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Cost Analysis of the Built Environment: The Case of Bike and Pedestrian Trials in Lincoln, Neb

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We estimated the annual cost of bike and pedestrian trails in Lincoln, Neb, using construction and maintenance costs provided by the Department of Parks and Recreation of Nebraska. We obtained the number of users of 5 trails from a 1998 census report. The annual construction cost of each trail was calculated by using 3%, 5%, and 10% discount rates for a period of useful life of 10, 30, and 50 years. The average cost per mile and per user was calculated.

Trail length averaged 3.6 miles (range = 1.6–4.6 miles). Annual cost in 2002 dollars ranged from $25 762 to $248 479 (mean = $124 927; median = $171 064). The cost per mile ranged from $5735 to $54 017 (mean = $35 355; median = $37 994). The annual cost per user was $235 (range = $83–$592), whereas per capita annual medical cost of inactivity was $622.

Construction of trails fits a wide range of budgets and may be a viable health amenity for most communities. To increase trail cost-effectiveness, efforts to decrease cost and increase the number of users should be considered. (*Am J Public Health*. 2004;94:549–553)

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ENVIRONMENTAL FACTORS affect the health of all people in both developed and developing countries. Because of industrialization and the consequent environmental pollution, environmental changes in the past several decades have led to new challenges for public health.

Many studies have documented links between the environment and human health.[1–7] For example, household amenities and other environmental exposures have been linked to children's health problems such as cancer and asthma,[1–3] and environmental pollution has been linked to high morbidity and mortality in the general population.[4–7] In recent years, the worldwide increase of obesity has prompted discussions of environmental interventions such as increasing the availability of healthy snacks and building environments that are amenable to physical activity as possible effective means to prevent and control obesity and other costly chronic diseases.[8–11]

Because of suburbanization, the transportation systems in the United States have been designed for automobile use. Although automobile-oriented transportation is a necessity for economic development and people's daily lives, the modern transportation system may pose a hazardous environment for public health. Recently, 42% of American adults expressed a great deal of concern about urban sprawl and loss of open space,[12] which can create an environment of physical inactivity, a major risk factor for several chronic diseases and obesity.[13–25] One study has demonstrated the association between the built environment and physical activity by showing the effects of urban environment on walking behavior.[22] Another study showed that environmental features such as neighborhood design appeared to affect whether residents walked to work.[24]

Pedestrian-oriented urban environments may promote physical activity,[22,23] and a combination of urban design, land use patterns, and transportation systems that promote walking and bicycling may help create more livable communities.[26–28] Lieberman recently suggested that proper design and land use patterns and policies can increase public transit use as well as walking and bicycling.[26] Efforts to increase the pedestrian-oriented environment through mixed-use development, street connectivity, and good community design can enhance both the feasibility and attractiveness of walking and bicycling.

Participation in regular physical activity depends in part on the availability and proximity to such resources as community recreation facilities and walking and bicycling trails, so building such environments holds much promise in health promotion.[29–31] Studies on the economic costs of the built environment must proceed, because they may provide critical information to policymakers regarding resource allocations. We conducted a cost analysis of building bike and pedestrian trails to provide some of this information.

DATA SOURCE

We obtained the costs of construction and maintenance of 5 bike and pedestrian trails in Lincoln, Neb, from the Department of Parks and Recreation of Nebraska, and the number of trail

TABLE 1—Number of Users and Costs of Construction and Maintenance of Trails

Trail Description	Date Built	Trail Length (mi)	Number of Users	Construction Cost (2002 $)	Maintenance Cost (2002 $)
1. Concrete, 2 bridges	1995	4.6	1638	2 366 927	26 183
2. Limestone chip, 0 bridges	1997	4.5	232	90 982	14 980
3. Concrete, 3 bridges	1996	4.1	1878	1 621 994	11 828
4. Concrete, 0 bridges	1989	3.1	238	979 600	17 196
5. Concrete, 1 bridge	1999	1.6	Not available	598 863	7 040

users from the Great Plains Trails Network (Table 1).[32] In addition to the cost and number of users, information about surface type, date built, and length was also obtained for each trail. The construction cost was a 1-time investment on building the trails. Ideally, the cost would be divided into labor cost and capital cost, but we were able to obtain only the total cost without further details. Maintenance cost was based on annual upkeep expenditures. The construction and maintenance costs were adjusted to 2002 dollars using a 5% inflation rate based on the date each trail was built.

The number of users was determined by the Lincoln Recreational Trails Census, which was conducted on Sunday, July 12, 1998 (Table 1). The census began at 7:00 AM and concluded at 9:00 PM the same day. Census volunteers, working in 2-hour shifts, counted cyclists, runners, walkers, skaters, and miscellaneous users (such as persons with skateboards, wheelchairs, and horses.) Ideally, this number would be adjusted according to weather and date of the week to determine a representative number of users, but this information was unavailable.

The census report used this information for the number of users in 1998, which is comparable to the number of users in other years. We used this number as a snapshot of the use of trails for a conservative estimate of cost-effectiveness of trails. This value is conservative because the number of users during a year should be more than that during a day. Additionally, we varied the number of trail users listed in the census report by increasing or decreasing by 50% to calculate a range for the cost per user.

DATA ANALYSIS

The construction cost is a large 1-time capital investment, so it is necessary to spread the investment over the useful life in years by determining an annual value of the capital investment. To do this, we calculated an annuity factor that takes into account time preference (r, discount rate) and length of useful life (t, number of useful years). The annuity (A) rate [$A(t,r)$] for time t years at r discount rate was derived by using $A(t,r)=1/r[1-1/(1+r)^t]$. The annual equivalent cost (AEC) of trail construction was calculated by $AEC=C\times A(t,r)$, where C is the 1-time capital expenditure.

The time preference needs to be incorporated into the cost estimate even with zero inflation because people prefer paying later and getting benefits earlier.[33] The discount rate, r, is a quantitative measure of time preference.

Different discount rates have been used in empirical studies; the normal range is 3% to 10%. We used 3%, 5%, and 10% as discount rates for cost estimation to cover a wide range of time preference. The higher the discount rate, the more people value current dollars. In the case of trail investment, a higher discount rate was associated with a higher AEC for construction. For the number of years of useful life of the trails, we used 10, 30, and 50 years to cover a wide range of situations. The longer the useful life of the trails, the lower the construction AEC.

For the case of a 5% discount rate and 30 years of useful life, we calculated annual cost per mile for construction, maintenance, and a total (construction and maintenance costs combined). In addition, for the total cost, we calculated the annual average cost per user as a measure of cost-effectiveness. We also analyzed the composition of cost (construction versus maintenance) and types of users.

RESULTS

The 5 trails were built between 1989 and 1999. Their average length was 3.6 miles (range=1.6–4.6 miles) (Table 1). Four trails had a concrete surface, and 1 had a limestone-chip surface. On the day of census, the number of users ranged from 232 persons on the limestone-chip trail (trail 2) to 1878 persons on the most heavily used concrete trail (trail 3, a concrete surface with 3 bridges). The total construction cost ranged from $90 982 ($20 218 per mile) for trail 2, the limestone-chip trail, to $2 366 927 ($514 549 per mile) for trail 1, a concrete surface with 2 bridges. The annual maintenance cost ranged from $7040 ($4400 per mile) for trail 5, a concrete surface with 1 bridge, to $26 183 ($5692 per mile) for trail 1.

The AEC for construction of the 5 trails under all the scenarios of time preference and period of useful years is useful information for those deciding on resource allocations (Table 2). Among all the scenarios, the highest cost ($542 021) was incurred for the 4.6-mile concrete trail 1 with its 2 bridges under the assumption of a 10% discount rate and 10 years of useful life. The lowest cost ($4513) was incurred for the 4.5-mile limestone-chip trail under the assumption of a 3% discount rate and 50 years of useful life.

Using a 5% discount rate and 30 years of useful life, we found that the annual average cost per mile for trail 4 (concrete with no bridges) was $45 505, and the cost for trail 3 (concrete with 3 bridges) was $37 994 per mile. The annual total cost per user for trail 4 was $592, whereas the cost per user for trail 3 was $83 (Table 3). The cost ranged from $55 to $1185 per user.

For cost composition, 85% of the total cost was construction cost (range=29%–91%) under the assumption of a 5% discount rate and 30 years of useful life (Figure 1). Because only 1 trail was made of limestone chips and it cost much less than the con-

TABLE 2—Annual Equivalent Construction Cost of Trails (2002 $)

		Annual Equivalent Construction Cost		
Trail	Years of Useful Life	3% Discount	5% Discount	10% Discount
1	Concrete, 2 bridges			
	10	390 437	458 009	542 021
	30	169 920	216 653	353 298
	50	129 442	182 434	335 912
2	Limestone chip, 0 bridges			
	10	13 613	15 969	18 898
	30	5924	7554	12 318
	50	4513	6361	11 712
3	Concrete, 3 bridges			
	10	254 816	298 916	353 746
	30	110 897	141 397	230 577
	50	84 479	119 064	219 231
4	Concrete, 0 bridges			
	10	216 524	254 023	300 619
	30	94 242	120 162	195 948
	50	71 792	101 183	186 306
5	Concrete, 1 bridge			
	10	81 271	95 337	112 824
	30	35 370	45 097	73 540
	50	26 944	37 975	69 922

crete trails, the average cost composition was very close to the cost compositions of the concrete trails. The composition was similar for all the concrete trails. The majority of users were bicyclists (73%), followed by runners/walkers (20%) (Figure 2). Because of data limitations, we did not know how the types of users varied with the type of trails.

DISCUSSION

When communities decide to build a bike or pedestrian trail, financial budgeting should be based on trail surface type, length, and other features such as bridges. Both construction and maintenance costs should be considered, because although the construction cost of the limestone-chip trail was much lower than that of the concrete surface trails, the maintenance cost was not necessarily lower.

The construction AEC varied with the discount rate and number of years of useful life. Specifically, the cost increased as the discount rate increased, and decreased as the number of years of useful life increased. The figures suggest that the cost of building a trail can vary greatly and that trails can be developed to meet a variety of budgets.

As an example of the variances, the construction AEC (at a 5% discount rate and 30 years of useful life) of building a concrete trail with 1 bridge was 6 times as expensive as building a limestone-chip trail. The total annual cost (including both maintenance and construction costs) for a concrete trail was 5 times more than that for the limestone-chip trail.

Although the cost of building and maintaining a limestone-chip trail was lower than the cost for a concrete trail, the limestone-chip trail may not be the most cost-effective strategy if the number of users is taken into account. The cost per user for the limestone-chip trail ($111) was more than for a concrete trail with 3 bridges ($83). Thus, both the total cost of trails and the number of users should be considered when decisions about trails are made. On average across all the trails, the cost per user was $235. This figure is much lower than the economic benefit of physical activity. A conservative estimate of direct medical cost savings from physical activity was $330 per person in 1987.[34] Using a 5% inflation rate, this savings is about $622 in 2002, nearly 3 times as high as the trail cost. Therefore, developing trails may be a cost-effective means to promote physical activity.

The fact that there were more users on concrete trails than on the limestone-chip trail (except trail 4, built in 1989, on which there were similar number of users) may suggest that concrete trails have more desirable features and are more convenient for cycling. Because most of these users were bicyclists (unfortunately, we did not have detailed information about user type on the limestone-chip trail versus the concrete trails), building trails to fit the needs of cyclists may substantially increase the cost-effectiveness and net health benefits of trails.

Several limitations should be noted to interpret the findings properly. (1) We cannot analyze total construction costs such as labor and material in more detail because of data limitations. This lack of information restricted our ability to examine how other major factors (e.g., material cost, land value, funding sources) influenced the total cost and how to minimize project costs. (2) The number of trails is small, and each trail was built in a different year. Technology and funding sources change over time, so the cost of each trail may not be fully comparable. Therefore, the average cost across trails may be somewhat inaccurate, although

TABLE 3—Annual Total Cost (2002 $) of Trails Using a 5% Discount Rate and 30 Years of Useful Life

		Construction Cost		Maintenance Cost		Total Cost		
Description	Trail	Total	Per Mile	Total	Per Mile	Total	Per Mile	Per User[a]
Concrete, 2 bridges	1	216 653	47 098	31 826	6919	248 479	54 017	152 (101, 303)
Limestone chip, 0 bridges	2	7 554	1 679	18 208	4046	25 762	5 725	111 (74, 222)
Concrete, 3 bridges	3	141 397	34 487	14 377	3507	155 774	37 994	83 (55, 166)
Concrete, 0 bridges	4	120 162	38 761	20 902	6743	141 064	45 505	592 (395, 1185)
Concrete, 1 bridge	5	45 097	28 186	8 557	5348	53 654	33 534	Not available
Average		106 173	30 042	18 774	5312	124 947	35 355	235 (156, 469)

[a]Figures in parentheses are the cost per user calculated by increasing or decreasing the number of users listed in the census report by 50%.

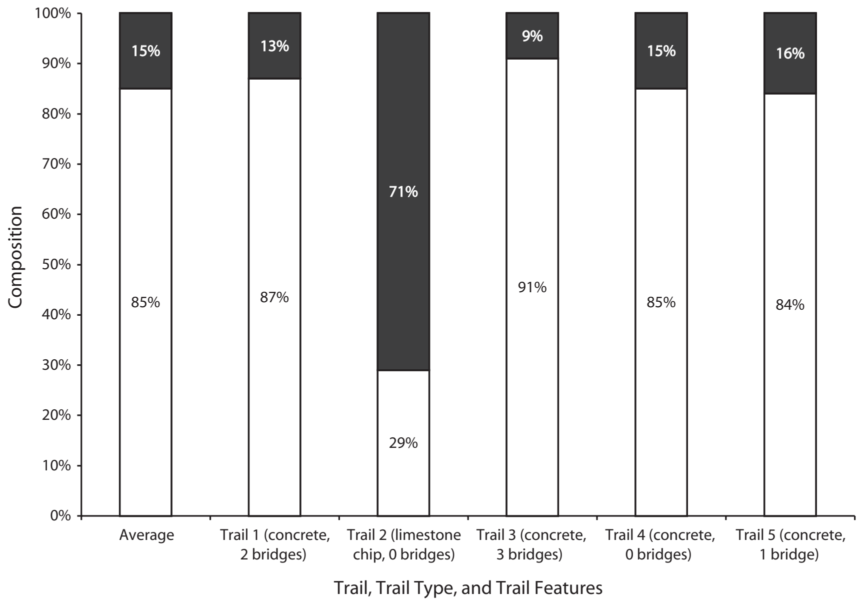

FIGURE 1—Cost composition (black = maintenance; white = construction) of 5 trails in Lincoln, Neb, using a 5% discount rate and 30 years of useful life.

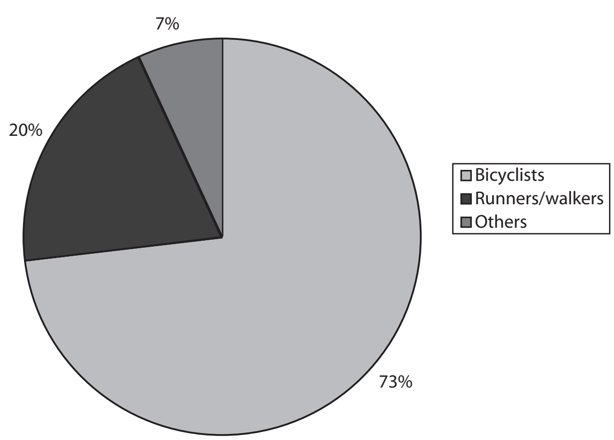

FIGURE 2—Trail user type in Lincoln, Neb.

we adjusted all the costs to 2002 dollars. (3) The census was conducted on a Sunday in summer; we cannot claim that it was representative of the number and type of users on an average day. The lack of information means we cannot adjust the number of users according to weather, day of the week, purpose of using trails, and other factors. For example, many users may commute to work. The number of users on a Sunday would not capture this. Therefore, if the majority of trail users used trails for commuting, the cost per user may be severely underestimated. (4) Information on various qualitative aspects of trails was lacking. We have information only on the surface type, length, and number of bridges for each trail. Other attributes such as safety and convenient access to trails also affect the cost of construction and maintenance. Because of these information gaps, the cost estimates according to trail length and surface type should be interpreted cautiously. (5) The trails analyzed in this study were built as a part of community design or development planning, not as a public health intervention project. Factors such as increased property value or a more attractive environment may have been major determinants of building trails rather than health promotion. These added values may have significantly biased our cost estimates because we analyzed only financial cost and did not consider the effects of other community features such as location and land value. (6) We analyzed only the cost data of trails in a local community area. The results should not be generalized to other areas because household income levels, natural characteristics, and local politics influence the development of trails.

Despite these limitations, we derived a framework of cost analysis based on the available data, and several strengths should be noted. (1) We derived the costs of construction and maintenance for each trail and adjusted all costs to 2002 dollars, which should increase the comparability of the cost across the 5 trails. (2) We incorporated different discount rates and number of useful years into the analysis, and therefore covered a wide range of possible cost values for trails. (3) We used trail length and number of users on each trail to derive the cost per mile and cost per user. The cost per mile is useful for community planners who are deciding to build trails based on financial feasibility. The cost per user is useful to demonstrate the usability of trails as a measure of cost-effectiveness.

For future economic research on the built environment, detailed cost information should be collected systematically. This information will make analysis much more useful in identifying factors influencing the cost of trails. In addition, effectiveness of trails in changing physical activity behaviors should be incorporated into the economic analysis. To do this, data such as consumer willingness to pay for trail construction and use if trails are built should be collected. When information about trail effectiveness is available, cost-effectiveness of trails on health promotion can be soundly evaluated.

CONCLUSIONS

Trails can fit a wide range of budgets depending on the needs and resources of the community. Our research demonstrates the need to increase cost-effectiveness efforts by researching ways to decrease the cost of building trails and to increase the number of users of trails. We have also outlined specific information that should be gathered to more completely explore the construction and use of trails in the future. Policymakers and community developers may use the cost information to determine their needs and the cost-effectiveness and feasibility of built environments in their community. ■

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Contributors

All authors helped plan the study. G. Wang and B. Scudder-Soucie obtained the data. G. Wang also performed data analysis and wrote the article. C.A. Macera, T. Schmid, D. Buchner, G. Heath, and M. Pratt revised the article. Pratt also supervised the project.

Human Participant Protection

No protocol approval was needed for this study.

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