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The Connection Between Neighborhood Walkability and Life Longevity in a Midsized City

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Riggs and Gilderbloom discuss a study for Louisville, KY that confirms the relationship between walkability and health, offering lessons for similar urban areas. Investigating years of projected life lost as it relates to neighborhood walkability, they found that more walkable areas are predictors of longevity. The study suggests that the trend toward longer lifespan may be connected to gentrification-related displacement and racial homogenization in walkable neighborhoods. The findings can help shape urban design policies and interventions that support physical activity.

With a population in the United States exceeding 300 million, and 80 percent urbanized, the 'complex web' of causality between the urban environment and health is getting renewed interest (Corburn, 2005; Krieger, 1994). In recent years, many practitioners and researchers in planning and public health have sought to reinforce the synergies between the built environment and health outcomes. They have looked at large cities like Seattle, San Francisco and Minneapolis, suggesting that increased walkability, through greater urban density, land use variation and street grid connectivity, can help improve activity levels and address broader public health issues such as obesity.[1] Yet, there is little research on mid-sized cities—which face similar challenges but different urban dynamics.[2]

Research has shown that many of these mid-sized cities face similar issues related to the built environment travel and health, as they compete to maintain economic competitiveness and increase livability for residents.[3] Mid-size city geographies and neighborhood characteristics differ from megacities (Appelbaum, 1978; Batty, 2013; Coulton, Korbin, Chan, & Su, 2001). Very little work has evaluated the relationship between the built environment attributes that facilitate active travel and health. While some work has evaluated urban design and level-of-service indicators (Ameli, Hamidi, Garfinkel-Castro, & Ewing, 2015; Sahani & Bhuyan, 2014; Van Loon et al., 2013), none focuses on accessibility-based measures and quantifiable public health outcomes such as reduction in lifespan.

This study evaluates the connection between walkability and one of the most widely used public health indicators—estimating years of potential life lost (YPLL). This evaluation uses the case of Louisville, Kentucky—a mid-sized city with more far-reaching validity and normative policy outcomes than larger cities that have been the subject of prior work. The authors provide a brief review of the literature on the relationship between walkability and health, and discuss the data and methods, noting the unique attributes of neighborhoods in mid-sized cities. The analysis and discussion makes policy recommendations in the spirit of the new epistemology of public health and planning research (Corburn, 2007; Krieger & Higgins, 2002), which seeks to translate research into meaningful action.

Literature

Many studies suggest less walkable locations have less active residents who are obese, or have obesegenic trajectories.[4] Despite this many neighborhoods have been designed for automobiles, with little connectivity, limiting the ease of moving via walking or cycling to schools, stores and workplaces.[5] Research has confirmed these connections between built envi-

[1] See: Cao, 2014; Cervero & Kockelman, 1997; Cho & Rodríguez, 2015; Ewing & Cervero, 2010; Ewing & Cervero, 2001; Ewing, Hajrasouliha, Neckerman, Purciel-Hill, & Greene, 2015; Forsyth & Krizek, 2010; Forsyth, Oakes, Schmitz, & Hearst, 2007a; Frank, Andresen, & Schmid, 2004; Frumkin, Frank, & Jackson, 2004; Riggs, 2011; Riggs, 2016b; Smith et al., 2008.

[2] See: Appelbaum, Bigelow, Kramer, Molotch, & Relis, 1976; Bolton & Hildreth, 2013; Brewer & Grant, 2015; Burayidi, 2013; Hall & Pfeiffer, 2013.

[3] See: Gilderbloom, Ambrosius, Squires, Hanka, & Kenitzer, 2012; Gilderbloom, Riggs, & Meares, 2014; Hummel, 2014; Martinez-Fernandez, Audirac, Fol, & Cunningham-Sabot, 2012; Riggs, 2014; Riggs & Gilderbloom, 2016.

[4] See: Cao, 2015; Cho & Rodríguez, 2015; Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003; Frank et al., 2004; Kurka et al., 2015; Lovasi, Hutson, Guerra, & Neckerman, 2009; Riggs, 2014.

ronment attributes and active travel (Ewing & Cervero, 2010), and shown that increased time in cars and decreased walking can lead to increased probability of hypertension, obesity and race-related health disparities.[6]

There is now consensus in the medical community that being overweight and obese increases the risk of high blood pressure, high cholesterol, heart disease, stroke, certain types of cancer, gall-bladder and respiratory disease, joint and bone disease and many other afflictions, including diabetes (Avenell et al., 2004; Pi-Sunyer, 1993; Reilly & Kelly, 2011; Withrow & Alter, 2011). Inactive lifestyles are associated with elevated risk of obesity and diabetes, showing that even light-to-moderate activity correlates with reduced risk of developing such conditions (Hu, Li, Colditz, Willett, & Manson, 2003; Thompson, Edelsberg, Colditz, Bird, & Oster, 1999). Compounding issues of obesity, less walkable locations have been associated with social isolation and disconnection—conditions likely to result in chronic mental or physical health conditions (Cerin, Leslie, & Owen, 2009; Cutts, Darby, Boone, & Brewis, 2009; Putnam, 2001; Sturm & Cohen, 2004). Much of this work looked at built-environment attributes correlated with such activity.

More recent work has documented revealed travel behavior and is beginning to suggest a stonger relationship (Carlson et al., 2015; Duncan, Cash, Horn, & Turkheimer, 2015). Obesity affects large portions of the US population regardless of socioeconomic status.mHowever, public health studies connect socioeconomics and race to increased risk of obesity (Ellen, 2008; Ellen, Cutler, & Dickens, 2000; Ellen & Turner, 1997; Lovasi et al., 2009). These studies do not consider the growing issues of marginalization, disinvestment and displacement in many small and mid-sized urban communities, where the attributes correlated with walking and active travel are not present (Martinez-Fernandez et al., 2012; Vojnovic et al., 2014). Many cities experience pressures of dispersion as downtowns gentrify. This is a social justice issue that policy needs to address.[7]

This study hypothesizes that the walkable aspects of the built environment are significantly connected to population health, or years of potential life lost, in midsized cities. Thus, investing in walkable areas will promote both health and social justice. Equitable attention to neighborhood walkability has the potential to improve the duration and quality of life for residents of all races and socioeconomic groups. To test this hypothesis, the study uses the case of Louisville, Kentucky, a typical mid-sized city in the United States (US) that is semi isolated and not located within another 90 miles of another mid-sized city of 50,000 or more and has been used many times to study modern neighborhood dynamics of a city.

The city of Louisville, Kentucky contains both walkable urban neighborhoods and less walkable suburban neighborhoods. The 170 Census Tracts in Louisville provide an excellent case study because of: 1) their translatable scale for other cities and geographies; 2) their stable and modest market dynamics; 3) the availability of high-quality data at the Census Tract level;[8] and, 4) the Tract level more accurately reflects the neighborhood scale in Louisville—an attribute has been shown to be similar in other mid-sized cities including Cleveland, Ohio, Jackson City, Mississippi, and Raleigh-Durham, North Carolina.[9]

These factors make the scale of Louisville large enough for a thorough assessment of urban trends, but small enough to comprehend. Louisville is one of 375 metropolitan areas identified by the U.S. Census and ranks as the 47th largest metropolitan area. Its population of roughly 741,000 spreads across 385 square miles along the Ohio River, in a simple, relatively mono-centric format, ringed by two freeways. It has one central business district (CBD), with approximately 52,000 jobs (13 percent of the total), forming an inner beltway with high density housing, an in-between area with smaller homes, and an outside beltway where there has been increased building of larger, more suburban homes (Ambrosius et al., 2010).

This urban / suburban dynamic is an important distinction to make because of the differences in physical form at the neighborhood level that might influence walking, as well as the underlying behavioral /driving habits for those who live outside of the CBD. Research has shown that areas of higher density may encourage more walking for transportation purposes; however, lower density areas offer more opportunities for leisure walking (Kang, Moudon, Hurvitz, & Saelens, 2015). Louisville provides a range of these neighborhood types, with a large variation in density and walkability—representative of trends in smaller and midsized cities versus a megalopolis such as New York, San Francisco, Chicago or Los Angeles.

Methods

Model & Data

From a methodological perspective this study uses a statistical model based on the ecological model framework that has been well-explored in the literature.[10] This model takes into account intrapersonal characteristics within the context of the

[5] See: Frank et al., 2006; Kurka et al., 2015; Renalds, Smith, & Hale, 2010; Riggs, 2011; Saelens & Handy, 2008; Sallis et al., 2009; Sallis, Frank, Saelens, & Kraft, 2004a.

[6] See: Brulle & Pellow, 2006; Cerin & Leslie, 2008; Forsyth et al., 2007a; Gordon-Larsen, Nelson, Page, & Popkin, 2006; Macintyre, 1989; Sooman & Macintyre, 1995; Williams & Jackson, 2005.

[7] See: Gilderbloom, Anaker, Squires, Hanka, & Ambrosius, 2011; Gilderbloom, 2015; Goetz & Chapple, 2010a, 2010b; Schafran, 2013; Zuk et al., 2015.

[8] See: Ambrosius et al, 2010; Appelbaum, 1978; Appelbaum et al., 1976; Hanka et al, 2015; Molotch, 1976.

[9] See: Coulton et al., 2001; Coulton & Pandey, 1991; Morland, Wing, Diez Roux, & Poole, 2002.

[10] See: Giles-Corti, Timperio, Bull, & Pikora, 2005; Sallis et al., 2006; Sallis et al, 2008; Sallis & Owen, 2015.

neighborhood and policy environments, as shown in Figure 1. This focuses on the intrapersonal and neighborhood factors. Beginning with intrapersonal factors, the associated variables are rotated in to multiple regression models to analyze the correlation between walkability (the dependent variable in most cases), years of potential life lost (YPLL) and other controlling variables typically used to account for issues of multicollinearity and heteroscedasticity, consistent with the described ecological model. β coefficients (and 95% CIs) from the best fitting regression models are reported.

For independent variables, the authors rely on data from the following sources: the 2000 and 2010 U.S. Census; the U.S. Census Bureau's Transportation Planning Package; the Louisville Metro Police Department (LMPD); Louisville Metro Department of Health and Wellness; and, the City Louisville Property Value Assessor (PVA). The study employs the 'Street Smart' Walk Score™ tool developed by Frontlane to incorporate many neighborhood level factors associated with livability and accessibility.[11] This Street Smart' Walk Score™ tool aggregates variables that account for most of the classic land use D's that have been associated with walking behavior, including residential density, destination accessibility (a gravity function as distance increases up to a 1 ½ mile buffer), land use diversity (the number of varied uses in this buffer) and design (block length and number of intersection nodes / intersection density) (Cervero & Kockelman, 1997; Lee & Moudon, 2006). More on this measure can be found on the Walk Score™ website (https://www.walkscore.com/methodology.shtml).

Since Walk Score™ is obtained at an individual address level, this study uses ArcGIS to aggregate individual scores at the Census Tract level by applying the average Walk Score™ for each residential address to a Tract-level GIS centroid. This approach to measuring walkability is limited in that it measures only an indicator of built environment attributes that have been associated with walking behavior and propensity to walk (not behavior). This approach may suffer from some aggregation error and does not account for the aspects of street quality related (such as the presence of trees, sidewalk width, etc.), safety (from traffic or crime) and terrain characteristics (slope). Yet, this model allows us to compare data at the Census level to this metric and may help wash out issues related to spatial auto-correlation in the analysis (e.g. any unforeseen measurement errors are consistent across tracts).

Census and all other covariate data were obtained from publicly available databases housed at the Kentucky State Data Center at the University of Louisville. Covariates for crime were from the Louisville Metro Police Department. This includes all types of crimes reported annually by geo-coordinate. Foreclosures were similarly treated, received with exact geo-coordinates

[11] See: Cao, 2010; Carr, Dunsiger, & Marcus, 2010, 2011; Duncan et al, 2013; Duncan et al, 2011.

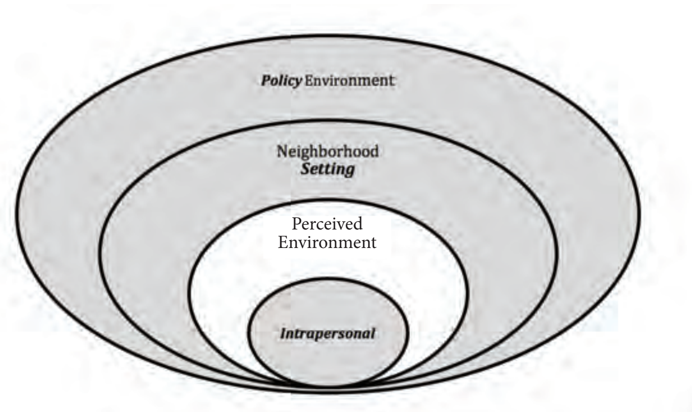


Figure 3: Conceptual model.

from the Jefferson County Property Valuation Administrator and then aggregated to the Census Tract level. These variables are summarized in Table 1 next page.

Dependent Variable: YPLL

To measure premature death, at the neighborhood level, the analysis uses one of the most common public health indicators that measures social and economic loss due to premature death—years of potential life lost (YPLL) (Blane, Smith, & Bartley, 1990; Gardner & Sanborn, 1990). Similar to methods used by the Centers for Disease Control and Prevention, this is calculated per 100,000 residents over a multi-year period between 2000 and 2010 (Centers for Disease Control and Prevention, 2008; Colton & Manderscheid, 2006). The YPLL variable stems from data collected by the Louisville Metro Department of Health and Wellness, giving the year of death, age at death, and last known address of all deceased persons in Jefferson County, between the years 2000 and 2010. This data was received anonymously, with all of the individual addresses and personal identifiers scrubbed, and converted this data into the YPLL variable using the following equation:

$$YPLL = \Sigma (E - A)/P$$

Where:
E is the standardized expected age of death (=75),
A is the age at death,
P is the 2010 population of each Tract divided by 100,000.

Total YPLL is summed by tract, and divided by each Tract's population (Census 2010), then divided by 100,000 to control for the differences in population across tracts. Higher numbers denote increases in YPLL—indicating a decreased life expectancy. This method allows us to evaluate how pre-mature death affects younger age groups, even in areas with a greater concentration of older adults and it highlights potential geographic clusters where individuals experience premature death. Due to the secondary use of anonymous data, this project did not require full human subject review. Researchers were required

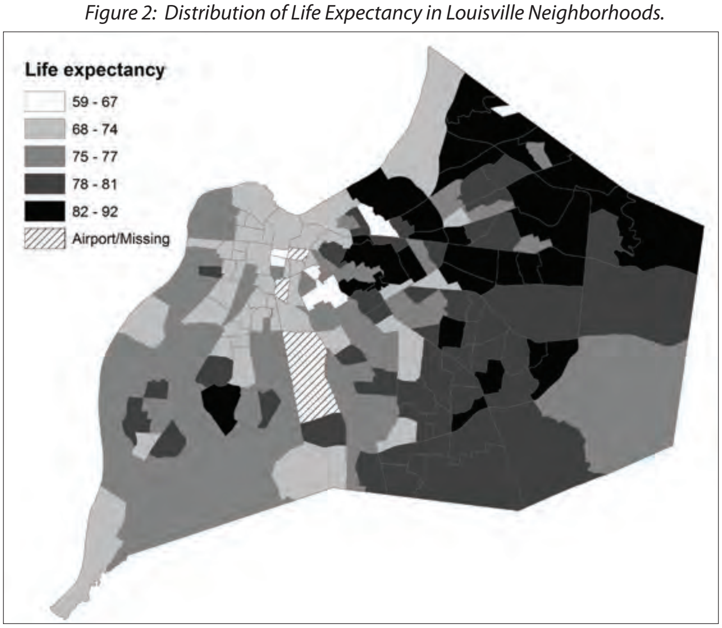
Table 1: Descriptive Statistics.

	Years of Potential Life Lost (YPLL)	Median household income, 1999 (2000 Census)	Percent of nonwhite residents, 2000 (ratio*100)	Distance to the central business district (CBD) tract (49) in miles	Walk High	Walk Score
Type	Interpersonal	Interpersonal	Interpersonal	Setting	Setting	Setting
Year	2000	2000	2000	2000	2010	2010
Source	JCHD	Census	Census	Census	Walkscore	Walk Score
Measure	rate per 100k	$	%	Mile	#	#
Min	2477.5	6086	1.4	0.0	0.0	0
Max	21688.0	110472	99.4	18.6	1.0	97
Mean	8455.6	40524.5	25.4	7.0	0.2	42.7
Std Dev	3883.7	19527.8	29.5	4.0	0.4	23.6
N	170	170	170	170	162	170

	Median housing age, 2000	Number of housing units, 2000	Total Crimes per 100,000	High interest loan foreclosures	Foreclosures 04-08
Type	Setting	Setting	Setting	Policy	Policy
Year	2000	2000	2007	04-08	04-08
Source	Census	Census	LMPD	JCPVA	JCPVA
Measure	#	#	# per 100,000 residents	NA	$
Min	2	10	193.7	0	0
Max	60	3358	51216.6	38	197
Mean	38.7	1296.4	6500.3	9.9	54.8
Std Dev	15.1	605.0	5432.8	7.3	44.6
N	170	170	170	170	170

Notes: JCPVA= Jefferson County Property Valuation Administrator; LMPD= Louisville Metro Police Department; WI=Walkability Index; MAV= Median assessed value; AAV= AVG Assessed Value; FS= Foreclosure sales; YPLL= Years of Potential Life Lost; JCHD= Jefferson County Health Department.

Figure 2: Distribution of Life Expectancy in Louisville Neighborhoods.



to ensure that personally identifiable information would be removed from the data collected. Figure 2 maps the YPLL variable across Louisville's neighborhoods.

<u>Statistical Model</u>

The analysis makes use of OLS regression to predict neighborhood years of projected life lost, with the key test variable—walkability, and other control variables consistent with the model. Multiple models were tested for the appropriate control variables. Consistent with ecological models on population health, the variables for education and income were found to be collinear. Since income provided a better fit, it was chosen as an appropriate control. Age was not significantly correlated; thus, it was not included in final models. For purposes of validity and reliability, all models shown were tested for multicollinearity by calculating tolerance scores and examining zero-order correlation coefficients (Lewis-Beck, 1980; Oakes, 2004). All tolerance scores for variables used in the equation exceed 0.30. The full final regression equation is as follows:

$YPLL = \beta 0 + \beta 1{*}Nonwhite\ percent + \beta 2{*}Housing\ age + \beta 3{*}Income + \beta 4{*}Crime\ rate + \beta 5 walkaiblity + \varepsilon$,

Where β1 through β6 are the coefficients to be estimated and ε is the error term.

Results

As is shown in Table 2, the analysis found a connection with many factors that underscore previously discussed epidemiological models about the complex nature of health planning, something scholars like Webber have defined as a 'wicked' problem— one without easy solutions (Rittel & Webber, 1974; Webber, 1979).

In Model 1, which had an explanatory value of .72 based on the adjusted R square and looked at individual characteristics, the analysis revealed a significant negative relationship between income and YPLL, and a highly significant positive relationship between non-white residents and increased mortality. This is consistent with literature by Massy and Williams, which documents the weathering effect chronic poverty has on racial minorities (Massey, 2004; Williams & Jackson, 2005). It also illustrates that factors such as income (or education) can serve as intervening factors, especially in areas that are gentrifying (Riggs, 2014).

When adding built environment setting and policy-related factors, there are correlations between walkability and housing characterstics that extend beyond the individual, as well as a significant relationship with foreclosures. Specifically with regard to walkability factors, the model shows that when walkability decreases, the YPLL increases – a factor significant at the .05 level.

When moving to Model 2, it is evident that, in the most walkable locations, the connection between health, interpersonal and environmental factors increases in significance. When rotating in a dummy variable focused on the most walkable locations (Walk High), the significance of the walkability covariate improves, and there is a better fitting model altogether. Again, the most walkable areas have less YPLL by a factor of 10, significant at the .05 level. The adjusted R squre also improves and explains four fifths of the variation.

Discussion

This analysis confirms that the impacts of walkable neighborhoods in a mid-sized city are not isolated to the econometric factors that other literature has found to be connected to such environs (Gilderbloom et al., 2014; Pivo, 2013; Pivo & Fisher, 2011). In fact, the analysis shows there are true 'human costs' to less walkable and livable environments. Specifically, people

Table 2: Relationship Between YPPL and Neighborhood Factors.

Specification	Model 1		Model 2	
	Unst.	Beta	Unst.	Beta
Constant	6963.160***		-56.108***	
Median household income, 1999 (2000 Census)	-.079***	-.396*	.000**	-.188**
Percent of nonwhite residents, 2000 (ratio*100)	54.652***	.415***	.662***	.437***
Distance to the central business district (CBD) tract (49) in miles	57.340	.060	2.693**	.224**
Walk Score (Model1) / Walk High (Model 2)	-23.041*	-.140*	-11.722**	-0.103**
Median housing age, 2000	67.196***	.261***	.885***	.287***
Number of housing units, 2000	.220***	0.034***	.022***	.294***
Total crimes per 100,000 residents 2007	.140***	.196***	.001	.069
High interest loan foreclosures	8.426	.016***	3.036***	.495***
F	55		85.12	
R Square	0.732		0.814	
Adjusted R Square	0.719		0.804	
N	170		170	

Notes: Unstandardized coefficients (standardized Beta). P<0.1. *p<0.05. **p<0.01. ***p<0.001. DV = Years of Potential Life Lost (YPLL) rate per 100k. Model 1 uses WalkScore index as Independent Variable. Model 2 uses Walk High group as Independent Variable tend to die at a younger age in these locations. When walkability is sacrificed, YPLL is likely to increase. Specifically, in Louisville's more walkable environments there are often historical concentrations of poor and higher minority individuals, there is a clear gain in life longevity. This result confirms other studies focusing on large municipalities with similar findings.

Limitations

The concept of walkability has limitations in that it is both aggregate in nature and provides an index of correlates related to walking behavior, not a representation of actual behavior. The analysis did not control for local spatial autocorrelation, however, other work suggests that there is a lack of significant autocorrelation at the zipcode and Tract level using these aggregate measures (Bjørnstad, 2004; Riggs & Sethi, 2016; Zuur, Ieno, Walker, Saveliev, & Smith, 2009).

An important limitation of this study is cross-sectional in nature. It provides a snapshot, not accounting for residential location changes over a lifespan. For example, the key variable YPLL basis assumes age at death relative to a nominal standard of 75 years. This is summed over all deceased persons, and then converted into a metric per 100,000 people in the census tract population. This does not account for: 1) changes between walkable vs. nonwalkable tracts during the lifespan; 2) the related environmental exposures associated with residential changes; or 3) the notion that the geography of Tract may not define a neighborhood. The Census Bureau indicates that most moves occur before the age of 20 after which there is a large taper (Chalabi, 2015); however, it is possible the numbers are impacted by older adults who move in later life. Furthermore, it is possible (although not probable) that this traditional public health indicator may be undermined by the urban migration trends of Millenials (Myers & Pitkin, 2009), who often locate in walkable locations, only to live a normal, long life and not die young.

These limitations represent a complicated dynamic that relates back to Krieger's classic web of causality. Clearly there are individuals that are not representative of residents in the cohort of those who die in the each Census Tract, and clearly there are residential self-selection issues at play. While much of these relate to the aggregate nature of the data, these factors illustrate issues that continue to confound researchers in public health and planning, and emphasize the continued need for research in this area, as well as the need for policies. This is especially the case gentrification and displacement may be occuring amoung the poor and elderly causing them to locate in places other than the most walkable areas.

Policy Implications

The analysis suggests potential policy strategies, even if there are self-selection or location-based concentration-related issues embedded in this analysis. A growing body of literature documents higher concentrations of minorities and the poor moving to suburban areas, as urban areas gentrify and experience revitalization (Riggs, 2011; Schafran, 2013). This trend of displacement relates to the classic resource equity cases made by several scholars.[12] If the trend toward gentrification continues, planners and policy makers may begin to see even greater locational disparity between public health indicators like YPLL, where those in the least accessible and walkable areas are also the least healthy. Policy is needed to address this disparity in small and mid-sized communities. To conclude, the authors propose two policy solutions that can be rationally applied at both scales: 1) a focus on active design solutions in the built environment; and, 2) a programmatic behavioral approach to active living.

One policy strategy of active design is wider adoption of healthy design standards. One intervention method that is driving this market shift is the LEED-ND (Leadership in Energy and Environmental Design – Neighborhood Design) program. The LEED Reference Guide, published by the US Green Building Council, recommends many cost-saving and ecological methods of building design that can have an impact on health (Ewing, Kreutzer, & Frank, 2006; USGBC, 2008). Although the recommendations are voluntary, and based on developer preference, they are becoming highly visible in the construction world, since the standards recognize the impact of physical design on human health. Site selection for new structures should be sensitive to the ecosystem and the factors that have been correlated with physical activity including density and mix of uses, as well as simple transportation demand management strategies such as education and wayfinding, inclusion of showers, changing rooms, and bike storage (Black & Schreffler, 2010; William Riggs, 2015; Thompson & Suter, 2012).

Implementing many of these building-level design methods, and providing increased emphasis on transit-oriented development, could yield additional intervention methods and health benefits. The successful examples of developments in small or suburban cities, such as Orinco Station in Oregon, Atlantic Station in Georgia, and Village Homes near Davis in California, have been catalysts for healthier cities, providing opportunities for green developments along transit as well as incidental and non-incidental exercise (Szibbo, 2016; Hannon & Brown, 2008). In such communities, aspects of the built environment are associated with higher levels of adult walking, including measures to improve accessibility and safety. One example is the effort to increase the "percentage of blocks with sidewalks, mixed use (residential and at least one other use) and public space (outdoor, open spaces such as gardens, plazas, etc.)." Additional elements strongly associated with recreational walking are "including more windows facing the street and more street lighting, and fewer abandoned buildings, graffiti, rundown buildings, vacant lots,

[12] See, for instance: Kuklys, 2005; Kuklys & Robeyns, 2005; Nussbaum, 1986; Nussbaum & Glover, 1995; Rawls, 1975, 1988; Sen, 1999.

and undesirable land uses" (Alfonzo, Boarnet, Day, Mcmillan, & Anderson, 2008, 44).

There are recognizable fiscal tradeoffs for this kind of healthy design strategy. Based on data from the San Francisco Bay Area's Metropolitan Transportation Commission, street-level design elements such as bulb-outs and chokers, surfacing techniques and raised crosswalks, can cost as much as $20,000. Yet, this investment is not a loss for communities. Literature has already indicated that these strategies have an economic benefit and that design of streets and sidewalks yields higher property values, a higher tax base, and more a more resilient downtown community (Gilderbloom et al., 2014; Glaeser, 2008; Pivo, 2013; Riggs & Gilderbloom, 2015). Based on these studies, future work may find a direct return-on-investment from project specific on-street expenditures.

Another avenue for meaningful policy action is the encouragement of active living programs that shift behavioral norms—especially for smaller communities that may not have the financial means to engage in larger capital improvement projects. Literature indicates that behavioral programs represent a shift in public health strategies and necessitate the involvement of many disciplines (Sallis, Frank, Saelens, & Kraft, 2004b). Rather than focusing solely on the built environment, they focus on health-promoting activities that address personal and behavioral factors (Frank & Engelke, 2005). These include programs such as "Get Lean Houston", aimed at the fattest city in the US, a national "Active for Life" elderly fitness education program, and the pedometer-based step competitions used by some employers to reduce healthcare costs.

The work of Cerin and Leslie (2008) suggests that these immediate social and behavioral norm interventions can be especially effective, if they are

> aimed at reducing the gap in participation between socio-economic group… (and inform) the most disadvantaged segments of the population about the benefits of an active lifestyle and teaching them behavioral skills that can help to increase self-efficacy for regular engagement in leisure-time physical activity. (p. 11)

Cerin and Leslie discuss how such a program can encourage social and community groups to support increased physical activity, forging relationships that are sustained after policy-related programs have ended.

Technology can play a role in helping to reshape healthy behaviors. Recent work has looked at a how mobile frameworks can be used to gamify activities and change behavior using either social or market norms.[13] The use of self-tracking data to influence behavior is found in health-related applications such as Strava, Nike+ (run calculator & tracker), Zeo (sleep patterns), and Calorie Counter (caloric intake). The ability to know and disseminate location-based information including trips, time traveling, money spent, activities conducted, has created the idea of the "quantified self" – a theme useful for communities interested in influencing behavior using tools that positively influence knowledge, skills, attitudes and behaviors in relation to health and physical exercise (Papastergiou, 2009). Active design and behavior change strategies open the door for a portfolio of active-lifestyle policies for small-to-midsized communities that may not have resources to address built environment issues.

Conclusion

This research advances the urban science of how urban form shapes health. The study provides models that show a health connection with the most walkable locations. It confirms the hypothesis that walkable areas are significantly connected to a decrease in years of potential life lost, in midsized cities. Furthermore, this study finds that many of these locations are highly urban, minority dominant, and facing pressures of gentrification and displacement. Given this, investing in walkable areas may be a means to promote both health and social justice.

Such work is not without limitations, given the complex nature of such webs of causality, potential for aggregation error and the limitation of how public health indicators track residential changes over a lifetime. Nevertheless, the fit of the models is consistent with prior research and highlights factors worthy of the attention of public servants and an active citizenry. Figure 3 shows a street in Louisville suffering from neglect and disinvestment. The results are evident to the naked eye based on the inaccessibility of sidewalks for walking, lack of bike lanes for cycling, overgrown landscaping, and lack of places for socialization and community. In many communities the lack of active living features and pedestrian limitations are commonplace—something which can degrade housing

Figure 1: Housing in Louisville.

[13] See, for instance: Carrel, Ekambaram, Gaker, Sengupta, & Walker, 2012; Dugundji & Walker, 2005; Riggs, 2015, 2016a; Riggs & Kuo, 2015.

quality and impede the choice of active transportation and healthy lifestyles.

Research has documented that an environment with access to walking trails, bike routes, and green space, can increase the likelihood of exercise. Community-gathering places that encourage human interaction, are basic building blocks for mental health. Data shows that people who exercise are healthier and less susceptible to chronic health or mental issues than people who do not exercise. A built environment that encourages and supports walkability and exercise, can result in a more physically and mentally fit populace, which is less costly for society.

Such logic underscores the importance of policies supporting healthy community design and active living. These policies can mitigate some of the observed conditions in places like Louisville, Kentucky. Indeed, the benefit of engaging in policies that make neighborhoods greener and more walkable, may be greater than the cost. While construction of a healthier community does not fully address complexities of the ecological models, it likely has few downsides. It might yield more children walking to school on collision-free streets and more people grocery shopping without the use of their cars, while also aiding to unravel some of the mysteries behind the complex web of disease causality in global cities.

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