THE BENEFITS OF STREET-SCALE FEATURES FOR WALKING AND BIKING

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This report was authored by Lindsay Maurer Braun, doctoral student in the Department of City and Regional Planning at the University of North Carolina at Chapel Hill, and Anna Read, AICP, senior program and research associate at APA. The principal investigator for this project was Anna Ricklin, AICP, manager, Planning and Community Health Center.

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American Planning Association Staff: James M. Drinan, JD, Executive Director; David Rouse, AICP, managing director of Research and Advisory Services; Anna Ricklin, AICP, manager, Planning and Community Health Center; Anna Read, AICP, senior program and research associate; Nick Ammerman, library and taxonomy manager; Danielle Moore, library intern (formerly with APA); Julie Von Bergen, copy editor; and Susan Deegan, senior graphic designer.

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INTRODUCTION

As the car became the dominant mode of transportation throughout the 20th century, the priority for cities and towns to support safe walking and biking—for either transportation or recreation—diminished. Designing our communities to efficiently move cars impacted the scale and form of our streetscapes and the connectivity of bicycle and pedestrian networks. Today, for example, walking represents less than three percent of commuting trips and, while its mode share is increasing, biking represents less than one percent of commuting activity.[A]

As the costs of physical inactivity become increasingly evident, and as planners, public health professionals, and others working in the field of active transportation strive to promote walking and biking, the necessity of retrofitting and updating street facilities and sidewalk features is apparent. The benefits of incorporating infrastructure that supports active transportation into our streetscapes are many. While efforts to encourage walking and biking often focus on physical activity benefits, it is important to recognize that investments in these travel modes offer a wider set of potential co-benefits for communities.

This literature review focuses on the benefits that may arise from investment in different types of street-scale features, either independently or in combination. The review considers not only potential impacts related to physical activity—which have been treated extensively in the literature to date—but also a variety of co-benefits including social cohesion, crime prevention and public safety, multimodal traffic safety, mental health, and economic effects. The review links these co-benefits to various types of street-scale features that encourage walking and biking, such as sidewalks, bicycle lanes, traffic calming, crossing aids, aesthetics and placemaking, public space, street trees, green infrastructure, and street furniture.

This analysis provides background information and supportive data for **planners, transportation professionals, advocates,** and **policy makers** working to encourage community design that promotes active transportation. Through this report, individuals working locally will be able to highlight the co-benefits of street-scale interventions that support walking and biking.

Methodology

Definitions of features and co-benefits

This analysis focuses on nine street-scale features and related co-benefits. The features, defined in Table 1, are those that can be deployed at the street scale, rather than requiring deployment on a broader network scale. In addition to feature definitions, Table 1 also indicates the number of resources included in the literature review that address each feature.

Table 1. Street-Scale Features and Definitions[B]

Feature	Definition	Number of resources
Sidewalks	Maintained areas in the public right-of-way dedicated to pedestrian use, ideally at least five feet wide	57
Bicycle Facilities	Bike lanes, separated bike lanes (cycle tracks), shared lane markings (sharrows), off-road paths, and other facilities such as bike racks	49
Traffic Calming	Physical interventions in street design, including traffic circles and roundabouts, neck downs, center island narrowings, chicanes, speed bumps, and textured surfaces, among others, that can reduce speeds and traffic volumes, improving the experience and safety of users of nonmotorized transportation	53
Crossing Aids	Marked and unmarked crosswalks, pedestrian signals	32
Aesthetics and Placemaking	Public art, fountains, splash pads, decorative features, and other streetscape interventions that create human scale and sense of place	20
Public Space	Parks, plazas, and other spaces accessible to and usable by the public	16
Street Trees	Trees planted along the street or sidewalk to provide shade or for aesthetic purposes	38
Green Infrastructure	Green infrastructure features at the neighborhood or site scale, including greenways, rain gardens, riparian buffers, bioswales, pervious pavement, and green streets	10
Street Furniture	Small-scale features – generally in a fixed location – including bike racks, benches, bus shelters, and signs, which are both functional and create a sense of place	18

The co-benefits examined in this review are identified and defined in Table 2. This table also includes the number of resources in the review that address each co-benefit.

Table 2. Co-benefits and Definitions[c]

Co-benefit	Definition	Number of resources
Physical Activity	Increased levels of physical activity, including walking and biking, for transportation or leisure purposes	65
Social Cohesion	Increased levels of social interaction, social support, collective monitoring, social trust, sense of community, shared cultural identity	36
Crime Prevention and Public Safety	Reductions in actual property and violent crime and perceptions of crime; improvements in public safety	17
Multimodal Traffic Safety	Reductions in frequency and/or severity of crashes or injury to pedestrians, bicyclists, and motorists; increased compliance with traffic regulations	34
Mental Health	Improvements in stress, anxiety, depression, energy levels, sleep quality, and fear of crime	22
Economic	Increased consumer spending, return on investment, job creation, tourism/visitors, and pedestrian and bicycle traffic for local businesses	31

Literature review

This literature review summarizes current evidence on the relationships between the street-scale features and co-benefits defined in Tables 1 and 2. To gain a broad understanding of these relationships, we considered a variety of resources both within and beyond the academic literature. A total of 152 resources were reviewed. The types of resources include:

- Academic journal articles
- Published books
- Reports by transportation and public health agencies, policy makers, and other groups
- Case studies of existing policies and projects

We used the street-scale features and co-benefits in Tables 1 and 2 as search terms in a variety of research databases. We also reviewed the reference lists of existing literature reviews on related topics—such as physical activity promotion, the built environment, and urban design—to identify resources that relate to the topic of interest for this review. Our review included resources that met the following criteria:

- Addressed the direct link between at least one street-scale feature and one co-benefit
- Presented either background information or empirical evidence for this link

We generally excluded resources that focused on broad measures of the built environment (e.g., larger street network connectivity, urban sprawl, metropolitan area density and land-use patterns) or on broad community benefits that cannot easily be attributed to specific street-scale interventions (e.g., larger environmental impacts, overall livability and sustainability, mobility). However, as we reviewed the background materials cited in many of our resources, we identified several studies that measured one or more street-scale features as part of an overall measure of the built environment (e.g., a walkability index). We included these resources as they were identified, provided that they met the other inclusion criteria.

Strengths and limitations of the review

As previously noted, this review captures only a subset of the co-benefits of active transportation investments: those that can be tied to a specific street-scale feature. Active transportation investments may have broader benefits beyond those considered in this review. Additionally, many of the case study resources focus on large cities that have invested extensively in multimodal transportation, such as New York City or Portland, Oregon, or on international locations, such as the Netherlands, whose experiences may not be broadly applicable to all areas of the United States.

Despite these limitations, the literature review is based on a diverse set of resources—beyond the academic literature—that are relevant to broad audiences, including policy makers, planners, academics, and advocates. While some community benefits are not addressed, the review is focused in scope and summarizes a subset of the evidence that can be used to further support and justify active transportation investments.

Summary of Findings

Physical activity

Street-scale features can promote walking and biking, leading to increases in physical activity. While cultural and social influences play a role and while active transportation is not highly prevalent in the United States (25, 80), individuals are more likely to walk and bike when the built environment is more supportive of physical activity and provides more opportunities for active transportation to and from local destinations.

- **Dedicated pedestrian facilities and related street-scale features increase walking.** Most pedestrians choose to use sidewalks when they are available (36), and sidewalk availability in a neighborhood is positively associated with total amounts of walking (58). Residents of areas with features such as streetlights, pedestrian crossings, and traffic calming are likely to walk more (13). In a study of the Twin Cities in Minnesota, positive correlations were found between miles walked per day and the presence of sidewalks, as well as other street-scale features such as street lighting and traffic-calming measures. Additionally, transportation-related walking (i.e., walking to reach destinations) was positively associated with these street-scale features (25).
- **Aesthetic and placemaking features are important elements of environments that encourage pedestrian activity.** Features that create "streetscape texture"—including public art, street furniture, and buildings of different types, styles, and colors—help to maintain pedestrian interest (80). For example, a New York City study found that the presence of sidewalk cafes is positively associated with both walking and biking (53).
- **Dedicated bicycle facilities increase biking.** Dedicated bicycle facilities have been found to lead to an increase in bike trips (1, 75, 77). In a study of cycling and the built environment in King County, Washington, cyclists and noncyclists indicated that improvements to the cycling environment—including bike lanes and trails, and features such as lighting at night and bicycle racks—would encourage them to bike more (60). A study conducted in the East Village neighborhood in New York City found that protected bike lanes led to an increase in cycling, and study participants stated that they were more likely to bike with the addition of protected lanes (77).
- **New bicycle facilities are likely to increase the overall amount of biking.** Because sidewalks are more widespread than bike lanes or other bicycle facilities, investing in new bicycle facilities is more likely to have an impact on the *total* amount of cycling, whereas investing in new sidewalks will more likely affect *where* people walk (43).
- **There are equity concerns related to where active transportation facilities are located.** A study conducted in the central Puget Sound region found that, despite the lack of pedestrian infrastructure, between 400 and 800 people walked to suburban commercial centers during the workday. The study also found that pedestrians at these sites were disproportionately young and pedestrians of color, when compared to the corresponding census populations (36). A study in Michigan found that communities with walkable environments tend to have several characteristics: educated and homogenous populations, as well as available funding to support street-scale interventions (80). These demographic and socioeconomic differences may have implications for where and how active transportation facilities are built, promoted, and supported for diverse population subgroups.

Residential self-selection and physical activity

Residential self-selection—the idea that people who *want* to walk and bike may *choose* to live in neighborhoods that support walking and biking—has been examined extensively in the literature. This subset of the literature examines residential self-selection as a confounding variable in order to determine whether features of the built environment still have an impact on transportation behavior after controlling for neighborhood choice. Several studies have found that, when residential self-selection is accounted for, built environment factors remain significant predictors of active transportation (14, 15, 17). Studies that do not account for residential self-selection may overstate the benefits of built environment features.

Social cohesion

Street-scale features can influence social cohesion by fostering social interaction, building community trust, supporting social equity, and creating a shared sense of identity.

- **Walkable streets provide opportunities for social interaction.** Street-scale features that encourage walking in the public realm can lead to opportunities for social interaction—planned or unplanned, one-time or repeated—with other members of a neighborhood or community (2, 16, 29, 42, 29, 50, 66, 72, 83). These types of interactions, especially when repeated over time, can build community cohesion and trust. A case study of three neighborhoods in Boston found that the following features had the greatest influence on social interaction: seating (both formal and informal), sidewalk width, building facades (e.g., nooks, small setbacks), shade/shelter (e.g., trees, awnings), and unique storefronts (59).
- **Street-scale features promote "eyes on the street."** Street-scale features can offer "natural surveillance" or "eyes on the street" (12, 29, 40), which supports community trust and deters both *actual* crime and *fear* of crime (72). The effects of neighborhood disorder can be buffered by strong, informal social ties (67). While walkable streets may also increase the number of "outsiders" (visitors) and present problems for social monitoring, this effect is generally outweighed by the effects of natural surveillance and residents of walkable neighborhoods tend to feel safer than residents of less walkable neighborhoods (26,29, 82).
- **Walkable streets can enhance sense of community.** Public spaces and attractive environments in which many people walk and cycle can create a unique sense of place and shared social identity (27, 42, 54, 83). A study of the Kentlands development in Maryland found street-scale features including block size, street landscaping, arrangement of buildings, pedestrian amenities, architecture, and street frontage (e.g., garage location) to be correlated with sense of community (42). Another study in Portland, Oregon, found walkable pedestrian environmental features to be associated with stronger sense of community, even after controlling for attitudes (54). Specific features such as public art (34, 71) and historic preservation (50) can build a shared sense of culture and history.
- **Street-scale features can influence social support, and social support can encourage physical activity.** Environments that encourage walking and cycling can increase social interaction and support. One study in the Netherlands found low quantities of green space to be associated with loneliness and perceived lack of social support (57), while another study in Miami found architectural features that promote visual contact (e.g., porches, windows, setbacks) to be correlated with higher social support among elderly residents (12). This relationship can also work in the opposite direction: Several studies have found social support to be an important predictor of walking, cycling, and overall physical activity (5, 7, 68). The relationship between environment, physical activity, and social support can therefore be a self-reinforcing cycle, albeit complex.
- **Planning for walking and cycling supports social equity.** Investing in street-scale features that support active transportation are particularly important for those who depend on alternatives to the automobile. These groups may include socioeconomically disadvantaged populations, disabled individuals, older adults, and children (20, 29, 30, 50, 72, 76, 78). Investments in active transportation can improve equity and access to economic opportunities (30, 50). Additionally, walkable streets can foster social interaction among individuals with diverse backgrounds (49), and thereby increase social trust.
- **The act of creating community spaces can support social cohesion.** While evidence shows that green spaces can support social cohesion once they are in place, the act of creating these spaces may also be important. Community-based creation of green spaces and community gardens (e.g., public involvement in planning, tree planting and garden-building events) can build social capital and empower community members to improve their neighborhoods (4, 81).

Crime prevention and public safety

Community members engaging in active transportation create street-level activity. This activity can have effects on *actual* crime and safety, as well as *perceptions* of crime and safety.

- **Greenery can increase actual and perceived safety.** While several studies note the perception that vegetation leads to higher crime rates by providing places for criminals to hide and crime to take place (44, 46), research has found that the greener a building's surroundings, the lower are both violent and property crime rates (46). Research has also found that tree density and grass maintenance increase the sense of safety in inner-city neighborhoods (44).
- **Other street-scale features can increase actual and perceived safety**. As noted in the social cohesion section above, both actual safety and perceptions of safety influence the decision to walk (72). This may occur due to "eyes on the street" and a greater sense of social trust, both of which can be supported by features that encourage street-level activity.

- **Interventions that do not lead to lower crime rates may have other safety-related benefits.** A study of community gardens in Houston found that areas with community gardens have comparable crime rates to areas with similar demographic profiles; however, they are perceived by community members to be safer, and they may result in other positive outcomes such as less illegal dumping, less noticeable drug activity, and higher property values (31).
- **Safety is not just an important co-benefit of active transportation—it is important to *supporting* active transportation.** A study in New York City found that safety concerns can discourage active transportation in neighborhoods that otherwise have walkable urban form. For example, neighborhoods with high homicide rates have lower rates of active transportation (53).

Multimodal traffic safety

Street-scale interventions that create dedicated facilities for pedestrians and bicyclists, as well as those that are intended to calm traffic, can have safety benefits for all street users. Bicycle and pedestrian facilities can raise awareness and visibility of these travel modes within the transportation network and traffic calming measures can slow traffic speeds, thereby reducing the number of crashes that result in injury.

- **Pedestrian-specific infrastructure interventions improve safety.** Street-scale interventions that support walking lead to improvements in pedestrian safety (23, 35, 64). Specific interventions found to be highly effective include sidewalks, pedestrian refuge islands, exclusive pedestrian signal phasing, more intense roadway lighting, and single-lane roundabouts (64). Well-marked crosswalks also lead to a higher observance rate (i.e., compliance with crossing regulations) by both pedestrians and drivers (35).
- **Cyclist-specific infrastructure interventions improve safety.** Just as pedestrian-specific interventions improve safety, street-scale interventions designed for biking have positive safety implications for cyclists and other road users (6, 23, 65). Safety improvements have been observed following the implementation of sharrows (a shared lane marking that indicates to drivers that bicyclists are allowed to use the full lane), including increased driver awareness of cyclists, safer passing by drivers, and increased lane observation by cyclists (10, 23, 39, 69, 70). There is a lower rate of injury for bicyclists on cycle-tracks (physically separated bike lanes) than on roadways (55, 56, 75). Other street-scale interventions, including street lighting and proper maintenance of bicycle routes, have safety benefits for cyclists (65).
- **Traffic calming measures improve safety.** Traffic calming measures affect the speed and volume of traffic, which can improve safety for all street users by reducing the frequency and severity of crashes (22, 37, 51, 84). A meta-analysis of area-wide traffic calming-measures in eight countries found the overall rate of injury crashes to be 15 percent lower in these areas, with an average reduction of 25 percent on residential streets and 10 percent on main roads (22). This finding illustrates the benefit of implementing broad street-scale interventions, rather than installing traffic calming in just a small number of locations.
- **The number of pedestrian and bicycle incidents may initially increase even as the *risk* of active transportation decreases.** It is important to note that improvements to pedestrian and bicycle infrastructure may not immediately reduce the *total number* of collisions and injuries; indeed, if these improvements lead to an increase in walking and biking, they will also increase opportunities for collisions with automobiles (53). However, even if the total number of collisions remains stable or increases, the greater number of pedestrians and bicyclists means that the collision *rate* or *risk* per individual traveler is lower. This may occur due to a "safety in numbers" effect, in which drivers become more aware of pedestrians and bicyclists and these modes become a more integrated part of the transportation network. This effect may take time to appear, and bicycle facilities—particularly those that cross intersections—may be subject to an increased risk of "looked-but-failed-to-see" collisions between bicyclists and cars, which occur when drivers look for other vehicular traffic, but fail to see bicycle traffic (65).
- **Perceptions of safety from traffic are important to increasing active transportation.** Safety-related concerns are a commonly cited reason for deciding not to bike (65). A review of the literature on cycling in six European cities found perceptions of safety, along with comfort and continuity of the network, to be the key factors determining whether people will bike (38).
- **There are equity concerns related to where street-scale features are installed.** Neighborhoods with high percentages of low- or middle-income populations are less likely to have street-scale features, including sidewalks and traffic safety measures, which make walking safe and appealing. A study that examined more than 10,000 streets in 154 communities across the United States found that a variety of street-scale pedestrian and traffic safety features—including streetlights, sidewalks, marked crosswalks, and traffic-calming features—were more likely to be found in high-income areas than in their low- and middle-income counterparts (11).

Mental health

Walking and cycling can have multiple benefits for both physical and mental health (72). Many characteristics of the neighborhood environment—particularly street trees and green spaces—are also associated with positive mental health.

- **Walking promotes mental health.** Walking is associated with reduced anxiety symptoms, better sleep quality, more positive affect (e.g., happiness, enthusiasm, contentment), and better cognitive performance (e.g., for children at school, for older adults) (13). These benefits may be greater when walking takes place in proximity to certain environmental features, such as greenery and water (13, 41). The benefits may also be greater among those who already have relatively poor mental health status (13).
- **Social cohesion promotes mental health.** As previously described, street-scale features can foster social cohesion and other forms of social capital. Higher social capital, in turn, is associated with improved mental health outcomes (29).
- **Various aspects of walkability and neighborhood quality are associated with mental health.** A study in King County, Washington, found higher neighborhood walkability—based on distance to and number of amenities, block size, dwelling unit density, and other factors—to be associated with reduced depressive symptoms in older men; this relationship was not found for women or for younger populations (8). Another study in South Wales found higher neighborhood quality—based on indicators such as litter, graffiti, vandalism, green areas, and aesthetics—to be correlated with greater mental health (3). Specific components of neighborhood satisfaction (safety and walkability, social network, and traffic noise) were positively associated with mental health in a study in Australia (48), and other researchers found perceived green space, noise, and safety to be correlated with mental health in Greenwich, London (33).
- **Green spaces and street trees play an important role in mental health.** Research shows that forest views have a more positive impact on mental health than urban views (47, 79), suggesting the value of incorporating green space into urban environments. Green spaces may have "restorative effects" on mental health, and in a nationwide survey in the United States, a "calming effect" was rated as the second most important benefit of street trees (behind shade/cooling) (52). Studies in the United States, Denmark, Australia, and Sweden have found neighborhood green spaces and street trees to be associated with lower symptoms of depression, anxiety, and stress (9, 21, 32, 61, 73, 74). In fact, one study in London found that for every one-unit increase in the density of street trees per kilometer of street, the antidepressant prescription rate decreased by 1.18 prescriptions per 1,000 residents (74). In a study in Chicago, levels of aggression, violence, and mental fatigue were higher among urban public housing residents living in "relatively barren" areas, compared to those living in areas with nearby trees and grass (45).
- **Quality and distance are important considerations.** The *quality* of green spaces (e.g., variation, maintenance, orderly arrangement, absence of litter, and general impression) may be more important to mental health than their *quantity* (21). Finally, because research shows that people may not go out of their way to access green spaces (32), incorporating green space into the urban fabric (and thus everyday life) is an important mental health objective. This relationship may be particularly important for socioeconomically disadvantaged populations. Lower-income neighborhoods tend to have lower levels of access to street-scale features that are positively associated with mental health, which further burdens these communities.

Economic

Economic benefits are also associated with street-scale features for walking and biking. These benefits include higher property values, an increase in visitors, an increase in pedestrian and bicycle traffic near businesses, and job creation for construction and maintenance of bicycle and pedestrian facilities. Pedestrians and bicyclists may be more likely than motorists to stop at local establishments, as they are moving at a slower pace and may be more likely to notice shops or restaurants.

- **Street-scale interventions have a positive impact on property values.** Location in a walkable neighborhood has a positive impact on housing values, as does proximity to bike facilities; traffic calming measures can also improve property values (13, 24, 63, 43, 50, 51, 72). A Vermont Agency of Transportation study found that property values of homes in walkable neighborhoods were $6,500 higher than those of homes in less walkable or more car-dependent neighborhoods (63), while homes within a half-mile of Indianapolis's Monon trail were found to sell for 11 percent more than comparable homes not near the trail (24).
- **People who walk or bike to retail establishments spend more over time than people who drive to the same places.** A Portland study found that when trips are examined by mode choice, people who drive spend the most per visit, but cyclists spend the most per month and make more frequent visits to different types of establishments, including bars, convenience stores, and restaurants (19). A survey of East Village shoppers in New York City similarly found that bicyclists spend the most per capita per week, followed by pedestrians, and that both bicyclists and pedestrians spend more than drivers or subway

users. Bicyclists and pedestrians also visit the neighborhood more frequently than people arriving by cab, subway, or car (77). A survey of Toronto's Bloor Street found that pedestrians spent the most over the course of a month (and visited the area the most often), followed by bicyclists (24).

- **Street-scale interventions create jobs.** Investment in and maintenance of bicycle and pedestrian facilities creates both direct and indirect jobs (24, 28, 62, 63). A study of bicycle, pedestrian, and road infrastructure in Baltimore found that spending on bicycle and pedestrian facilities creates more jobs per $1 million spent than road infrastructure, due to the percentage of expenditures spent on labor relative to materials and the relationship between construction and engineering costs (28). A study of North Carolina's Northern Outer Banks found that spending by bicyclists is responsible for creating or supporting 1,400 annual jobs (62), while Boulder, Colorado's bicycle economy is estimated to support 330 full-time jobs in manufacturing; education, advocacy, and outreach; and retail, rental, and repair (24).
- **Access to bicycle facilities is a tool for recruiting workers.** Proximity to bicycle facilities provides workers with the option of bicycle commuting and can be an important tool for attracting employees. As a result, some businesses are intentionally choosing locations near bicycle lanes and other bicycle facilities (1).

Conclusions

Street-scale features of the built environment can positively impact not only physical activity, but also a variety of other co-benefits that enhance community health and livability. As outlined in the sections that follow, these benefits have implications for policy and planning practice, as well as for future research.

Policy and planning implications

The key conclusions of this review are summarized below, with further consideration of their implications for policy and planning practice:

- **Benefits for the Local Economy.** Strategic investments in street-scale features can have benefits for the local economy. Pedestrians and bicyclists are more frequent visitors to a range of business types and, as a result, may spend more over time. These facilities can add value to surrounding properties, and investment in pedestrian and bicycle infrastructure can create both direct and indirect jobs. Benefits to the local economy should be incorporated into cost-benefit analyses and other decision-making processes for active transportation investments.
- **Equity Concerns.** Low-income neighborhoods are less likely to have environments where walking is safe and appealing. It is important for planners, policy makers, advocates, and others to consider equity of location and access when prioritizing locations for street-scale interventions. Focused interventions in disadvantaged neighborhoods and communities may help reduce disparities in safety, use of active transportation modes, and corresponding health outcomes such as obesity and mental health.
- **Facility Maintenance.** Just like roads, street-scale features that support walking and biking require ongoing maintenance. Benefits from street-scale interventions may also take time to appear, and it is therefore important that bicycle and pedestrian facilities and other street-scale features are maintained over time to ensure that their full potential is realized.
- **Education and Awareness.** While street-scale features can lead to an increase in walking and biking, as well as other co-benefits, there is a need for education and awareness efforts for the full benefits of these interventions to be realized. Currently, active transportation is not the norm in most communities in the United States, and education and awareness campaigns to promote a cultural shift are needed as a complement to infrastructure investments. Education and awareness campaigns are also important for safety, teaching users of all modes to interact safely as pedestrian and bicycle travel becomes more commonplace.
- **Increased Safety.** Street-scale interventions can have important safety benefits, both in terms of traffic safety (e.g., reduced crashes, increased driver awareness) and in terms of crime prevention and public safety. Both types of safety are important considerations in the decision to walk or bike, and have broader benefits for the surrounding community.
- **Perceptions of Safety.** While actual safety is an important co-benefit of street-scale features, *perceptions* of both multimodal traffic safety and crime prevention and public safety are also important. Individuals are more likely to engage in active transportation when they perceive the environment to be safe, and street-scale features that support perceptions of safety—such as streetlighting, street furniture, and aesthetic amenities—can go a long way towards increasing rates of physical activity for transportation or recreation.
- **Where People Live.** Individuals who prefer to walk or bike may be more likely to choose to live in neighborhoods that have features that support this preference. However, research has shown that the built environment and street-scale interventions can lead to more walking and biking even when residential self-selection is accounted for. As a result, and—even more

importantly—for reasons related to equity, investments should not be limited to areas or neighborhoods that are likely to have the most vocal advocates for active transportation. Instead, investing in a broad range of communities can maximize the direct and indirect benefits of street-scale features and lead to more equitable planning and outcomes.

- **Part of the Larger Network.** While this review has focused on the street scale, no project exists in isolation. Rather, the success of individual projects depends largely on their integration into the larger network of pedestrian and bicycle infrastructure. For example, a bike lane in isolation will have few benefits if not connected to a larger network of bicycle facilities allowing for seamless travel. It is therefore important to consider street-scale features as part of the larger network and to pursue coordinated plans and projects that lead to connected facilities. Similarly, while this review focused exclusively on benefits that could be tied to specific street-scale interventions, individual projects and coordinated planning efforts may also be justified based on larger network scale benefits, such as reduced health care costs, reduced traffic, and improved air quality.

Future research

In addition to the policy and planning implications discussed above, the findings of this review suggest several opportunities for future research.

- **Additional Research on Street-Scale Features.** While a wealth of research has addressed larger aspects of the built environment—such as road network connectivity, population density, jobs-housing balance, and urban sprawl—research at the finer scale of the streetscape has been more limited to date. Further research should be conducted to assess the impacts of specific street-scale interventions on walking, biking, and related co-benefits. This effort may be best undertaken through partnerships between researchers in the fields of planning, urban design, landscape architecture, economic development, and other social sciences.
- **Longitudinal, Intervention-Based Research.** The majority of studies reviewed for this report used cross-sectional research designs that examine different locations at the same point in time. Future research should examine data in the same places over time, particularly in areas that receive a streetscape or other environmental intervention. A crucial direction for future research is to examine the impacts of street-scale interventions that combine infrastructure investments with education and awareness campaigns intended to change behavior.
- **Quantifying the Benefits.** Many of the studies in this review were designed to determine whether an impact was present, but not to measure the magnitude of that impact. Further work to quantify the co-benefits of active transportation investments would be valuable for project evaluation efforts, cost-benefit analyses, and other aspects of the decision-making process.
- **More Case Studies and Broader Contexts.** There is a need for additional case studies on the co-benefits of street-scale interventions. The majority of resources included in this review were academic studies or agency reports, while relatively few were detailed case studies of interventions, policies, or programs in specific communities. Case studies may be helpful to highlight the planning processes and nuances that lead to project success. Additionally, many of the studies in this review focused on cities in other countries; on larger U.S. cities such as New York City or San Francisco; or on cities with strong walking and biking cultures, such as Portland and Seattle. Future work should examine broader and potentially more representative settings that will increase the applicability of findings.
- **Equity Considerations.** As noted throughout this report, the location of street-scale interventions raises important challenges and opportunities for social equity. On the one hand, interventions that generate local revenue and increase property values may raise concerns related to displacement and gentrification. On the other hand, street-scale interventions may also result in equity-related benefits such as expanded transportation options for those who rely on alternatives to car travel. These trade-offs have not been examined extensively with reference to street-scale features. Future research should examine the equity-related impacts of street-scale interventions and consider how equity challenges and opportunities can be most effectively addressed in practice.

ENDNOTES

A McKenzie, Brian. "Modes Less Traveled—Bicycling and Walking to Work in the United States: 2008–2012." U.S. Census Bureau, May 2014. https://www.census.gov/prod/2014pubs/acs-25.pdf.

B Definitions of street-scale features are drawn from the literature as well as from American Planning Association . 2006. *Planning and Urban Design Standards*. Hoboken, New Jersey: John C. Wiley & Sons.

C Definitions of co-benefits are broadly drawn from the resources included in the literature review.

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