–ecological systems* perspective within public health (Sallis and Owen 1997). Brofenbrenner’s (1977, 1979) ecosocial perspective emphasizes host–agent–environment interactions at the micro-, meso- and macrosystem levels without targeted guidance for health promotion interventions. McLeroy et al. (1988) defines the layered factors of influence beginning with the intrapersonal (characteristics of the individual), interpersonal (formal and informal social networks and social support systems), institutional (social institutions), community (mediating institutions, relationships and power), and public policy (multilevel laws and policies). While genetics plays a powerful role in personal health outcomes, biological development is governed by the process of “embodiment” of the human body’s material environment and social structure, and the ways that these create different pathways between exposure, susceptibility, and resistance (Bartley, Blane, and Montgomery 1997; Krieger 2001). Just as public health’s social ecological model (SEM) considers the impact that biological, ecological, and social factors have on population health, an SEM for planning recognizes that community health is affected by these factors in addition to those related, but more specific factors traditionally attributed (e.g., economic vitality, housing, and education; Lee and Moudon 2004).

The planning literature has shown an increased interest in models integrating the social, behavioral, and economic sciences with the study of ecosystems (Grimm et al. 2000; Tzoulas et al. 2007; Van Kamp et al. 2003). An example of such that is particularly relevant to urban planning might be residential segregation or exclusionary zoning policies and how they affect health outcomes differentially among population subgroups. Residential segregation leads to higher rates of economic deprivation among many African Americans who choose neighborhoods based on housing affordability (Williams 1999). Many of these neighborhoods have poor access to healthy foods, unsafe and inaccessible places for physical activity (PA), limited transportation options, and higher exposure to environmental toxins such as waste facilities and lead paint in older homes (PolicyLink 2011). At the individual level, these exposures increase risk in turn for obesity (Hyman 2010), mental illness (Genuis 2008), hypertension (Taylor 1996), and chronic kidney disease (Soderland et al. 2010).

This demonstrates the important role urban planners can play in addressing actual causes of death, by systematically shaping “ecological” dimensions of health (Trowbridge et al. 2013; Corburn 2004). Chronic diseases and the distribution thereof are the long-term, cumulative effect of the daily choices people make, based on the choices available to them to be active or sedentary, to eat a healthy diet, or to engage in certain risk behaviors. These choices are shaped for each individual by socioeconomic circumstances, environmental conditions, and/or the public policies and regulations that, when compounded upon one another, lead to either good health or chronic disease (Bartley, Blane, and Montgomery 1997; Botchwey et al. 2009). The choices essentially become default routine behaviors that have a major impact on health outcomes (Frieden 2010). The quality of the built environment can have profound effects on these health outcomes; for example, in one study (Diez-Roux et al. 1997), neighborhood variables were shown to have greater correlation with prevalence of chronic heart disease than with factors relating to the individual. Thus, planning practitioners should find the recent research on actual causes of death to be helpful in justifying planning decisions; they can point to the evidence from these studies to show that planning strategies such as parks, bike lanes, and traffic caliming devices are important because they support the health and safety of the population.

Planners are charged with the duty to uphold the health and welfare of populations. The American Institute of Certified Planners (AICP 2009) Code of Ethics and Professional Conduct obligates certified planners to “have special concern for the long-range consequences of present actions” and to “pay special attention to the interrelatedness of decisions.” Planners are able to cast visions, evaluate multiple paths, and implement the soundest approach.

In the nineteenth century, the primary health concerns were infectious diseases with much of the solutions targeting direct transmission pathways and thus elimination of the source or limiting access to it as done with the concerns over Cholera and the Broad Street Pump in 1854, and Typhoid Fever in the 1880s. Planners of the twentieth and twenty-first centuries are still addressing issues like clean water, safe sewage disposal, and overcrowding especially in developing nations and discrete parts of developed nations. Today’s planners have chronic rather than infectious diseases—obesity, cardiovascular disease, and the like—as the dominant disease burden of the population that are associated with environmental exposure or to the complex ecological framework developed over the course of an individual’s life. While planning research recognizes
PA, dietary choices, and other place-based risk behaviors as important factors for consideration, the majority of this work to date has not adequately integrated assessments and recommendations according to an ecological framework that addresses the multiple scales and complex interactions of the resulting health outcomes.

These are “upstream” approaches, with the intention of “ameliorating the social and environmental conditions producing disease” (Brandt and Gardner 2000, 708). The current shift in public health toward actual causes of death perspective presents an opportunity for urban planners, architects, and designers to promote their important role in addressing root health risks—including poor diet, physical inactivity, and motor vehicle injuries—through improved design of the built environment. If US obesity rates continue as projected, by 2018 the United States will spend US$344 billion in health care costs to address comorbidities like diabetes and hypertension, representing approximately 21 percent of total projected health spending on direct health care (United Health Foundation 2009). Treatment of these related chronic diseases with “downstream” approaches such as medication and hospitalization is a limited and costly approach. Instead, upstream approaches provide a population-based strategy to improve social and physical contexts; these focus on healthy diet, PA, and remediation of other default risk behaviors based on interventions in the built environment that planners can orchestrate. These changes can support healthy lifestyles and may extend health benefits to both obese and nonobese populations, as well as reducing future prevalence of obesity (Botchwey, Trowbridge, and Grimm 2010; Flegal et al. 2010).

The climate is ripe for these upstream solutions, many of which have come into prominence in the recent years. Numerous public health and planning institutions recognize the need to address public health issues through planning. US Surgeon General, Regina Benjamin, pointed this out in her 2010 Vision for a Healthy and Fit Nation (US Department of Health and Human Services 2010), recommending community-based strategies for provision of access to healthy food and PA. The Community Health Needs Assessments that nonprofit hospitals are required to complete under the Affordable Care Act (Section 9007) offers another avenue for professionals in the medical, public health, and planning fields to identify local health concerns and implement evidence-based interventions that include those addressing the “social, economic and environmental conditions that act as the primary determinant of individual and population health determinant of health” (Rosenbaum 2013, 1; US CDC 2013). Likewise, the US Department of Health and Human Services’ Healthy People 2020 (2011) calls for addressing health issues through planning interventions. This select set of the Healthy People 2020 objectives that fall within the realm of engagement for planners and designers, regarding the social determinants and changing contexts, represent an important subset of avenues for participation in this arena (see Table 2).

A number of efforts that are central to planning have called for more multi-sector approaches to healthy communities. The Partnership for Sustainable Communities (2013, 1) Initiative recognizes the need to work across disciplines in order to “creating vibrant, healthy neighborhoods that provide more housing options, economic opportunities and efficient transportation.” The American Planning Association refers to public health practitioners as natural allies (Morris 2006). The Community Design and Public Health Workforce Expert Panel, convened in 2012, recommends both practice and academic training to improving the supply of ready professionals to advance this work (Dyjack, Botchwey, and Marziale 2013).

The aim of this article is to clarify planning’s role in public health initiatives that focus on health risk factors and follow an ecological framework. The authors critically assess recent research and findings on three preventable actual causes of death that have demonstrated key built environment components—namely, physical inactivity, poor nutrition, and traffic-induced injury (see Table 3). Because it illustrates so well the importance of integrating competencies and knowledge bases across fields, these three high-priority areas are discussed from an SEM perspective, one that integrates individual variables into a multidimensional framework that considers the impact each one has on the others. This article then ends with guidance on planning practice, research, and teaching organized around the research divisions of the Association of Collegiate Schools of Planning.

**Method**

The authors sampled recent literature to summarize and establish the current knowledge base on PA, nutrition, and injury related to the built environment. The review is in part secondary, with a significant basis in existing literature reviews. To begin, authors identified recent literature reviews on PA, food, and injury related to the design of the built environment. These reviews established the current state of knowledge on health and the built environment. The authors used these reviews as baseline knowledge and a source for additional search terms to apply to extend and connect the knowledge on all three actual causes of death topics.

The authors used the online database Academic Search Complete to identify peer-reviewed articles associated with the actual causes of death, focusing specifically on PA, nutrition and injury, and the built environment. The authors acknowledge the limitations of using just one search engine, as it may not cover all of the relevant literature. Only studies with measurable outcomes were used for this article. Studies were analyzed to determine data sources and sample populations and were compared with findings from previous literature reviews.

The range of search terms for PA, food, and traffic injury articles was broad, mirroring the approach taken in Mokdad et al. (2004). This was done to ensure a complete list of sources from which to draw (see Table 4). The search results revealed that since 2002 there has been a significant increase in the number of articles discussing these topics. Yet, as Figure 1 illustrates, there is still a limited number of studies measuring the association between traffic injury and the built environment.
Table 2. Healthy People 2020 Physical Activity, Food, and Injury Actual Causes of Death Related Topics.a

<table>
<thead>
<tr>
<th>Actual Cause of Death</th>
<th>Objectives</th>
<th>Target Measurement</th>
<th>Baseline Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical activity</td>
<td>Increase the proportion of the Nation’s public and private schools that provide access to their physical activity spaces ad facilities for all persons outside of normal school hours</td>
<td>31.7 percent</td>
<td>28.8 percent</td>
</tr>
<tr>
<td></td>
<td>Increase the proportion of trips made by walking</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td>Increase the proportion of trips made by bicycling:</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td>• Adults aged eighteen years and older, one to five miles or less</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Children and adolescents, trips to school of one to two miles or less</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase legislative policies for the built environment that enhances access to and availability of physical activity opportunities:</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td>• Community-scale policies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Street-scale policies</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Transportation and travel policies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrition/food</td>
<td>Increase the proportion of schools that do not sell or offer nutritious foods and beverages outside of school meals</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td>Increase the proportion of schools that offer calorically sweetened beverages to students</td>
<td>21.3 percent</td>
<td>9.3 percent</td>
</tr>
<tr>
<td></td>
<td>Increase the proportion of school districts that require schools to make fruits or vegetables available whenever other food is offered or sold</td>
<td>18.6 percent</td>
<td>6.6 percent</td>
</tr>
<tr>
<td></td>
<td>Increase the number of states that have state-level policies that incentivize food retail outlets to provide foods that are encouraged by the Dietary Guidelines</td>
<td>18 states</td>
<td>8 states</td>
</tr>
<tr>
<td></td>
<td>Increase the proportion of Americans who have access to food retail outlets that sells a variety of foods that are encouraged by the Dietary Guidelines for Americans</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Injury</td>
<td>Eliminate very low food security among childrenb</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td>Reduce motor vehicle crash-related deaths</td>
<td>13.8 deaths per 100,000 people</td>
<td>12.4 deaths per 100,000 people</td>
</tr>
<tr>
<td></td>
<td>Reduce nonfatal motor vehicle crash-related injuries</td>
<td>775.1 injuries per 100,000 people</td>
<td>694.4 nonfatal injuries per 100,000 people</td>
</tr>
<tr>
<td></td>
<td>Reduce pedestrian deaths on public roads</td>
<td>1.4 deaths per 100,000 people</td>
<td>1.3 deaths per 100,000 people</td>
</tr>
<tr>
<td></td>
<td>Reduce nonfatal pedestrian injuries on public roads</td>
<td>22.6 injuries per 100,000 people</td>
<td>20.3 injuries per 100,000 people</td>
</tr>
<tr>
<td></td>
<td>Reduce pedal cyclist deaths on public roads</td>
<td>0.24 pedal cyclist deaths per 100,000 people</td>
<td>0.22 pedal cyclist deaths per 100,000 people</td>
</tr>
</tbody>
</table>

*aEvery ten years, the healthy people initiative offers new, measureable, and developmental objectives for the coming decade. With each measureable objective, there is a target value to be reached by the year 2020, usually as a percentage, with a baseline set from 2010. The objectives that lack both targets and baseline measurements are new additions that address issues of national importance and have not been a part of data collection. While they do not yet have national baseline data, they do have either a nationally representative data source or state-level data as a proxy. These new data sets will measure change in the named objectives and is viewed as an important investment.

*bFood security refers to an individual’s ability to access food, both physically and economically, that can consistently sustain his or her daily dietary needs.

Table 3. Built Environment and Public Health Defining Terms.

Built environment: all things human-created and human-influenced, including those urban design features of places and characteristics of the physical and natural environment that influence the population’s daily choices and cumulatively health outcomes

Physical activity: moderate and vigorous aerobic physical movement that increases cardiorespiratory fitness and contributes to muscle strengthening. Based on definitions set by Healthy People 2020 (2011)

Healthy food: foods recommended by the Dietary Guidelines for Americans, specifically nutrient-dense foods and beverages that are low in added sugar, as well as fruits and vegetables, whole grains, and lean proteins (US Department of Agriculture and US Department of Health and Human Services 2010). Access to healthy food focuses on poverty, youth and elderly population, transportation, and residents’ proximity to food sources

Injury: in this article, “injury” refers to traffic safety because it is the most relevant, as traffic accidents are one of the leading actual causes of death and tend to be closely affected by the built environment. Traffic safety is measured in the literature in various ways, ranging from measuring incidences of traffic collision or severity of injuries sustained in traffic collisions to simply measuring numbers of fatalities occurring from traffic collisions
Food-related articles have become more numerous within the past five years, but the discussion of health and the built environment is still predominantly focused on PA.

**Findings**

**Physical Activity and the Built Environment**

Physical inactivity is the actual cause of death, receiving the most attention in public health and planning literature. PA is essential to a healthy lifestyle, yet many Americans do not meet the recommended levels of exercise. According to the CDC, only 21.9 percent of adults engage in some form of PA at least five times a week (Centers for Disease Control Prevention—National Center for Health Statistics 2010). Because physical inactivity is the second highest in the ranking of actual causes of death, and because planners’ significant impact on the built environment can contribute very directly to this issue, it is worth investigating how planning can be used to deal with the problem of physical inactivity. This section discusses a number of studies examining the relationship between PA and design features, such as sidewalks and bike lanes, street connectivity, mixed-use developments, parks, and public transit.

Features of the built environment that impact PA include street connectivity and safety, the presence of pedestrian/bicycle infrastructure, availability of desirable destinations, and a wide range of other determinants. The findings from Frost et al.’s (2010) review of the built environment and health, although limited to rural settings, echoes findings from Dill’s (2009) study of Portland’s urban environment, which found that bicyclists heavily favored routes with bicycle lanes and paths or streets that include dedicated bicycle boulevards. Only 8 percent of Portland’s road network contains such bicycle infrastructure, yet 50 percent of the miles logged by participants in the study, a somewhat limited sample of 166 people, occurred on a street with some type of bicycle infrastructure. Sixty percent of the participants, although all frequent cyclists and thus not a fully representative study group, were able to meet or exceed recommended levels of PA by bicycling for everyday travel. Similarly, studies find that the presence, connectivity, and quality of sidewalks in both urban and suburban locations were associated with higher rates of walking (Hess et al. 2001; Rodriguez, Khattak, and Evenson 2006; DeBourdeaudhuij, Sallis, and Saelens 2003). The presence of street lighting, especially in unsafe or crime-ridden areas, is also a significant factor affecting use of active transportation modes (Painter 1996). Studies on street connectivity found that, after controlling for demographic, economic, and geographic variables, smaller block size and better street connectivity (greater intersection density) are associated with high levels of walking and cycling (Baran, Rodriguez, and Khattak 2008; Berrigan, Pickel, and Dill 2010; Hess et al. 2001; Rodriguez, Khattak, and Evenson 2006). Pikora et al. (2003) undertook a Delphi study—an emergent technique used to creatively extract ideas from a body of experts—to look at environmental factors affecting walking and cycling, and derived from it a framework for active transportation mode choice that comprises four sets of determinant features: functional, safety, aesthetic, and destination. High density and a mixture of land uses have also been shown to affect PA. Both high residential density and housing unit density have been associated with higher levels of moderate to vigorous physical activity (MVPA; Troped et al. 2010), while the presence of vegetation had a negative correlation. Both high-density and mixed-use development have been associated with utilitarian walking, while controlling for those who choose such communities because they like to walk (Handy, Cao, and Mokhtarian 2006). Land use mix was associated with...
a 12 percent reduction of the likelihood of obesity across gender and ethnicity in an Atlanta, Georgia study (Frank, Andresen, and Schmid 2004), with each additional hour spent in a car per day associated with a 6 percent increase in the likelihood of obesity and each additional kilometer walking per day, a 4.8 percent decrease. Likewise, the presence of destinations such as schools and stores within 1,500 meters has been associated with higher walking levels among residents (McCormack, Giles-Corti, and Bulsara 2008).

Several studies discuss the impact of parks on neighborhood PA. Studies show that people with access to parks are more likely to attain high levels of PA (Diez-Roux et al. 2007; Giles-Corti et al. 2005; Zlot and Schmid 2005), and the higher the density of resources in a park, the farther people will travel to use them. PA levels increased, especially among youth under driving age, with both the number of parks located near participants’ homes (Cohen et al. 2006; Kaczynski et al. 2009) and with total acreage of parks within participants’ neighborhoods (Zlot and Schmid 2005; Kaczynski et al. 2009). In one Canadian city, researchers found that each additional park within a one kilometer radius of participants’ homes (N = 585) increased the likelihood of participating in MVPA by 17 percent (Kaczynski et al. 2009). Furthermore, parks with facilities such as basketball courts, playgrounds, and walking paths tend to have higher numbers of physically active people than do parks lacking these features (Shores and West 2008). Such active facilities have been associated with lower body mass index (BMI) in children (Potwarka, Kaczynski, and Flak 2008).

Research has also found school environments to be predictors of PA among children. The presence of street trees along routes to school, as well as higher land use mix, has been associated with higher rates of walking among children aged eleven to thirteen living within one mile of school (Larsen et al. 2009). Opening up schoolyards, with supervision during nonschool hours to address safety concerns, has been found to increase PA levels in children (Parley et al. 2007; Sallis et al. 2001). Facilities within schoolyards such as basketball courts and soccer fields were found to increase PA levels during recess and after school (Sallis et al. 2001), and multicolored playgrounds that allow for different types of activities were found to increase MVPA levels during recess (Ridgers et al. 2007) over unmarked or unstructured play areas.

Another significant predictor of PA is the presence and use of public transit. Children living near a high density of subway stations were found, on average, to have lower rates of obesity (Oreskovic et al. 2009), and a higher density of bus and subway stops has been associated with lower rates of overweight among adults in New York City (Rundle et al. 2007), controlling for all other factors. On average, public transit users have been found to walk 8.3 more minutes per day (Edwards 2008), and train commuters regularly walk 30 percent more steps per day than car commuters (Wener and Evans 2007). In Salt Lake City (n = 51), 65 percent of those who did not ride transit were obese, compared to 15 percent of longtime transit riders and 26 percent of new transit riders (Brown and Werner 2008; see Table 5).

These studies demonstrate that neighborhood features including the presence of sidewalks and bike lanes, street connectivity, mixed-use developments, parks, and public transit are associated with increased levels of walking and PA among residents, even though other factors, such as poverty levels and neighborhood safety and sidewalk connectivity, also influence the amount of walking and PA people engage in. Matters of planning and health are inherently intertwined. More studies are needed to measure the cumulative impacts of these built environment features and to address the lack of knowledge about their interactions.

Food and the Built Environment

Food has gained a great deal of attention since 2003, when conversations broadened from organic growing to highlighting local food production and issues around food security (Morland, Wing, and Diez-Roux 2002; Oberholser and Tuttle 2004; Raja, Born, and Russell 2008). Studies showed more emphasis on the fact that patterns of eating differed between neighborhoods and that these differences had potentially significant effects (Diez-Roux et al. 1999). The literature on food has thus progressed to emphasize access as well as healthy and unhealthy foods (Pothukuchi 2009). A diet rich in nutritious foods such as fruits and vegetables has been associated with lower rates of heart disease, certain cancers, and diabetes. Yet, national studies have shown that less than 3 percent of men and less than 6 percent of women meet the recommended daily intake of fruits and vegetables (McCormack et al. 2010). Many studies have shown that inadequate access to healthy food is associated with poor health (see Table 6).

In one study of minority populations in Detroit, Zenk et al. (2009) found that the presence of a large grocery store within a half-mile buffer of participants’ homes was associated with higher fruit and vegetable intake. However, the increase in healthy food consumption was only significant among Latinos and not significant among whites or African Americans. The presence of a convenience store and fast-food restaurants was negatively associated with fruit and vegetable consumption (Zenk et al. 2009) and has been identified as a determinant of fast-food consumption (Lucan, Barg, and Long 2010). Lucan, Barg, and Long’s work with low-income African Americans (n = 40) in Philadelphia found that availability and cost were top barriers to fruit and vegetable consumption. In another study (N = 10,623), African Americans’ fruit and vegetable intake increased by 32 percent and white Americans’ intake increased by 11 percent for each additional supermarket in the neighborhood census tract (Morland, Wing, and Diez-Roux 2002).

Local food environments have also been found to impact residents’ weights. In one study, the presence of supermarkets was associated with a lower rate of neighborhood obesity, whereas the presence of convenience stores was found to be associated with higher neighborhood obesity rates (Morland, Diez-Roux, and Wing 2006). Another study, however, found no association between childhood obesity and proximity to
<table>
<thead>
<tr>
<th>Category</th>
<th>First Author, Year</th>
<th>Data Sources (D) and Sample (S)</th>
<th>Independent (I) and Dependent (D) Variables</th>
<th>Findings</th>
</tr>
</thead>
</table>
| Street connectivity and street features | Baran, 2008 | • D: mail-in survey with travel diary  
• S: residents of suburban (n = 210) and new urbanist neighborhood (n = 243) in NC | • I: control, local integration, and global integration  
• D: walking behavior | Residents living on streets that are better integrated within the larger network and better connected to nearby streets were associated with higher rates of utilitarian walking |
| | | | • I: street connectivity  
• D: active transportation | Short blocks and high intersection density, particularly four-way intersections are associated with more active transportation |
| Street connectivity and street features | Berrigan, 2010 | • D: nine objectively measured street connectivity variables  
• S: 2001 California Health Interview Survey respondents in San Diego (n = 1,883) and Los Angeles Counties (n = 8,506) | • I: neighborhood design and recreational environmental variables  
• D: levels of walking and MVPA | Quality of sidewalks and access to shopping and public transportation was associated with higher levels of walking in Belgium |
| Street connectivity and street features | DeBourdeaudhuij, 2003 | • D: IPAQ;  
• S: adults living in Ghent, Belgium (n = 521) | • I: presence of bicycle infrastructure  
• D: bicycle route chosen | A well-connected network of various levels of bicycle infrastructure (bicycle lanes, paths, boulevards, etc.) appears necessary to achieve high rates of bicycling |
| Street connectivity and street features | Dill, 2009 | • D: GPS devices carried on all bicycle trips for one week  
• S: adult cyclists in Portland (n = 166) | • I: living in a new urbanist neighborhood  
• D: level of PA | Street connectivity and smaller block size are associated with higher levels of walking |
| Street connectivity and street features | Hess, 2001 | • D: observational methods  
• S: pedestrians in twelve neighborhood commercial centers in Puget Sound | • I: block size and completeness of sidewalk systems  
• D: pedestrian volume | Street lighting can decrease crime and fear of crime which leads to more nighttime pedestrian street activity |
| | Painter, 1996 | • D: pedestrian surveys, counting of crime incidents and pedestrians  
• S: users of three London streets | • I: street lighting  
• D: crime and fear of crime, and pedestrian activity | Residents of new urbanist neighborhoods, which are marked by traditional block patterns and presence of sidewalks, report more walking for utilitarian purposes than residents of the suburbs |
| Street connectivity and street features | Rodriguez, 2006 | • D: household survey and travel diary based on 2001 NHTS and BRFSS  
• S: residents of new urbanist neighborhood (n = 243) and suburbs (n = 210) in Chapel Hill, NC | • I: living in a new urbanist neighborhood  
• D: level of PA | Land use mix in Atlanta, Georgia, was associated with a 12 percent reduction in the likelihood of obesity |
| Mixed use and high density | Frank, 2004 | • D: travel survey and objective measures of built environment around participants’ homes  
• S: Atlanta adults (n = 10,878) | • I: built environment variables (land use mix, net residential density, and street connectivity)  
• D: travel patterns, BMI, and obesity | High density/mixed-use development was associated with more people walking for transportation purposes |
| Mixed use and high density | Handy, 2006 | • D: mail-in survey and perceived and objective measures of built environment  
• S: recent movers and longtime residents of traditional and suburban neighborhoods in California (n = 1,672) | • I: living in suburbs versus traditional neighborhoods  
• D: walking for transportation | The presence of schools, stores, and other destinations within a neighborhood was associated with higher rates of walking among residents |
| Mixed use and high density | McCormack, 2008 | • D: survey measuring physical activity, GIS, and counting to measure destinations  
• S: Western Australian adults (n = 1,394) | • I: the presence and mix of destinations located within 400 and 1,500 m from respondents home  
• D: walking for transit, recreation, and physical activity | The presence of schools, stores, and other destinations within a neighborhood was associated with higher rates of walking among residents |
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<tr>
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</table>
| Mixed use and high density     | Troped, 2010       | D: accelerometer and GPS devices, observational built environment measures  
S: Eastern Massachusetts adults (n = 148) | I: intersection density, land use mix, population density, housing density, greenness within home and work environments  
D: levels of MVPA | Land use mix, residential population density, and housing unit density were associated with higher levels of moderate to vigorous physical activity within one kilometer of home |
| Parks                          | Cohen, 2006        | D: accelerometers, mapping parks, and counting facilities  
S: grade 6 girls in six different cities (n = 1,556) | I: Parks type and number, park facilities  
D: MVPA level | The number of parks located near participants home was associated with increased MVPA levels as was the presence of “active features” within parks such as path, playgrounds, and sports facilities |
| Parks                          | Diez-Roux, 2007    | D: multiethnic study of atherosclerosis, GIS, and other sources measure recreation facilities  
S: Adults in New York, Baltimore, and Forsyth County, NC (n = 2,723) | I: density of parks near participants’ homes  
D: PA levels | Participants with the higher density of parks reported more PA than those with the lowest density of parks near their homes |
| Parks                          | Giles-Corti, 2005  | D: personal interviews, environmental audit of POS  
S: adults in Perth, Australia (n = 1,803) | I: access to POS  
D: PA levels | Access to POS, especially spaces that are large and attractive, was associated with higher levels of walking |
| Parks                          | Kaczynski, 2009    | D: questionnaire and physical activity log, GIS data  
P: adults in a Canadian municipality (n = 585) | D: number and total size of neighborhood parks  
I: MSPA | The number and the total area of parks located within a one kilometer radius of participants’ homes were associated with higher levels of MSPA that occurred in parks and neighborhoods |
| Parks                          | Potwarka, 2008     | D: survey of parents, GIS data, EAPRS  
S: children within an Ontario, Canada city (n = 108) | D: Park facilities  
I: BMI | Children living near a park playground were much more likely (nearly five times) to have a healthy BMI than children not living near a park playground |
| Parks                          | Shores, 2008       | D: system for observing play and recreation in communities  
S: Park users in an Eastern US suburban community (n = 2,113) | D: Park facilities  
I: PA levels | Visitors of parks with playgrounds, sport courts, and paths were more physically active than visitors in parks lacking these features |
| Parks                          | Zlot, 2005         | D: Behavioral Risk Surveillance System, Nationwide Personal Transportation Survey, and Trust for Public Land  
S: MSAs is common among three data sets (n = 34) | D: acres of neighborhood parks  
I: level of walking and bicycling | Acres of neighborhood parks was associated with higher levels of utilitarian walking and bicycling |
| Public transit                | Brown, 2008        | D: surveys and accelerometers  
S: residents of revitalizing, mixed use, Salt Lake City neighborhood before and after construction of new light rail stop (n = 51) | D: presence of a light rail stop in the neighborhood  
I: obesity, MVPA, and car trips | Those who did not ride transit had higher obesity rates (65 percent) than transit riders (15 percent) and new transit riders were in the middle (26 percent). Long-term transit riders took the fewest car rides and had more periods of moderate physical activity. New riders reported fewer car trips after transit service became available in their neighborhood |
| Public transit                | Edwards, 2008      | D: 2001 NHTS  
S: survey respondents (n = 28,771) | D: use of public transit  
I: time spent walking | On average, public transit users walked 83 more minutes per day than those who do not use transit |
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<th>Category</th>
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<tbody>
<tr>
<td>Public transit</td>
<td>Oreskovic, 2009</td>
<td>D: clinical data, GIS data S: children aged two to eighteen who visited a large integrated medical system in 2006 (n = 21,008)</td>
<td>D: proximity to subway stations I: BMI in children</td>
<td>A higher density of subway stations near participants homes was associated with lower BMI in children</td>
</tr>
<tr>
<td>Public transit</td>
<td>Rundle, 2007</td>
<td>D: survey, geographical data, multilevel analysis of urban form S: adult volunteers in New York City (n = 13,102)</td>
<td>D: density of bus and subway stops I: BMI</td>
<td>Higher density of bus and subway stops was associated with lower rates of overweight among New Yorkers after controlling for socioeconomic factors</td>
</tr>
<tr>
<td>Public transit</td>
<td>Wener, 2007</td>
<td>D: pedometer and self-report of physical activity S: train and car commuters (n = 111)</td>
<td>I: use of train versus car for commute D: walking level</td>
<td>On average, train commuters walked 30 percent more steps per day per day than car commuters</td>
</tr>
<tr>
<td>School environments</td>
<td>Larsen, 2009</td>
<td>D: travel behavior survey, GIS data S: students in London, Ontario (n = 614)</td>
<td>I: land use mix and trees along route D: likelihood of walking to school</td>
<td>The presence of trees along routes to school and higher land use mix was associated with higher rates of children walking to school</td>
</tr>
<tr>
<td>School environments</td>
<td>Parley, 2007</td>
<td>D: observational data and survey S: children in an intervention and comparison neighborhood in New Orleans</td>
<td>I: opening school yard and having attendants present during nonschool hours D: number of children playing and PA rates</td>
<td>Opening schoolyards with supervision during nonschool hours was associated with increased levels of children's physical activity</td>
</tr>
<tr>
<td>School environments</td>
<td>Ridgers, 2007</td>
<td>D: heart rate telemetry and accelerometry S: children at fifteen intervention schools and eleven control schools in an England city (n = 470)</td>
<td>I: presence of playground redesign with multicolor structures D: MVPA among children during recess</td>
<td>Playgrounds with multicolor markings and structures were associated with increased levels of MVPA during school recess</td>
</tr>
<tr>
<td>School environments</td>
<td>Sallis, 2001</td>
<td>D: SOPLAY and parent survey S: children at twenty-four public middle schools</td>
<td>I: presence of supervision and equipment on school playgrounds D: PA levels</td>
<td>School environments that include equipment such as basketball hoops and adult supervision were associated with increased physical activity rates among students during lunch and after school</td>
</tr>
</tbody>
</table>

Note: MVPA = moderate to vigorous physical activity; SOPLAY = System for Observing Play and Leisure Activity in Youth; IPAQ = International Physical Activity Questionnaire; BMI = body mass index; GIS = geographic information system; EAPRS = Environmental Assessment of Public Recreation Spaces; BRFSS = Behavioral Risk Factor Surveillance System; PA = physical activity; NC = North Carolina; POS = public open space; MSPA = moderate-to-strenuous physical activity; MSA = Metropolitan Statistical Area; NHTS = National Household Travel Survey.
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<tbody>
<tr>
<td>Neighborhood food environment and weight status</td>
<td>Babey, 2008</td>
<td>• D: 2005 CHIS, InfoUSA Business File, GIS data to calculate REFI&lt;br&gt;• S: participants of 2005 CHIS ($n = 40,000$)</td>
<td>• I: proximity to fast food&lt;br&gt;• D: obesity</td>
<td>Obesity prevalence was highest for adults who had the most fast food and convenience stores near their homes relative to grocery stores</td>
</tr>
<tr>
<td>Neighborhood food environment and weight status</td>
<td>Burdette, 2004</td>
<td>• D: data from WIC and GIS data&lt;br&gt;• S: low-income three- to four-year-olds living in Cincinnati, OH ($n = 7,020$)</td>
<td>• I: proximity to fast food&lt;br&gt;• D: BMI</td>
<td>No association found between childhood overweight and proximity to fast-food stores</td>
</tr>
<tr>
<td>Neighborhood food environment and weight status</td>
<td>Morland, 2006</td>
<td>• D: ARIC study results and food store data from DOA&lt;br&gt;• S: participants in the third visit (1993–1995) of the ARIC Study in Mississippi, North Carolina, Maryland, and Minnesota ($n = 10,763$)</td>
<td>• I: the presence of grocery stores&lt;br&gt;• D: obesity</td>
<td>Presence of supermarkets was associated with higher neighborhood obesity rate and presence of convenience stores was associated with a higher neighborhood obesity rate</td>
</tr>
<tr>
<td>Neighborhood food environment and weight status</td>
<td>Schafft, 2009</td>
<td>• D: DOH census and GIS data&lt;br&gt;• S: fifth graders within ninety-two rural PA study districts in 1999 and same students again 2001 ($n = 25,000$)</td>
<td>• I: presence of grocery stores&lt;br&gt;• D: BMI</td>
<td>Percentage of overweight students in food deserts higher than in nonfood deserts</td>
</tr>
<tr>
<td>Neighborhood food environment and fruit and vegetable intake</td>
<td>Lucan, 2010</td>
<td>• D: interviews&lt;br&gt;• S: residents of low-income primarily African American community in Philadelphia aged eighteen to eighty-one ($n = 40$)</td>
<td>• I: availability, cost, and convenience of fruit and vegetables and fast food&lt;br&gt;• D: fruit and vegetables and fast food intake</td>
<td>Cost, finances, availability, and convenience were identified as top barriers to fruit and vegetable consumption</td>
</tr>
<tr>
<td>Neighborhood food environment and fruit and vegetable intake</td>
<td>Morland, 2002</td>
<td>• D: food frequency questionnaires, DOA data&lt;br&gt;• S: ARIC participants in 221 census tracts in Washington County, MD, Forsyth County, NC, Jackson City, MI, and Minneapolis ($n = 10,623$)</td>
<td>• I: the presence of grocery stores&lt;br&gt;• D: fruit and vegetable intake</td>
<td>Convenience and availability were promoters of fast-food consumption</td>
</tr>
<tr>
<td>Neighborhood food environment and fruit and vegetable intake</td>
<td>Zenk, 2009</td>
<td>• D: food frequency questionnaire, count of neighborhood food stores&lt;br&gt;• S: African American, Latino, and white adults in Detroit ($n = 919$)</td>
<td>• I: perceived and observed neighborhood fresh fruit and vegetable supply&lt;br&gt;• D: fruit and vegetable intake</td>
<td>Black Americans’ fruit and vegetable intake increased by 32 percent for each additional supermarket in the census track</td>
</tr>
<tr>
<td>Community agriculture</td>
<td>Kingsley, 2008</td>
<td>• D: interviews&lt;br&gt;• S: members from an urban community garden in Port Melbourne, Australia ($n = 10$)</td>
<td>• I: participation in community gardens&lt;br&gt;• D: perceived health benefits</td>
<td>White Americans’ intake increased by 11 percent with the presence of one or more supermarket</td>
</tr>
<tr>
<td>Community agriculture</td>
<td>Macias, 2008</td>
<td>• D: interviews&lt;br&gt;• S: CSA farmers, partners in a direct-market organic farm, community garden site coordinators working in the Intervale, in Burlington, VT ($n = 12$)</td>
<td>• I: participation in community gardens, CSA, and farmers’ markets&lt;br&gt;• D: observed health benefits</td>
<td>Presence of a large grocery store was associated with an average of .69 more servings of fruit and vegetables per day</td>
</tr>
<tr>
<td>Community agriculture</td>
<td>Teig, 2009</td>
<td>• D: interviews&lt;br&gt;• S: community gardeners in Denver ($n = 67$)</td>
<td>• I: participation in community gardens&lt;br&gt;• D: perceived health benefits</td>
<td>Latinos compared with African Americans who had a large grocery store nearby consumed 2.2 more daily servings</td>
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</tbody>
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<tr>
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</thead>
<tbody>
<tr>
<td>Community agriculture</td>
<td>Wakefield, 2007</td>
<td>D: participant observation, focus groups, and in-depth interviews</td>
<td>I: participation in community gardens</td>
<td>Participants noted that community gardens provide the following health benefits: improved nutrition, increased PA, and improved mental and social health, among others</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S: garden participants in South-East Toronto (n = 68)</td>
<td>D: perceived health benefits</td>
<td></td>
</tr>
<tr>
<td>Grocery store characteristics</td>
<td>Laska, 2009</td>
<td>D: audits of food stores</td>
<td>I: grocery store size</td>
<td>The availability of fruit and vegetables was low for single isle and small stores. Availability increased significantly as store size increased</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S: food stores in Baltimore, Minneapolis/St. Paul, Oakland, and Philadelphia in proximity to low-income schools (n = 105)</td>
<td>D: availability of fruit and vegetables</td>
<td></td>
</tr>
<tr>
<td>Food access and poverty</td>
<td>Rose, 2009</td>
<td>D: InfoUSA, neighborhood observation, and in-store survey</td>
<td>I: use of available food desert metrics</td>
<td>Using food desert measures as found in the literature the existence of food deserts in New Orleans covers anywhere from 17 percent to 87 percent of the city’s census tracts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S: census tracts in New Orleans (n = 175)</td>
<td>D: presence of food desert in New Orleans</td>
<td></td>
</tr>
<tr>
<td>Food access and poverty</td>
<td>Sharkey, 2009</td>
<td>D: census data, GPS data, and direct observation</td>
<td>I: neighborhood need (socioeconomic deprivation and vehicle availability)</td>
<td>A poor and minority community in Texas had the best access to convenience stores and fast food restaurants both in distance and in number</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S: CBGs in Hidalgo County (n = 197)</td>
<td>D: food access (distance to and number of food stores)</td>
<td></td>
</tr>
</tbody>
</table>

Note: GIS = geographic information system; REFI = Retail Food Environment Index; WIC = Women, Infants, and Children; BMI = body mass index; ARIC = atherosclerosis risk in communities; DOA = Department of Agriculture; DOH = Department of Health; PA = physical activity; CSA = community-supported agriculture; CBG = census block group.
fast-food outlets in urban, low-income neighborhoods already saturated with such establishments, suggesting, as the authors write, “that altering fast-food restaurant locations without decreasing their number would not influence the prevalence of overweight in these children” (Burdette and Whitaker 2004, 62).

Larson, Story, and Nelson (2009) completed a review of fifty-four studies and in doing so found that residents with better access to supermarkets and reduced access to convenience stores had lower rates of obesity and were more likely to meet recommended fruit and vegetable intake. However, neighborhoods with limited access to retail stores offering healthy food are often predominantly low-income, minority, or rural neighborhoods. Farmers’ markets and community gardens are often seen as low-investment interventions to remedy food deserts in communities across the United States. McCormack et al. (2010) reviewed sixteen studies measuring the nutrition-related outcomes of farmers’ markets. These measured the influence of the Women, Infants, and Children (WIC) food assistance program, various programs for seniors and community garden programs on behaviors, perceptions, and dietary intake. Overall, those receiving farmers’ market benefits or with access to community gardens were more likely to increase their intake of fruit and vegetables (McCormack et al. 2010).

Further research is needed to determine health outcomes. In this review, the authors did not identify any studies with control groups that measure the dietary impacts of farmers’ markets or weight-related outcomes. Studies on community garden projects in Australia and Toronto found participants to perceive that the garden improved their fruit and vegetable intake, increased PA, and provided a number of social benefits including learning opportunities, a sense of achievement, and a sense of connectedness with others (Kingsley, Townsend, and Henderson-Wilson 2008; Wakefield et al. 2007). The findings of a similar study in Denver (Teig et al. 2009) echo these social benefits that derive from volunteer activity, leadership, organizational activity, and recruitment involving outreach to other neighbors. Social capital can be derived from farmers’ markets and community gardens, and educational opportunities about growing food can be derived from community gardens and community-supported agriculture (CSA) programs (Macias 2008).

Areas with little or no access to healthy foods are often called “food deserts.” Food deserts are areas that lack adequate availability of stores selling healthy foods. For instance, the colonias (neighborhoods) of Hidalgo County, Texas, along the Mexican border, were identified as a food desert community because residents have much better access to convenience stores and fast-food restaurants than to grocery stores or supermarkets. Within the block groups contained by the colonias, 255 convenience stores and 204 fast-food restaurants were identified, compared to only three supercenters, eleven supermarkets, and seven grocery stores. The majority of residents ($n = 197; 78$ percent) did not have access to a supermarket within one mile of their homes and many did not have a reliable mode of transportation to travel longer distances (Sharkey et al. 2009). This is important because convenience stores and other small stores do not offer the same availability of healthy foods as do large grocery stores and supermarkets (Laska et al. 2009). Studies have demonstrated that food deserts are more likely to occur in low-income neighborhoods and neighborhoods with high proportions of minorities, although reasons for the lack of healthy foods in small stores may differ across regions (Babey et al. 2008; Sharkey et al. 2009; Laska et al. 2009).

Studies demonstrate that residents of food deserts often have higher rates of obesity; however, the association between food deserts and obesity is complex (Schafft, Jensen, and Hinrichs 2009). Rose et al. (2009) studied food deserts in New Orleans post–Hurricane Katrina and found that the term food desert has been broadly defined within the literature using a range of different measurement criteria. From their observations, the authors concluded that the term food swamps may be a more accurate portrayal of urban food access, describing areas in which unhealthy food options are significantly more abundant than healthy food options. Furthermore, a new online tool to help identify and plan targeted interventions for food deserts, the Food Desert Locator that was developed out of First Lady Michelle Obama’s “Let’s Move!” (2011) campaign, shows which census tracts are more than one mile from a supermarket in urban areas or more than ten miles from a grocery store in rural areas (USDA 2011). Healthy food access is the current term and emphasis for interventions that emphasize the significance of mobility as the most important determinant for healthy food access (Botchwey et al. in press; Coveney and O’Dwyer 2009; Burns and Inglis 2007; White et al. 2004).

The healthiness of food has been shown to directly affect physical health in the form of disease and body weight (World Health Organization [WHO] 2003). However, eating healthy food is not simply a matter of choice; in some contexts, doing so is not even an option, and public health interventions alone can only go so far to change this fact. Planning plays a critical role in siting locations that sell healthy food and, thus, plays a critical role in public health, especially regarding equitable distribution of these amenities. Further research is needed on the structural and context-specific reasons that more healthy food options do not exist and to determine what needs to change in order for those options to become more possible.

Traffic Safety and the Built Environment

Due to their overwhelming frequency and thus impact, motor vehicle crashes are already a prominent focus of public health and policy efforts. Approximately 40,000 fatalities and 800,000 injuries occur each year from traffic accidents on American roads (Ewing and Dumbaugh 2009), making traffic injuries both the leading cause of death for US adolescents (CDC 2010) and the sixth-ranking actual cause of death for the entire US population (Mokdad et al. 2004). Overall, the research indicates that suburban and rural areas tend to have higher rates of traffic fatality, particularly along suburban arterials and rural, undivided two-lane highways.
Recent literature establishes that features in the built environment at a variety of scales influence the prevalence of automobile collisions and the severity of resulting injuries to motorists and pedestrians. Urban sprawl has been associated with heightened traffic fatality risk, both of severity and of frequency (Ewing, Schieber, and Zegeer 2003; Clifton, Burnier, and Akar 2009; Dumbaugh and Rae 2009: Lucy 2003). Traffic fatality rates have been found to be highest in the exurbs, compared to inner suburbs and cities (Lucy 2003), and more compact development has been associated with lower traffic fatality rates among both drivers and pedestrians. Ewing, Schieber, and Zegeer (2003) call for further research into the relationship between development patterns and pedestrian fatality.

Regarding pedestrian–motor vehicle crashes, on average, 12 percent of those involved in traffic fatalities are pedestrians, a percentage that is disproportionately higher than the amount of walking that occurs within this country (Insurance Institute for Highway Safety 2014). Suburban areas are often associated with more pedestrian fatalities related to motor vehicle accidents (Ewing, Schieber, and Zegeer 2003), and the occurrence of vehicle–pedestrian crashes tends to increase with vehicle operating speeds; therefore, low-speed urban streets often have fewer crashes involving pedestrians (Gärder 2004). Pedestrian injury severity is also sensitive to vehicle impact; the higher speed in crashes with speeds of thirty miles per hour or greater results in dramatically increased fatality risk (Leaf and Preusser 1999). It was previously thought that, because of greater traffic volume, urban roads are more dangerous than suburban or rural roads; however, current literature establishes that the incidence of motor vehicle collisions does not adequately measure the traffic safety risk of an area. Traffic speed has greater positive correlation with risk, when controlling for vehicle miles traveled (VMT) or crash severity, than does traffic volume (Ewing and Dumbaugh 2009). Although traffic volume does positively correlate with the incidence of crashes, fatalities correlate more with VMT (Wier et al. 2009). New tools based on this emerging research, such as the Healthy Development Measurement Tool developed in 2006 by the San Francisco Department of Public Health, can estimate the potential impacts of land use and street-level planning choices on pedestrian crash risk.

Given the relationship between vehicle operating speed and pedestrian–vehicle crash severity, it is not surprising that nearly 25 percent of fatal or injurious motor vehicle accidents involving pedestrians or bicyclists occur on rural highways. Rural roads offer a different set of challenges for planners and traffic engineers trying to plan for pedestrian and bicycle safety. One study conducted in North Carolina (Carter and Council 2007) found that rural, undivided two-lane roads have the highest number of crashes fatal to pedestrians. Such severe crashes were most frequent on high-speed roads with unpaved shoulders and less roadway lighting (see Table 7).

Big box stores and commercial developments along high-speed arterials have been associated with higher crash incidences than have been pedestrian-oriented retail neighborhoods (Dumbaugh and Rae 2009). Connectivity of pedestrian infrastructure and access to transit have been found to be negatively correlated, and the width of roads positively correlated, with the severity of injury sustained in pedestrian–motor vehicle crashes (Clifton, Burnier, and Akar 2009). Sprawl has also been demonstrated to increase risk exposure among already high-risk teen drivers (Trowbridge and McDonald 2008) as well as to counteract efforts to decrease the number of hours teens spend behind the wheel (McDonald and Trowbridge 2009).

Traffic volume is also impacted by development patterns. Using the sprawl index, researchers have measured the relationship between certain development patterns and traffic safety. Their findings establish that density, mix of uses, and the presence of urban activity centers are associated with decreased daily mileage and lower traffic fatality rates (Trowbridge and McDonald 2008). Importantly, fatality rates decline at an even faster rate than VMT when these features are present (Ewing, Schieber, and Zegeer 2003).

Roadway design challenges old operating assumptions as well. Planners and traffic engineers, focused almost entirely on the safety of vehicle occupants rather than on the comprehensive safety of all potential road and sidewalk users, have long operated on the assumption that wider, straighter roads are safer. However, recent literature shows that this is not always true, particularly in urban areas. Narrower roads with features such as trees and planters alongside in urban areas are often safer for drivers, because these obstacles slow traffic down by design (Ewing and Dumbaugh 2009).

These studies show that traffic safety has a significant adverse effect on public health. It is also evident that planning plays a crucial role in this area of public health. In comparison with public health practitioners, planners have potential authority over some of the traffic factors which affect public health, including street design, traffic flow and speed, and access to transit.

Discussion

Placed within context, these findings show significant opportunity for intervention into public health issues on the part of planners and other community design professionals. This article is not the only such review to examine this space for opportunity. Early reviews limit their scope, and thus their framing, to a specific correspondence. This includes, for example, Frank and Engelke’s (2001) exploration of urban form and PA, Evans’ (2003) review of the connection between mental health and built environment features, and Shaw’s (2004) look at aspects of housing as determinants of health.

Moving further, a number of well-developed models for understanding the link between health and the built environment have been proposed. Northridge, Sclar, and Biswas (2003), for example, put forward a conceptual framework characterized by four sets of social determinants of health, the components of which interact with each other in various ways to affect health outcomes. The authors saw the social determinants that exist at the community level (built environment and
Table 7. Evidence Based on Traffic Safety and Built Environment with Health Outcomes.

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<tbody>
<tr>
<td>Various built environment characteristics</td>
<td>Clifton, 2009</td>
<td>• D: MD motor vehicle accident report, GIS data and S: pedestrian–motor vehicle crashes in Baltimore (n = 4,500)</td>
<td>• I: transit access and pedestrian connectivity and D: severity of injury sustained in pedestrian–motor vehicle crashes</td>
<td>Transit access and pedestrian connectivity were negatively correlated with the severity of injury sustained in pedestrian–motor vehicle crashes</td>
</tr>
<tr>
<td>Various built environment characteristics</td>
<td>Dumbaugh, 2009</td>
<td>• D: GIS data on crash incidence and urban from various built environment characteristics and S: crashes in San Antonio from 2004 to 2006 (n = 150,626)</td>
<td>• I: presence of conventional community design features (box stores, miles of arterials, etc.) and D: crash incidence</td>
<td>Big box stores, the presence of high speed urban arterials, and commercial developments along arterials were associated with higher motor–vehicle crash incidences and high density and pedestrian oriented retail were associated with fewer crash incidences</td>
</tr>
<tr>
<td>Various built environment characteristics</td>
<td>Gärder, 2004</td>
<td>• D: Maine DOT data and S: pedestrian–motor vehicle crashes in Maine from 1994 to 1998 (n = 1,589)</td>
<td>• I: speed, road width, presence of signals, and safety features and D: pedestrian–motor vehicle crash incidence</td>
<td>Wide roads and high speeds were associated with more pedestrian motor vehicle crashes</td>
</tr>
<tr>
<td>Various built environment characteristics</td>
<td>Kuhimann, 2009</td>
<td>• D: publicly available data on collisions, land use, etc., and S: pedestrian–motor vehicle collisions in Denver, CO from 2000 to 2003 (n = 1,811)</td>
<td>• I: liquor licenses, density, walking to work and D: pedestrian–motor vehicle crash incidence</td>
<td>Presence of liquor licenses, high rates of walking to work, high population density were associated with higher incidences of pedestrian–motor vehicle crashes</td>
</tr>
<tr>
<td>Various built environment characteristics</td>
<td>Wier, 2009</td>
<td>• D: environmental and population data in 176 San Francisco, California census tracts and S: census tract vehicle–pedestrian injury collisions (n = 4,039)</td>
<td>• I: street features, land use, and population characteristics and D: pedestrian–motor vehicle crash incidence</td>
<td>Traffic volume has been determined to be the largest predictor of vehicle–pedestrian injury collisions</td>
</tr>
<tr>
<td>Residential density</td>
<td>Lucy, 2003</td>
<td>• D: city, county, state, federal data for traffic fatalities and S: traffic fatalities in fifteen metropolitan areas</td>
<td>• I: location: central city, inner suburbs, or exurbs and D: traffic fatalities</td>
<td>Traffic fatality rates were highest in exurbs than in inner city and inner suburbs</td>
</tr>
<tr>
<td>Residential density</td>
<td>McDonald, 2009</td>
<td>• D: 2001 NHTS and S: teens aged sixteen to nineteen (n = 3,976)</td>
<td>• I: residential density and D: teen driving rates</td>
<td>Teens living in high-density neighborhoods had lower driving rates than teens living in less dense neighborhoods</td>
</tr>
<tr>
<td>Urban sprawl</td>
<td>Ewing, 2003</td>
<td>• D: sprawl index (census and data from Natural Resources Inventory of the US DOA) and S: traffic fatalities in 448 US counties in largest 101 MSAs.</td>
<td>• I: sprawl index and D: traffic fatalities</td>
<td>More compact development was associated with lower traffic fatality among drivers and pedestrians</td>
</tr>
<tr>
<td>Urban sprawl</td>
<td>Trowbridge, 2008</td>
<td>• D: 2001 NHTS and residential population density and S: teens aged sixteen to nineteen (n = 4,528)</td>
<td>• I: sprawl index and D: teen driving rates</td>
<td>More pronounced sprawl was associated with higher daily driving distances among teens</td>
</tr>
<tr>
<td>Rural roads</td>
<td>Carter, 2007</td>
<td>• D: NC crash data and road characteristics from HSIS and S: bicycle–vehicle crashes (n = 1,849) and pedestrian–vehicle crashes (n = 3,598) occurring from 1997 to 2002 in NC</td>
<td>• I: rural road characteristics and D: pedestrian–motor vehicle crash incidence</td>
<td>Rural two-lane, undivided, nonfreeways with higher vehicle speeds, lack of roadway lighting, and unpaved shoulders had the highest number of bicycle and pedestrian–motor vehicle crashes</td>
</tr>
</tbody>
</table>

Note: MD = Maryland; GIS = geographic information system; DOT = Department of Transportation; NHTS = National Household Travel Survey; DOA = Department of Agriculture; MSA = Metropolitan Statistical Area; HSIS = Highway Safety Information System.
social context) and interpersonal level (stressors) as those most ripe for planning-focused interventions. Frumkin (2005, A290) offers environmental justice, with its focus on “the needs of disenfranchised populations, especially poor people and people of color,” as a base upon which built environment and environmental health practitioners can and must build solutions together. The World Health Organization’s Healthy Urban Planning model directs planners to consider health in all planning and policy decisions as “all the major aspects of planning policy influence health” (Barton and Tsourou 2000, 13). Frieden’s (2010) Health Impact Pyramid model envisions a five-tiered progression of intervention types, where interventions on each tier moving upward are narrower in scope than the previous one. This model implicitly emphasizes the importance of built environment-based interventions or the determinants of health emphasized by other models, because they tend to fall under the first tier. Thus, “[i]nterventions focusing on lower levels of the pyramid tend to be more effective because they reach broader segments of society and require less individual effort” (p. 590).

While each of these models is powerful in presenting a way of understanding the role planners can play in public health, the introduction of an actual causes of death approach as a connector between planning and public health fields adds an important new way to underscore the necessity of cross-disciplinary thought and practice. It necessarily encourages upstream collaboration on the part of these fields. This is not dissimilar, in theory, from the implications of Frieden’s Health Impact Pyramid model, yet the ability to tie the framework to quantitative data such as that of Mokdad et al. lends the actual causes of death framework particular explanatory potential.

Conclusions

The adoption of actual causes of death perspective within public health has potentially significant implications for urban planning, architecture, and other design fields. A focus on upstream causes and intervention opportunities in dealing with high-priority epidemics such as childhood obesity naturally emphasizes the important role of the built environment in public health; it can center efforts on behaviors that involve significant environmental interaction, such as PA, eating, and transportation safety. Adoption among urban planning and design practitioners, researchers, and educators of an actual causes of death perspective can help better engage public health partners and health-oriented decision makers can help maximize positive quality of life and health outcomes and mitigate the negative.

Planning Practice

Planning practitioners and other place-based designers make decisions that shape the built environment, and thus the context that influences our decisions and health outcomes (Malizia 2005). When gathering and analyzing information, practitioners can incorporate public health and safety as a prominent goal, and include data and analysis in their forecasting that connects place to health. Emerging tools such as Health Impact Assessment (Collins and Koplan 2009; Rutt et al. 2005; Ross et al. 2012; Ross, Orenstein, and Botchwey 2014), design tools such as the Active Design Guidelines developed by the New York City Department of Health (Lee 2012), and policies like that requiring Community Health Needs Assessments can greatly facilitate this process.

A variety of resources that are becoming available enables practitioners to quickly review and synthesize this growing body of literature, from one of the American Planning Association’s Planning Advisory Service reports (Morris 2006) to resources focusing on individual topics or providing access to materials cutting across categories. To date, the American Planning Association has published at least fifteen reports guiding practicing planners who are interested in integrating health, food planning, and accessibility into their projects, complete with case studies, work sheets, and model zoning language. Two notable reports are “Comprehensive Planning for Public Health” (Hodgson 2011) and “Healthy Plan Making” (Ricklin and Kushner 2013), which document how health components are in practice incorporated into comprehensive plans, either as a functional plan specifically targeting food, active transportation, and other public health factors or as one featuring these components woven through the primary planning document and offer case studies emphasizing health topics.

Among the first online sources was Design for Health (2009), a web site “bridg[ing] the gap between the emerging research base on community design and healthy living and the everyday realities of local government planning . . . and tool development and public education.” This includes research summaries concerning twelve topical areas and health impact assessment for planners. These summaries convey the state of current knowledge, gaps, and innovations, and offer a guide on benchmark values for quantifying assessments in this area. Another resource, InformeDesign (see http://www.informe-design.org/, accessed July 29, 2013), offers periodic syntheses of recent articles on health and the built environment. This work began in 2000 and now includes thousands of article summaries on twenty-six topics. The Built Environment and Public Health Clearinghouse (www.bephc.gatech.edu) explicitly offers a set of primers to help practitioners who are just beginning to work with these issues. It also offers model curriculum for planning, architecture, landscape architecture, and health impact assessment, readings, presentations, and a gateway to the built environment and public health community of researchers and practitioners.

Planning Research

Researchers in planning can use these resources to guide their engagement with this work using a multiscaled and multitopeical systems approach. Ideas on how scholars can apply actual causes of death systems framework to research and practice are outlined here using the fifteen academic tracks of the
Association of Collegiate Schools of Planning (ACSP 2009), many of which are combined in synergistic groupings.

The ACSP tracks “analytical methods and computer applications” and “planning for human health and safety,” both of which offer overarching themes and research applications that touch on all five tiers of Frieden’s (2010) Health Impact Pyramid. Qualitative and quantitative analysis methods, as well as spatial analysis with programs such as geographic information systems (GIS), can be utilized at each level of health intervention. The study of planning for human health and safety clearly involves research and interventions at all levels, thus providing the foundation for other planning tracks. “Planning history” and “planning theory” provide conceptual and historical foundations for the five tiers of Frieden’s (2010) Health Impact Pyramid. While history shows that Euclidean zoning and the growth of the suburbs were planning models that decreased the incidence of infectious diseases in the twentieth century, theory now highlights the influence of these models on the chronic diseases of the twenty-first century (Corburn 2004; Sloane 2006).

Planning tracks emphasizing Frieden’s tier-1 social determinants of health—“changes in socioeconomic factors […] that help form the basic foundation of a society” (p. 591)—include “economic development” and “gender and diversity in planning.” Such tracks aim to reduce economic and social disparities, especially among minorities, the elderly, children, and other disenfranchised groups most impacted by health and safety concerns related to the built environment.

ACSP planning tracks associated with tier-2 contexts for health decisions—“interventions that change the environmental context to make healthy options the default choice” (Frieden 2010, 591)—include “environmental planning and resource management,” “housing and community development,” “land use policy and governance,” “planning process and administration,” “regional planning,” “transportation and infrastructure,” and “urban design.” Some of these content areas, such as urban design and transportation, have obvious implications for environmental contexts. Matters in other tracks, such as “land use policy” and “regional planning,” can also have significant effects on community layout through planning tools and development policies that impact density and placement of jobs as well as other community and regional facilities (Malizia 2006). The development of new technological tools, such as complex systems modeling, the study of social networks, and spatial modeling capabilities like GIS continue to offer new insights into the complexity of battling the chronic disease epidemic.

Planning Pedagogy

Design and health curricula in higher education have grown exponentially; with just one cross-disciplinary course in 2003, there are now fifteen such courses taught across the United States as of 2013 (bephc.gatech.edu). The courses focus, variously, on Planning and Public Health Foundations, Natural and Built Environments, Vulnerable Populations and Health Disparities, and Health Policy and Global Impacts. They enroll students from a variety of disciplines including public health, planning, urban design, architecture, landscape architecture, and public policy (Botchwey et al. 2009). Other, allied courses can include modules or assignments to introduce this topic to students without taking up a full semester. A number of resources are available to guide instruction in this area, catalogued on www.bephc.gatech.edu.

A sustainable approach to strengthening planners’ and designers’ roles in bridging health and the built environment requires a three-pronged effort including practice, research, and teaching. Scholarship using actual causes of death perspective provides the basis for upstream policies and programs that integrate the rapidly expanding research base in urban planning and design. Research, teaching, and practice in planning and health could each benefit from a reframing that includes the social–ecological framework in order to better address the interaction and independence of variables that increase the influence of the prevailing actual causes of death: poor diet, physical inactivity, and motor vehicle injury.

To design places that address the socioeconomic determinants of health is within the ability of planners and designers of the built environment. In turn, creating healthy places itself also provides the evidence with which to justify further good planning. The planning disciplines of urban design, transportation, and land use have been shown to impact PA and, thus, directly improve public health. Likewise, planning has a direct impact on disease and obesity prevention due to its influence over access to healthy food. Finally, no field other than planning or civil engineering can have as great an impact on a population’s mortality and personal injuries in the area of transportation. Thus, built environment professionals have a unique and crucial role to play in joining their particular knowledge bases and abilities to the work being done by the public health field. By making these connections explicit, working from a systems-focused actual causes of death perspective will allow us to foster livable and healthy places, and, most importantly, healthy people.

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