Published in final edited form as:

J Phys Act Health. 2019 May 01; 16(5): 308–317. doi:10.1123/jpah.2018-0329.

Cost-Effectiveness of Improvements to the Built Environment Intended to Increase Physical Activity

Gregory Knell,

Department of Health Promotion & Behavioral Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Houston, TX, USA.

Michael & Susan Dell Center for Healthy Living, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Henry S. Brown,

Department of Health Promotion & Behavioral Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Houston, TX, USA.

Michael & Susan Dell Center for Healthy Living, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Department of Management, Policy, and Community Health, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Kelley P. Gabriel,

Department of Health Promotion & Behavioral Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Houston, TX, USA.

Michael & Susan Dell Center for Healthy Living, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Department of Epidemiology, Human Genetics & Environmental Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Department of Women's Health, Dell Medical School, The University of Texas at Austin, Austin, TX, USA.

Casey P. Durand,

Department of Health Promotion & Behavioral Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Houston, TX, USA.

Michael & Susan Dell Center for Healthy Living, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Kerem Shuval,

Department of Intramural Research, Economic and Health Policy Research Program, American Cancer Society, Atlanta, GA, USA and also with the Department of Epidemiology, School of Public Health, University of Haifa, Haifa, Israel.

Deborah Salvo, and

Department of Health Promotion & Behavioral Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Houston, TX, USA.

Michael & Susan Dell Center for Healthy Living, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Department of Epidemiology, Human Genetics & Environmental Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Harold W. Kohl III

Department of Health Promotion & Behavioral Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Houston, TX, USA.

Michael & Susan Dell Center for Healthy Living, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Department of Epidemiology, Human Genetics & Environmental Sciences, The University of Texas Health Science Center (UTHealth) at Houston School of Public Health, Austin, TX, USA.

Department of Kinesiology and Health Education, The University of Texas at Austin, Austin, TX, USA.

Abstract

Background—Improving sidewalks may encourage physical activity by providing safe, defined, and connected walking spaces. However, it is unknown if reduced health care expenditures assumed by increased physical activity offset the investment for sidewalk improvements.

Methods—This cost-effectiveness analysis of sidewalk improvements in Houston, TX, was among adults enrolled in the Houston Travel-Related Activity in Neighborhoods Study, 2013–2017. The 1-year change in physical activity was measured using self-report ($n = 430$) and accelerometry ($n = 228$) and expressed in metabolic equivalent (MET) hours per year ($\text{MET} \cdot \text{h} \cdot \text{y}^{-1}$). Cost-effectiveness ratios were calculated by comparing annualized sidewalk improvement costs (per person) with 1-year changes in physical activity.

Results—The estimated cost-effectiveness ratio were \$0.01 and $-\$0.46$ per $\text{MET} \cdot \text{h} \cdot \text{y}^{-1}$ for self-reported and accelerometer-derived physical activity, respectively. The cost-effectiveness benchmark was \$0.18 (95% confidence interval, \$0.06–\$0.43) per $\text{MET} \cdot \text{h} \cdot \text{y}^{-1}$ gained based on the volume of physical activity necessary to avoid health care costs.

Conclusions—Improving sidewalks was cost-effective based on self-reported physical activity, but not cost-effective based on accelerometry. Study findings suggest that improving sidewalks may not be a sufficient catalyst for changing total physical activity; however, other benefits of making sidewalks more walkable should be considered when deciding to invest in sidewalk improvements.

Keywords

accelerometry; active transport; epidemiology; walkability

The role of the built environment in physical activity behaviors has garnered increasing attention from the research and policy communities.^{1–3} Modifications to the built environment, such as improvements to sidewalks, may lead to more physical activity by providing safe, defined, and connected walking spaces.¹ Of particular interest is the economic value of sidewalk infrastructure, that is, could sidewalks promote increased physical activity to the extent it offsets the cost of the sidewalk improvements through reductions in health care expenditures?

This question could best be answered by conducting a cost-effectiveness analysis.^{4,5} Cost-effectiveness analyses express health outcomes as a unit of effect that is then presented in a ratio of cost, such as cost per life year saved or cost per case averted. In evaluations of interventions to increase physical activity, this ratio is often presented as the cost per metabolic equivalent (MET) of task. To determine cost-effectiveness, the ratio is then extrapolated to an estimated population level of inactivity cost (cost per MET hour).

The literature on economic evaluations of population-level interventions to increase physical activity is limited.^{4,5} Within these studies, there is wide variation in the quality of the physical activity assessment. Some have used self-reports or direct observations that have well-documented measurement properties,^{6–8} whereas others did not assess physical activity directly,^{9–11} or they utilized instruments that may not be sensitive enough to detect physical activity changes overtime.¹² No studies used accelerometers to measure ambulatory movement alongside contextual self-reports of physical activity behaviors. Moreover, most cost-effective analyses of changes to the built environment have used a hypothetical not an empirical data approach, which is pertinent to reaching policy conclusions.^{9–18}

Hence, we aimed to evaluate the cost-effectiveness of improvements to sidewalk infrastructure using data from the Houston Travel-Related Activity in Neighborhoods (TRAIN) Study, a diverse, community-based sample.

Methods

Study Design, Setting, and Participants

This study takes place in Houston, TX, United States. Houston is the largest city in Texas and the fourth largest city in the United States with an estimated population of 2.3 million in 2017.¹⁹ It is a diverse and multicultural city. Based on census data,¹⁹ nearly 23% of residents are non-Hispanic black or African American, 45% are Hispanic or Latino, and 58% are white race, and there are over 145 languages spoken in Houston. Houston's land area in 2010 was 599.59 square miles.¹⁹ It is located on the coastal plains of southern Texas that is prone to hurricanes and flooding and has a humid subtropical climate.²⁰ Generally speaking, Houston has historically invested in highway transportation infrastructure rather than public mass transportation systems or other active travel infrastructure.²¹ Among the working population in Houston, those aged 16 years and older report a mean travel time to work of 26.8 minutes.¹⁹

The current study examined baseline (2014–2016) and first follow-up (2015–2017) assessment data from the Houston TRAIN Study (median interval between assessments =

14.3 mo).²¹ Briefly, the TRAIN Study is a natural experiment designed to prospectively study the effect of expanding Houston's public light rail transit system on transportation use and various domains of physical activity. A rolling recruitment and enrollment strategy, involving telephone/e-mail/and targeted community outreach efforts, was employed from November 2013 to October 2015, at which time, the desired baseline cohort size was achieved. Participants were 18 years and older and lived within the 3-mile Euclidean buffer around the light rail system at baseline. As such, the sample is not considered representative of a greater population. Only 1 person per household could participate, and study materials were offered in English or Spanish languages. Figure 1 maps the participant address densities in relation to the light rail expansion at baseline and follow-up.

For our analysis, we included participants who completed the self-reported physical activity portion of the questionnaire at baseline and follow-up (n = 430). Participants who completed the accelerometer portion of the protocol and had sufficient wear time (4 of 7 d with 10 h each day, by convention)²² were included as an analytic subsample (n = 228). Based on the protocol, the participant completed questionnaire only or questionnaire plus accelerometer; financial incentives (\$25 and \$50, respectively) were provided for participation. Study power was calculated post hoc to determine if the sample size was sufficient to detect a change in the continuous estimates of physical activity between those living with and without a sidewalk improvement within 250 m of their home and found that the models for transit-related, leisure-time, and device-assessed physical activity were all sufficiently powered at a level greater than 0.80. Power was calculated in G*Power 3.1.9.2 (Franz Faul, Universität Kiel, Germany).²³

Data Collection

Sidewalk Infrastructure—Data on the exposure of interest, improvements to sidewalk infrastructure, were obtained from the City of Houston GIS Open Data ArcGIS website.²⁴ For this analysis, we used a sidewalk inventory feature class that detailed active sidewalk projects, including “programmed,” “design,” “construction,” “pending construction,” and “complete.” Only those projects with a completed construction date before participant follow-up (2015) were included in the analysis. See Figure 2 for a timeline of participant recruitment, data collection, and sidewalk infrastructure and light rail transit expansion. Exposure to a sidewalk improvement was operationalized as living near (within a 250-m pedestrian network buffer), a recently improved or installed sidewalk segment or not. A pedestrian network buffer (road network buffer with ramps and highways excluded) has been previously employed,²⁵ and it has been suggested that buffer lengths less than the traditionally used (800 m–1 km) distance are a more precise quantification of one's neighborhood.^{26,27}

Transportation- and Leisure Time–Related Physical Activity—A past-week (7 d), self-reported questionnaire (Self-Administered Modifiable Activity Questionnaire), derived from the Modifiable Activity Questionnaire,^{28,29} was used to assess transportation- and leisure time–related physical activities. Total self-reported physical activity was calculated as the sum of the leisure time– and transportation-related physical activity summary estimates, and each was expressed as MET minutes per week (MET·min·wk^{−1}).

Accelerometer-Derived Physical Activity—Raw triaxial accelerometer data (Actigraph Corporation, Pensacola, FL) were sampled at 40 Hz and reintegrated and expressed as 60-second epochs prior to further processing. Count intensity-level thresholds from Freedson et al³⁰ were used to estimate the time spent per day ($\text{min} \cdot \text{d}^{-1}$) at different intensity levels. Daily accelerometer count data from the vertical axis were converted using

$$\text{MET} \cdot \text{min} \cdot \text{d}^{-1} = 1.439008 + (0.000795 \times \text{counts min}^{-1}).$$

This prediction equation has been found to have strong measurement properties ($R^2 = .82$, $\text{SEE} = 1.12$) from validation of laboratory-based physical activities.³⁰

The self-reported (MET min wk^{-1}) and accelerometer-derived (MET min d^{-1}) physical activity estimates were extrapolated across a year ($\text{MET} \cdot \text{h} \cdot \text{y}^{-1}$) to harmonize across measurement devices and to express the estimate of physical activity gained in the same units as the yearly physical activity needed to offset health care costs.

Sidewalk Improvement Costs—Costs for sidewalk infrastructure improvements were obtained through personal correspondence with senior officials at the Planning and Public Works Departments, City of Houston. Projects contracted between 2013 and 2016 were included in the cost calculation. All costs included initial project planning, engineering, construction, and maintenance and were reported in 2013 US dollars, the first year of data collection.

Statistical Analysis

Data management and statistical analysis were performed in 2017 using StataSE 14.1 (StataCorp, College Station, TX). Univariate analyses were conducted on study participants' baseline characteristics and reported accordingly by sidewalk improvement exposure status. We adhered to the standard approach to estimate cost-effectiveness, utilizing a payer perspective, as presented by Wu et al⁵ and subsequently utilized by others.^{4,7,31–37} Specifically, we calculated cost-effectiveness by (1) estimating the costs of sidewalk improvements, (2) estimating the physical activity gained from exposure to sidewalk improvements, (3) computing the ratio of the cost of sidewalk improvements to the physical activity gained (cost-effectiveness ratio [CER]), and (4) computing the ratio of the cost per volume of physical activity needed to avert health care expenditures (cost-effectiveness benchmark [CEB]) and comparing it to the CER. If the CER did not exceed the CEB, then the sidewalk improvements were considered cost-effective.

Step 1: Sidewalk Improvement Costs—The mean cost of improving sidewalks in the City of Houston was applied to the total length (in meters) of sidewalk improvements to determine the mean cost per meter. The number of people exposed (total exposed population) was estimated as the total adult population in the City of Houston residing within a 250-m pedestrian network buffer around the sidewalk segments at the time of construction, as estimated from census records.³⁸ The total cost per meter was then divided by the total exposed population to estimate the mean sidewalk improvement cost per person.

The reported sidewalk life span (50 y) was used to annualize the per meter cost per person to arrive at the annualized mean cost of construction and maintenance per person.

Step 2: Physical Activity Gained—Multivariable linear regression models were used to estimate the 1-year absolute change in physical activity in $\text{MET} \cdot \text{h} \cdot \text{y}^{-1}$ among those living near sidewalk improvements compared with those not living near an improved sidewalk. Ordinary least squares regressions modeled the follow-up estimate of physical activity as the outcome with the baseline assessment locked in the model as a covariate.³⁹ Potential explanatory variables included in the models were those found in the literature to be influential in the relation between the built environment and physical activity (ie, age, sex, race, education, income, body mass index, transit usage, seasonality, transit stop access).^{1,2,40} Variable selection was conducted by an automated, backward, stepwise procedure with a predetermined alpha value for inclusion set at .10 to achieve a parsimonious model. Final models for self-reported activity only included the baseline $\text{MET} \cdot \text{h} \cdot \text{y}^{-1}$ as a covariate, and the final model for accelerometer-derived activity adjusted for sex, transit use, distance from home to nearest transit stop, and baseline $\text{MET} \cdot \text{h} \cdot \text{y}^{-1}$.

Step 3: Cost-Effectiveness Ratio—The annualized mean cost of construction per person was calculated as follows³⁸:

$$\text{CER} = \frac{\text{Annualized mean cost of construction per person}}{\text{MET} \cdot \text{h} \cdot \text{y}^{-1} \text{ gained per person}}.$$

Step 4: Cost-Effectiveness Benchmark—The proportion of direct health care expenditures in the United States attributable to physical inactivity was estimated based on Ding et al.⁴¹ We applied that proportion to the per capita health care expenditures to estimate per capita physical inactivity cost and then calculated the CEB as follows:

$$\text{CEB} = \frac{\text{Per capita cost of inactivity}}{\text{MET} \cdot \text{h} \cdot \text{y}^{-1} \text{ needed to offset costs}}.$$

Finally, the CER was compared with the CEB to determine if improving sidewalk was a cost-effective approach. If the CER was less than the CEB, then improved sidewalks were considered cost-effective.

Sensitivity Analysis—A Monte Carlo simulation was conducted to estimate the probability of cost-effectiveness ($\text{CER} < \text{CEB}$) based on the levels of uncertainty (95% confidence limits) in the parameters of interest used to calculate the CER.⁴² A separate simulation was conducted for accelerometer-derived and total self-reported physical activity estimates. A 2-way simulation (annualized mean cost of construction per person and $\text{MET} \cdot \text{h} \cdot \text{y}^{-1}$ gained per person) with a triangular distribution conducted 1000 iterations of the CER formula presented above.

The Houston TRAIN Study protocol and this secondary analysis were reviewed and approved by The University of Texas Health Science Center at Houston's Committee for the Protection of Human Subjects. Informed consent was obtained from all participants.

Results

Participant Characteristics

As shown in Table 1, there were no statistically significant differences in participant baseline characteristics based on sidewalk improvement exposure status, except for the distance from participants' homes to the nearest transit stop ($P < .001$).

Cost-effectiveness

Table 2 depicts each of the parameters, and their uncertainty bounds, used to calculate the CER and CEB.

Step 1: Sidewalk Improvement Costs—Sidewalk improvement costs were estimated to be \$219 per linear meter based on finalized contracted amounts between 2013 and 2015. Included in the current analysis were a total of 750,131 linear meters of sidewalk improvements occurring before 2015, amounting to a total of \$164,278,689. Based on a 50-year lifespan, the total annualized cost of sidewalk improvements in the City of Houston was \$3,285,574. Based on census records, an estimated 1,574,325 persons aged older than 18 years resided within a 250-m pedestrian network buffer of any sidewalk improvement. Therefore, the mean annualized cost of sidewalk improvements per person was \$2.09.

Step 2: Physical Activity Gained—Multivariable regression analyses indicated that living near a sidewalk improvement was associated with a mean (SD) increase of 53.1 (39.0), $P = .17$, and 230.3 (106.0), $P = .03$, MET·h·y⁻¹ of transportation- and leisure time-related physical activity, respectively. When self-reported physical activity was summed, living near a sidewalk improvement was associated with a mean (SD) increase of 203.3 (120.2), $P = .09$, MET·h·y⁻¹ of physical activity. Accelerometer measurements of physical activity resulted in an estimated mean (SD) decrease of -4.5 (21.9), $P = .84$, MET·h·y⁻¹ among those living near a sidewalk improvement.

Steps 3 and 4: CER and Benchmark—National annual health care expenditures in 2013 totaled \$2.8 trillion or \$9,110 per capita.⁴³ Direct annual health care cost attributable to physical inactivity was estimated to be \$24.7 billion or 0.86% of the national annual health care expenditures.⁴¹ If this proportion of health care expenditures attributable to physical inactivity is applied to the per capita health care expenditures, it is estimated that the per capita cost of physical inactivity is \$78.30 (95% confidence interval [CI], \$27.3–\$185.8). If one assumes that achieving the 2008 Physical Activity Guidelines for Americans (engaging in at least 434.5 MET·h·y⁻¹ [500 MET min wk⁻¹/60 min/7 d×365 d] of moderate- to vigorous-intensity aerobic physical activity) has the potential to prevent health care costs attributable to physical inactivity, then an successful intervention that has an annual cost of \$78.30 per capita may would be considered cost-effective. Therefore, for individuals who are not achieving the minimum recommended guidelines for physical activity, a ratio of \$0.18 per MET·h·y⁻¹ ($\$78.30/434.5 \text{ MET·h·y}^{-1}$) would be considered cost-effective. This benchmark was used to evaluate sidewalk infrastructure improvements in the current study.

The CER is the ratio of the mean annualized cost of sidewalk improvements per person (\$2.09; 95% CI, \$1.57–\$3.97) to the MET·h·y⁻¹ gained per person. This value was compared with the estimated benchmark value of \$0.18 (95% CI, \$0.05–\$0.36) to determine if the sidewalk improvements were cost-effective. For self-reported physical activity, the estimated CER was \$0.007–\$0.07/MET·h·y⁻¹ gained and remained below the established CEB of \$0.18/MET·h·y⁻¹ gained. However, based on accelerometry, an estimated 4.5 MET·h·y⁻¹ decrease associated with living near a sidewalk improvement resulted in the CER exceeding the CEB and, therefore, was not considered cost-effective.

The results of Monte Carlo simulation are presented in Table 3. Based on self-reported physical activity, the mean (95% CI) CER was \$0.07 (\$0.01–\$0.13) per MET·h·y⁻¹ gained by living near a sidewalk improvement. The CER was below the \$0.18 CEB point estimate in 98% of 1000 simulations. Considering the confidence limits for the CEB, 95% and 99% of simulations were below the \$0.06 lower and \$0.43 upper limits, respectively, for self-reported physical activity. Regarding the accelerometer-derived estimates of physical activity, the mean (95% CI) CER was \$1.57 (\$1.09–\$2.05) per MET·h·y⁻¹ gained by living near an improved sidewalk. The CER was below the \$0.18 CEB point estimate in 17% of 1000 simulations. Considering the confidence limits for the CEB, 0.5% and 30% of simulations were below the \$0.06 lower and \$0.43 upper limits, respectively, for accelerometer-derived physical activity. The Monte Carlo simulation CER estimates based on self-reported and accelerometer-derived physical activity are shown in Figure 3.

Discussion

To examine whether built environment features intended to improve health can be cost-effective, we looked at real-world changes (ie, a natural experiment) to sidewalk infrastructure in the city of Houston, TX. We analyzed empirical data and used both self-reported and device-assessed physical activity data. We found that improving sidewalks near participants' homes was a cost-effective approach based on self-reported physical activity. However, when using device-based estimates of ambulatory movement (accelerometer), which are less prone to bias, results indicated that improving sidewalks was not cost-effective.

These conflicting findings may suggest that simply building or improving sidewalks may not be a sufficient catalyst for individual-level change in physical activity behavior. The Task Force on Community Preventive Services (Community Guide) recommends changing the built environment, including connected sidewalks and streets, to support and provide opportunities for individuals to be physically active but also recognizes the need for complementary behavioral and social approaches to change physical activity behavior.⁴⁴ These results underline the need for campaigns and informational approaches (eg, point of decision prompts) coupled with individually adapted health behavior change programs, as recommended in the Community Guide. For example, Social Cognitive Theory posits that environmental factors shape individual decision making (reciprocal determination) alongside other factors (self-efficacy, incentives, and self-control) to be considered when attempting to change behavior.⁴⁵ In addition, behavioral economists suggest taking an asymmetric, paternalistic approach to behavior change, that is, making the *right* choice easier through

choice architecture.^{46,47} Thus, merely improving sidewalk infrastructure would not be sufficient to encourage people to use sidewalks for active transport if the alternative (driving the car) would be easier.

There are few studies that have evaluated the economics of sidewalks or similar infrastructure (eg, rail trails) changes. Some have modeled changes in physical activity based on hypothetical construction projects. For example, Guo and Gandavarapu⁹ used a nationally representative sample of US adults to model changes to walking and biking behavior based on proposed sidewalk construction. Laine et al⁴ indicate that sidewalks would result in sufficient increases in physical activity to offset the construction costs (\$0.10/MET·h·y⁻¹ gained). These findings, however, were not empirically based. Similarly, Dallat et al¹² used simulations to model the physical activity benefit of those living within a 1-mile radius of a community park and trail in Ireland. Their models indicated moderate increases in physical activity related to living near the park and trail, costing an estimated \$0.32 per MET gained, not below the CEB. However, the CEB threshold value would not be applicable here, as it is based on US health care expenditures attributable to inactivity. Nonetheless, Dallat et al¹² concluded the park and trail would be cost-effective. In comparison, Abildso et al⁶ examined real construction of rail trails (abandoned heavy railroad beds converted to walking trails) and determined a cost of \$157.27 per physically active person. Laine et al⁴ put this figure in the context of cost per MET gained and determined that rail trails were a cost-effective approach (\$0.006/MET·h·y⁻¹ gained). However, physical activity was estimated using acute measures (intercept interviews and trail sensor counts) rather than measures of habitual physical activity, which we used. Furthermore, they did not use a prospective design, which is essential to elucidate a temporal and causal relationship between trail construction and physical activity. Taken together, there does not appear to be sufficient evidence from prospective study designs, using empirical data, to suggest sidewalk/trail infrastructure improvements are cost-effective in terms of reducing health care expenditures by increasing physical activity. One must consider, however, that the primary purpose of sidewalks is not to decrease health care expenditures but rather to provide a safe and defined space for one to engage in walking or jogging for transportation or leisure. In addition, there are economic, social, and environmental benefits to making neighborhoods more walkable.⁴⁸ In light of the results of this study and the body of literature in the field, these cobenefits should be stressed when disseminating results to policy makers and stakeholders with the aim of demonstrating the societal benefit of improving “walk-ability” beyond health agencies (eg, planners and developers, transportation professionals, parks and recreation departments, geographers).⁴⁹

We recognize the limitation that although none of the sidewalk improvements in our analysis occurred after the follow-up activity assessment, it is possible that both the baseline and follow-up assessments occurred after the sidewalk improvements were completed. Limited data from the City of Houston on the sidewalk construction completion dates (lacking day, month, and year) did not allow for the establishment of a clear timeline. In addition, participants living near sidewalk improvements were exposed to up to 21 sidewalk improvements within their 250-m buffer. Many of those sidewalk construction projects were operating on varying timelines (some were bundled). Therefore, there may not be a true baseline assessment of physical activity for some, and as such, the results should be interpreted as the change in physical activity associated with living near a recently improved

sidewalk during the observation period. In addition, a sidewalk improvement could include the complete construction of a new sidewalk, a crack repair, or a curb cut to facilitate disability access. Other limitations include the use of a single axis (vertical) to measure physical activity using accelerometry, rather than the triaxial measurement, which includes movement in all 3 planes. Although the triaxial data may offer a more robust estimate of movement, there is evidence that triaxial data do not provide better estimates of energy expenditure (eg, METs).⁵⁰ In addition, using this data set, we have previously evaluated the change in physical activity associated with living near an improved sidewalk using triaxial data as well as vertical axis data and found the results to be consistent (decreases in physical activity from baseline to follow-up) across all units of analyses of accelerometry.⁵¹ Finally, the change in light rail transit infrastructure occurring in conjunction with the changes to sidewalk infrastructure may have acted as a confounder in the relation between changes in sidewalk infrastructure and physical activity. Participants may have reported or accumulated (accelerometry) greater levels of physical activity due to living near changes to transit infrastructure rather than the hypothesized sidewalk infrastructure. To test for this possibility, we measured the distance (in meters) between the nearest transit stop (bus and light rail) from a participant's home at baseline and compared that with the distance at follow-up. We found that the median change in distance to a transit stop from baseline to follow-up was 5.1m. Specifically, for bus stops, the median change in distance was 3.5 m, and for light rail transit stops, the median change in distance was 3.6 m. In addition, we evaluated the possibility of increasing transit use from baseline to follow-up as a possible confounder. At baseline, 82.1% of participants were transit users, and at follow-up, 81.0% of participants were transit users. These proportions were not found to be significantly different using a McNemar pairwise test of proportions ($P = .48$). Considering the small variability in distance to a transit stop from baseline to follow-up and the insignificant changes in transit use during follow-up, these factors did not likely account for any reported increases in physical activity. Nonetheless, these are important considerations for future research.

Conclusions

This report contributes to the limited literature on the cost-effectiveness of changes to the built environment intended to increase physical activity by presenting a real-life, natural experiment, based on real modifications of the built environment. Study findings indicate that improving sidewalk infrastructure is not cost-effective when physical activity is assessed through self-report and not when measured using a device (accelerometer). When behavioral theory is considered, these findings may suggest that improving sidewalks in isolation may not be a sufficient catalyst for individual-level change in total physical activity. Although these findings indicate sidewalks are not cost-effective based on more objective measures, other benefits of making sidewalks more walkable, and the primary purpose of sidewalks should be considered when deciding to invest in sidewalk infrastructure improvements.

Acknowledgments

The authors would like to thank the UT Health School of Public Health Physical Activity Workgroup for their contributions in conceiving this project. This research was supported primarily by NIH NIDDK to H.W.K. (grant NIH R01 DK101593). Additional support to G.K. for manuscript preparation is through a postdoctoral fellowship;

The University of Texas School of Public Health, Cancer Education and Career Development Program; and National Cancer Institute/NIH grant T32 CA57712.

References

1. McCormack GR, Shiell A. In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. *Int J Behav Nutr Phys Act.* 2011;8(1):125. doi:10.1186/1479-5868-8-125 [PubMed: 22077952]
2. Saelens BE, Handy SL. Built environment correlates of walking: a review. *Med Sci Sports Exerc.* 2008;40(suppl 7):S550–S566. doi:10.1249/MSS.0b013e31817c67a4 [PubMed: 18562973]
3. Sallis JF, Glanz K. The role of built environments in physical activity, eating, and obesity in childhood. *Future Child.* 2006;16(1):89–108. PubMed ID: 16532660 doi:10.1353/foc.2006.0009 [PubMed: 16532660]
4. Laine J, Kuvaja-Kollner V, Pietila E, Koivuneva M, Valtonen H, Kankaanpaa E. Cost-effectiveness of population-level physical activity interventions: a systematic review. *Am J Health Promot.* 2014; 29(2):71–80. PubMed ID: 25361461 doi:10.4278/ajhp.131210-LIT-622 [PubMed: 25361461]
5. Wu S, Cohen D, Shi Y, Pearson M, Sturm R. Economic analysis of physical activity interventions. *Am J Prev Med.* 2011;40(2):149–158. PubMed ID: 21238863 doi:10.1016/j.amepre.2010.10.029 [PubMed: 21238863]
6. Abildso CG, Zizzi SJ, Selin S, Gordon PM. Assessing the cost effectiveness of a community rail-trail in achieving physical activity gains. *J Park Recreat Admi.* 2012;30(2):102–113.
7. Cohen DA, Marsh T, Williamson S, Golinelli D, McKenzie TL. Impact and cost-effectiveness of family fitness zones: a natural experiment in urban public parks. *Health Place.* 2012;18(1):39–45. PubMed ID: 22243905 doi:10.1016/j.healthplace.2011.09.008 [PubMed: 22243905]
8. Wang G, Macera CA, Scudder-Soucie B, Schmid T, Pratt M, Buchner D. Cost effectiveness of a bicycle/pedestrian trail development in health promotion. *Prev Med.* 2004;38(2):237–242. PubMed ID: 14715217 doi:10.1016/j.ypmed.2003.10.002 [PubMed: 14715217]
9. Guo JY, Gandavarapu S. An economic evaluation of health-promotive built environment changes. *Prev Med.* 2010;50:S44–S49. PubMed ID: 19840817 doi:10.1016/j.ypmed.2009.08.019 [PubMed: 19840817]
10. Saelensminde K Cost–benefit analyses of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic. *Transp Res Part A Policy Pract.* 2004; 38(8):593–606.
11. Stokes RJ, MacDonald J, Ridgeway G. Estimating the effects of light rail transit on health care costs. *Health Place.* 2008;14(1):45–58. PubMed ID: 17543570 doi:10.1016/j.healthplace.2007.04.002 [PubMed: 17543570]
12. Dallat MA, Soerjomataram I, Hunter RF, Tully MA, Cairns KJ, Kee levels cost-effectively. *Eur J Public Health.* 2014;24(2):190–195. PubMed ID: 23531527 doi:10.1093/eurpub/ckt035 [PubMed: 23531527]
13. Beale SJ, Bending MW, Trueman P, Naidoo B. Should we invest in environmental interventions to encourage physical activity in England? An economic appraisal. *Eur J Public Health.* 2012;22(6): 869–873. PubMed ID: 23132876 doi:10.1093/eurpub/ckr151 [PubMed: 23132876]
14. Cohen DA, Golinelli D, Williamson S, Sehgal A, Marsh T, McKenzie TL. Effects of park improvements on park use and physical activity: policy and programming implications. *Am J Prev Med.* 2009; 37(6):475–480. PubMed ID: 19944911 doi:10.1016/j.amepre.2009.07.017 [PubMed: 19944911]
15. Deenihan G, Caulfield B. Estimating the health economic benefits of cycling. *J Transp Health.* 2014;1(2):141–149. doi:10.1016/j.jth.2014.02.001
16. Costs Gotschi T. and benefits of bicycling investments in Portland, Oregon. *J Phys Act Health.* 2011;8(s1):S49–S58. doi:10.1123/jpah.8.s1.s49 [PubMed: 21350262]
17. Macmillan A, Connor J, Witten K, Kearns R, Rees D, Woodward A. The societal costs and benefits of commuter bicycling: simulating the effects of specific policies using system dynamics modeling. *Environ Health Perspect.* 2014;122(4):335–344. PubMed ID: 24496244 doi:10.1289/ehp.1307250 [PubMed: 24496244]

18. Schweizer J, Rupi F. Performance evaluation of extreme bicycle scenarios. *Procedia Soc Behav Sci.* 2014;111:508–517. doi:10.1016/j.sbspro.2014.01.084
19. U.S. Census Bureau. QuickFacts Houston city, Texas. 2017. <https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>. Accessed October 30, 2018.
20. Trepanier JC, Tucker CS. Event-based climatology of tropical cyclone rainfall in Houston, Texas and Miami, Florida. *Atmosphere.* 2018;9(5):170. doi:10.3390/atmos9050170
21. Durand CP, Oluyomi AO, Gabriel KP, et al. The effect of light rail transit on physical activity: design and methods of the travel-related activity in neighborhoods study. *Front Public Health.* 2016;4:103 PubMed ID: 27376051 doi:10.3389/fpubh.2016.00103 [PubMed: 27376051]
22. Choi L, Ward SC, Schnelle JF, Buchowski MS. Assessment of wear/nonwear time classification algorithms for triaxial accelerometer. *Med Sci Sports Exerc.* 2012;44(10):2009–2016. PubMed ID: 22525772 doi:10.1249/MSS.0b013e318258cb36 [PubMed: 22525772]
23. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav Res Methods.* 2009;41(4):1149–1160. PubMed ID: 19897823 doi:10.3758/BRM.41.4.1149 [PubMed: 19897823]
24. City of Houston. COHGIS Open Data Portal. 2016 <http://cohgis.mycity.opendata.arcgis.com/>. Accessed March 17, 2017.
25. Morency C, Trépanier M, Demers M. Walking to transit: an unexpected source of physical activity. *Transp Policy.* 2011;18(6):800–806. doi:10.1016/j.tranpol.2011.03.010
26. Hoehner CM, Ramirez LK, Elliott MB, Handy SL, Brownson RC. Perceived and objective environmental measures and physical activity among urban adults. *Am J Prev Med.* 2005;28(2):105–116. doi:10.1016/j.amepre.2004.10.023 [PubMed: 15694518]
27. Shay E, Rodriguez DA, Cho G, Clifton KJ, Evenson KR. Comparing objective measures of environmental supports for pedestrian travel in adults. *Int J Health Geogr.* 2009;8(1):62. doi:10.1186/1476-072X-8-62 [PubMed: 19925658]
28. Gabriel KP, McClain JJ, Schmid KK, Storti KL, Ainsworth BE. Reliability and convergent validity of the past-week Modifiable Activity Questionnaire. *Public Health Nutr.* 2011;14(03):435–442. doi:10.1017/S1368980010002612 [PubMed: 20843404]
29. Kriska AM, Knowler WC, LaPorte RE, et al. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. *Diabetes Care.* 1990;13(4):401–411. PubMed ID: 2318100 doi:10.2337/diacare.13.4.401 [PubMed: 2318100]
30. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sports Exerc.* 1998;30(5):777–781. PubMed ID: 9588623 doi:10.1097/00005768-199805000-00021 [PubMed: 9588623]
31. Cohen DA, Han B, Derosé KP, Williamson S, Marsh T, McKenzie TL. Physical activity in parks: a randomized controlled trial using community engagement. *Am J Prev Med.* 2013;45(5): 590–597. PubMed ID: 24139772 doi:10.1016/j.amepre.2013.06.015 [PubMed: 24139772]
32. Cohen DA, Marsh T, Williamson S, et al. The potential for pocket parks to increase physical activity. *Am J Health Promot.* 2014;28-(suppl 3):S19–S26. doi:10.4278/ajhp.130430-QUAN-213 [PubMed: 24380461]
33. Barrett JL, Gortmaker SL, Long MW, et al. Cost effectiveness of an elementary school active physical education policy. *Am J Prev Med.* 2015;49(1):148–159. PubMed ID: 26094235 doi:10.1016/j.amepre.2015.02.005 [PubMed: 26094235]
34. Cohen DA, Han B, Isacoff J, et al. Impact of park renovations on park use and park-based physical activity. *J Phys Act Health.* 2015;12(2):289–295. PubMed ID: 24956608 doi:10.1123/jpah.2013-0165 [PubMed: 24956608]
35. Hankonen N, Heino MT, Araujo-Soares V, et al. ‘Let’s Move It’—a school-based multilevel intervention to increase physical activity and reduce sedentary behaviour among older adolescents in vocational secondary schools: a study protocol for a cluster-randomised trial. *BMC Public Health.* 2016;16(1):451. doi:10.1186/s12889-016-3094-x [PubMed: 27229682]
36. Sutherland R, Reeves P, Campbell E, et al. Cost effectiveness of a multi-component school-based physical activity intervention targeting adolescents: the ‘Physical Activity 4 Everyone’ cluster randomized trial. *Int J Behav Nutr Phys Act.* 2016;13(1):94. doi:10.1186/s12966-016-0418-2 [PubMed: 27549382]

37. Wang H, Li T, Siahpush M, Chen LW, Huberty J. Cost-Effectiveness of Ready for Recess to Promote Physical Activity in Children. *J Sch Health*. 2017;87(4):278–285. PubMed ID: 28260240 doi:10.1111/josh.12495 [PubMed: 28260240]
38. US Census Bureau. 5-year estimates of the block group data of the American Community Survey. 2007–2011. <https://www.census.gov/geo/maps-data/data/tiger-data.html>. Accessed April 3, 2017.
39. Vickers AJ, Altman DG. Statistics notes: analysing controlled trials with baseline and follow up measurements. *BMJ*. 2001;323(7321): 1123–1124. PubMed ID: 11701584 doi:10.1136/bmj.323.7321.1123 [PubMed: 11701584]
40. Van Dyck D, Cerin E, De Bourdeaudhuij I, et al. Moderating effects of age, gender and education on the associations of perceived neighborhood environment attributes with accelerometer-based physical activity: The IPEN adult study. *Health Place*. 2015; 36:65–73. PubMed ID: 26454247 doi: 10.1016/j.healthplace.2015.09.007 [PubMed: 26454247]
41. Ding D, Lawson KD, Kolbe-Alexander TL, et al. The economic burden of physical inactivity: a global analysis of major noncommunicable diseases. *The Lancet*. 2016;388(10051):1311–1324. doi:10.1016/S0140-6736(16)30383-X
42. Robert CP. Monte Carlo Statistical Methods. 2nd ed. New York, NY: Springer; 2004.
43. Centers for Medicare & Medicaid Services. National Healthcare Expenditures; Aggregate and Per Capita Amounts. Baltimore, MD: US Department of Health and Human Services; 2013.
44. Task Force on Community Preventive Services. Recommendations to increase physical activity in communities. *Am J Prev Med*. 2002; 22(4):67–72. doi:10.1016/S0749-3797(02)00433-6 [PubMed: 11985935]
45. Glanz K, Rimer BK, Viswanath K, Lewis FM. Health behavior and health education: theory, research, and practice. 3rd ed. San Francisco, CA: John Wiley & Sons; 2008.
46. Loewenstein G, Brennan T, Volpp KG. Asymmetric paternalism to improve health behaviors. *JAMA*. 2007;298(20):2415–2417. PubMed ID: 18042920 doi:10.1001/jama.298.20.2415 [PubMed: 18042920]
47. Shuval K, Leonard T, Drope J, et al. Physical activity counseling in primary care: insights from public health and behavioral economics. *CA Cancer J Clin*. 2017;67(3):233–244. [PubMed: 28198998]
48. Litman T Economic value of walking In: Mulley C, Gebel K, Ding D, eds. *Walking*. Bingley, UK: Emerald Publishing Limited; 2017:81–98.
49. Abbasi J As walking movement grows, neighborhood walkability gains attention. *JAMA*. 2016;316(4):382–383. PubMed ID: 27367440 doi:10.1001/jama.2016.7755 [PubMed: 27367440]
50. Howe CA, Staudenmayer JW, Freedson PS. Accelerometer prediction of energy expenditure: vector magnitude versus vertical axis. *Med Sci Sports Exerc*. 2009;41(12):2199–2206. PubMed ID: 19915498 doi:10.1249/MSS.0b013e3181aa3a0e [PubMed: 19915498]
51. Knell G, Durand CP, Shuval K, et al. If you build it, will they come? A quasi-experimental evaluation of sidewalk improvements and changes in physical activity. *Transl J Am Coll Sports Med*. 2018; 9:66–71.

Figure 1 —. Participant address densities and Houston Metropolitan Transit Authority of Harris County light rail infrastructure at baseline and follow-up in the greater Houston, TX metropolitan area, Houston TRAIN Study, 2013–2017. TRAIN indicates Travel-Related Activity in Neighborhoods.

Figure 2 —.
Houston TRAIN Study and Houston Metropolitan Transit Authority of Harris County LRT and sidewalk network expansion timeline, 2013–2017. TRAIN indicates Travel-Related Activity in Neighborhoods; LRT, light rail transit.

Figure 3 — Monte Carlo simulation of CERs of improving sidewalks, Houston TRAIN Study, 2013–2017. TRAIN indicates Travel-Related Activity in Neighborhoods; CER, cost-effectiveness ratio (cost/MET·h·y⁻¹ gained from living near a sidewalk improvement); MET·h·y⁻¹, metabolic equivalent hours per year; CEB, cost-effectiveness benchmark (per capita health care cost of physical inactivity/physical activity needed to offset health care expenditures).

Characteristics of Study Participants by Exposure to Improvements in Sidewalk Infrastructure at Baseline, Houston TRAIN Study, 2014–2016

Table 1

Characteristic at baseline	Total (N = 430) n (%)	Sidewalk improvement exposure		P value
		Not exposed (n = 234) n (%)	Exposed (n = 196) n (%)	
Physical activity, median (IQR) ^a				
Transportation-related	0.0 (0.0, 277.6)	29.1 (0.0, 338.9)	0.0 (0.0, 273.8)	.52
Leisure time	623.1 (79.3, 1442.5)	659.3 (68.0, 1453.8)	697.4 (123.8, 1613.2)	.38
Total self reported	832.6 (253.0, 1782.4)	845.8 (333.1, 1782.4)	843.0 (219.4, 1982.4)	.46
Accelerometer	1005.7 (932.3, 1094.0)	1003.2 (944.6, 1079.5)	1151.1 (1036.8, 1263.4)	.95
Sex				.44
Male	141 (32.8)	73 (31.2)	68 (34.7)	
Female	289 (67.2)	161 (68.8)	128 (65.3)	
Age, mean (SD), y				.54
18–44	116 (27.0)	59 (25.2)	57 (29.0)	
45–64	236 (54.9)	134 (57.3)	102 (52.0)	
>65	78 (18.1)	41 (17.5)	37 (18.9)	
Race/ethnicity				.22
White	143 (33.3)	78 (33.3)	65 (33.2)	
Black or African American	180 (41.9)	105 (44.9)	75 (38.3)	
Hispanic or Latino	79 (18.4)	34 (14.5)	45 (23.0)	
Other ^b	25 (5.8)	15 (6.4)	10 (5.1)	
Missing	3 (0.7)	2 (0.9)	1 (0.5)	
Household income				.65
<\$20k	168 (39.1)	89 (38.0)	79 (40.3)	
\$20k–\$39k	64 (14.9)	32 (13.7)	32 (16.3)	
\$40k–\$79k	71 (16.5)	44 (18.8)	27 (13.8)	
\$80k	89 (20.7)	46 (19.7)	43 (21.9)	
Do not know	29 (6.7)	17 (7.3)	12 (6.1)	
Missing	9 (2.1)	6 (2.6)	3 (1.5)	
Educational attainment				.20
High school degree or less	210 (48.8)	115 (49.2)	95 (48.5)	

Characteristic at baseline	Sidewalk improvement exposure			P value
	Total (N = 430) n (%)	Not exposed (n = 234) n (%)	Exposed (n = 196) n (%)	
College degree	201 (46.7)	105 (44.9)	96 (49.0)	
Missing	19 (4.4)	14 (6.0)	5 (2.6)	
Body mass index ^c				.65
Underweight/normal weight	117 (27.2)	62 (26.5)	55 (28.1)	
Overweight	132 (30.7)	74 (31.6)	58 (29.6)	
Obese	176 (40.9)	94 (40.2)	82 (41.8)	
Missing	5 (1.2)	4 (1.7)	1 (0.5)	
Transit user				.09
No	76 (17.7)	49 (20.9)	27 (13.8)	
Yes	353 (82.1)	185 (79.1)	168 (85.7)	
Missing	1 (0.2)	0 (0.0)	1 (0.5)	
Seasonality ^d				.57
Summer months	263 (61.2)	146 (62.4)	117 (59.7)	
Nonsummer months	167 (38.8)	88 (37.6)	79 (40.3)	
Distance from transit stop				<.01
10–93 m	99 (23.0)	41 (17.5)	58 (29.6)	
94–314 m	212 (49.3)	110 (47.0)	102 (52.0)	
315 m–5.3 km	119 (27.7)	83 (35.5)	36 (18.4)	

Abbreviations: IQR, interquartile range; MET·h·y⁻¹, metabolic equivalent hours per year; TRAIN, Travel-Related Activity in Neighborhoods.

^aPhysical activity estimates reported in MET·h·y⁻¹.

^bAmerican Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and Asian or East Indian.

^cWeight in kilograms/(height in meters)². Underweight: <18.5; normal: 18.5 to 24.9; overweight: 25 to 29.9; obese: ≥30.

^dTime of year the participant completed the self-report survey. Summer months are the top 50th percentile of average monthly temperature as reported from National Climatic Data Center (ncdc.noaa.gov), May to October; nonsummer months are from November to April.

Table 2
Cost-Effectiveness Threshold Calculation by Reported and Calculated Estimates, Houston TRAIN Study, 2014–2017

CEB elements	Estimate	Uncertainty level	
		Lower	Upper
Step 1: sidewalk improvement costs elements in Houston			
Mean sidewalk improvement cost (per linear meter)	\$219	\$165	\$417
Total sidewalk length improved, m	750,131	-	-
Sidewalk lifespan, y	50	-	-
Total annualized costs of improvements ^a	\$3,285,574	\$2,475,432	\$6,256,093
Estimated adult population living near sidewalk improvements ^b	1,574,325	-	-
Annualized cost of sidewalk improvements per person ^c	\$2.09	\$1.57	\$3.97
Step 2: physical activity gained per person, MET·h·y ⁻¹			
Transportation-related physical activity	53.1	23.6	129.7
Leisure-time physical activity	230.3	21.9	438.7
Total self-reported physical activity	203.3	-33.0	439.6
Accelerometer-derived physical activity ^e	-4.5	-47.8	38.8
Step 3: cost-effectiveness ratio (cost/MET·h·y ⁻¹ gained) ^f			
Transportation-related physical activity	\$0.04	-	-
Leisure-time physical activity	\$0.01	-	-
Total self-reported physical activity	\$0.01	-	-
Accelerometer-derived physical activity	-\$0.46	-	-
Step 4: CEB elements			
Health care expenditures, US\$ billion	\$2,877.6	-	-
Per capita health care expenditures	\$9,110.0	-	-
Direct costs attributable to inactivity, ^g US\$ billion	\$24.7	\$8.6	\$58.7
Health care expenditures attributable to physical inactivity ^h	0.86%	0.30%	2.04%
Physical activity needed to offset health care expenditures ⁱ MET·h·y ⁻¹	434.5	-	-
Per capita cost of physical inactivity ^j	\$78.30	\$27.30	\$185.80

CEB elements	Uncertainty level	
	Estimate	LowerUpper
CEB (cost/MET·h·y ⁻¹) ^k	\$0.18	\$0.06\$0.43

Abbreviations: CEB, cost-effectiveness benchmark; MET·h·y⁻¹, metabolic equivalent hours per year; TRAIN, Travel-Related Activity in Neighborhoods.

^a (Mean sidewalk improvement cost) × (total sidewalk length improved in Houston)/sidewalk lifespan.

^b The estimated adult population living near sidewalk improvements is the census-derived number of persons residing within a 250-m pedestrian network buffer of the sidewalk improvements at the time of construction completion.

^c (Total annualized costs of improvements in Houston)/(estimated adult population living near sidewalk improvements in Houston).

^d All estimates are modeled as the estimated MET·h·y⁻¹ at follow-up with adjustment for the baseline MET·h·y⁻¹ and confounders.

^e Adjusted for sex, transit use, and distance from home to nearest transit stop.

^f For clarity, cost effectiveness ratios equals the (annualized cost of sidewalk improvements per person [\$2.09])/MET·h·y⁻¹ gained.

^g Costs are estimated from Ding et al.⁴¹

^h (Direct costs attributable to inactivity [\$24.71]/health care expenditures [\$2,877.60]).

ⁱ (500 MET·min·wk⁻¹/60 min/7 d × 365 d).

^j (Per capita health care expenditures [\$9,110.0]) × (health care expenditures attributable to inactivity [0.86%]).

^k (Per capita health care cost of physical inactivity [\$78.30])/(physical activity needed to offset health care expenditures [434.5]).

Table 3

Sensitivity Analysis of CER US\$ and CEB US\$ of Improvements to Sidewalk Infrastructure to Avert Health Care Costs Through Increases in Physical Activity, Houston TRAIN Study, 2014–2017

Cost-effectiveness parameters	Physical activity assessment device	
	Self-reported	Accelerometer-derived
CER, \$/MET·h·y ⁻¹ gained		
Mean	0.07	1.57
95% CI	0.01–0.13	1.09–2.05
SE	0.03	0.24
Range	0.00–30.8	0.05–224.7
CEB (% below)		
Percent below benchmark		
\$0.18 (point estimate)	98%	18%
\$0.06 (lower limit)	95%	0.5%
\$0.43 (upper limit)	99%	30%

Abbreviations: CEB, cost-effectiveness benchmark; CER, cost-effectiveness ratio; CI, confidence interval; MET·h·y⁻¹, metabolic equivalent hours per year; TRAIN, Travel-Related Activity in Neighborhoods.